Benjamin Klement

Cumulative and Combinatorial Knowledge Dynamics:

Their Role for Continuity and Change in Regional Path Development

Cumulative and Combinatorial Knowledge Dynamics: Their Role for Continuity and Change in Regional Path Development

Kumulative Dissertation
zur Erlangung des Doktorgrades der Naturwissenschaften (Dr. rer. nat)

am Fachbereich Geographie der
Philipps-Universität Marburg
vorgelegt von:

Diplom-Geograph

Benjamin Klement

aus Wetzlar

Marburg, 2018

Vom Fachbereich Geographie (Fachbereich 19) der Philipps-Universität Marburg als Dissertation am 11.12.2017 angenommen. Die Disputation erfolgte am 16. Mai 2018 am Fachbereich Geographie (Fachbereich 19) der Philipps-Universität Marburg.

Erstgutachterin: Prof. Dr. Simone Strambach (Philipps-Universität Marburg)

Zweitgutachter: Prof. Bjørn Terje Asheim (Universitetet i Stavanger, Norwegen/ Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE), Lund, Schweden)

Drittgutachterin: Univ.-Prof. Mag. Dr. Michaela Trippl (Universität Wien)

Hochschulkennziffer: 1180

To Ria Eckhardt-Klement

PREFACE

i. Thesis Details

Title:	Cumulative and Combinatorial Knowledge Dynamics: Their Role for Continuity and Change in Regional Path Development
Ph.D. student:	Dipl.-Geogr. Benjamin Klement
Supervisor:	Prof. Dr. Simone Strambach, Philipps-Universität Marburg, Germany
2nd Referee:	Bjørn Terje Asheim, Universitetet i Stavanger, Norway/ Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE), Lund, Sweden

ii. Curriculum Vitae

30.11.1983	Born in Wetzlar, Germany
08.1990 – 06.1994	Grundschule Oberbiel
08.1994 – 06.2000	Kooperative Gesamtschule Eichendorffschule Wetzlar
08.2000 – 06.2003	Oberstufengymnasium Goetheschule Wetzlar **Allgemeine Hochschulreife (University-entrance diploma)** Grade: 1.6
10.2004 – 03.2011	Philipps-Universität Marburg **Diploma in Geography** Minor subjects: Economics, Sociology
11.2006	Mid-exam Vordiplom, grade: 1.4
03.2011	Degree: Diplom Diploma thesis*: The changing role of foreign-owned subsidiaries in India in organizationally decomposed innovation processes: Knowledge production between autonomy and interdependency* Supervisor: Prof. Dr. Simone Strambach, 2nd referee: Prof. Dr. Dr. Thomas Brenner Grade: 1,2
10.2011 – 07.2015	Philipps-Universität Marburg, Department of Geography **Lehrkraft für besondere Aufgaben**
07.2015 – 04.2017	Philipps-Universität Marburg, Department of Geography **Wissenschaftlicher Mitarbeiter**

iii. Eidesstattliche Erklärung

Benjamin Klement
Weißerde 6
35392 Gießen

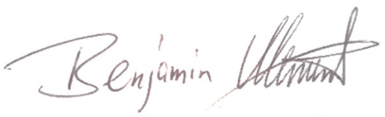
An den
Vorsitzenden des Promotionsprüfungsausschusses
Fachbereich Geographie
Philipps-Universität Marburg
Deutschhausstr. 10
35032 Marburg

Erklärung

(gemäß § 10, Abs. 1c der Promotionsordnung vom 15.07.2009)

Ich versichere wahrheitsgemäß, dass ich die vorliegende Dissertation selbst und ohne fremde Hilfe verfasst, keine anderen als die in ihr angegebenen Quellen oder Hilfsmittel benutzt sowie vollständig oder sinngemäß übernommenen Zitate als solche gekennzeichnet habe. Die Dissertation wurde in der vorliegenden oder einer ähnlichen Form noch bei keiner anderen in- oder ausländischen Hochschule eingereicht und hat noch keinen sonstigen Prüfungszwecken gedient.

Gießen, den 07.12.2017



Benjamin Klement

iv. Papers and Contributions

The following papers are included in this thesis.

No.	Title	Journal	Status	Co-authors (with contribution)	Own contribution
1	Cumulative and Combinatorial Micro-Dynamics of Knowledge: The Role of Space and Place in Knowledge Integration	European Planning Studies	Published in 2012, volume 20, issue 11, pages 1843-1866,	Simone Strambach (70%)	Co-author with significant contribution (30%)
2	Exploring plasticity in the development path of the automotive industry in Baden-Württemberg: the role of combinatorial knowledge dynamics	Zeitschrift für Wirtschafts-geographie	Published in 2013, volume 57, issue 1-2, pages 67-82	Simone Strambach (70%)	Co-author with significant contribution (30%)
3	Innovation in Creative Industries: Does (Related) Variety matter for the Creativity of Urban Music Scenes?	Economic Geography	Submitted on 26 July, 2017; 1st revision	Simone Strambach (25%)	Main author (75%)
4	How do new Music Genres emerge? Diversification Processes in Symbolic Knowledge Bases	Regional Studies	Submitted on 7 September, 2017	Simone Strambach (25%)	Main author (75%)

In addition to these papers, the following book chapters were also published, which are not part of this thesis:

Strambach, S. & Klement, B. (2016) Resilienz aus wirtschaftsgeographischer Perspektive: Impulse eines „neuen“ Konzepts. In: Wink, R. (ed.) Multidisziplinäre Perspektiven der Resilienzforschung. Springer, Wiesbaden, pp. 263–294.

Strambach, S. & Klement, B. (2012) The organizational decomposition of innovation and territorial knowledge dynamics: insights from the German software industry. In: Heidenreich, M. (ed.) Innovation and institutional embeddedness of multinational companies. Elgar, Cheltenham, pp. 193–221.

v. Acknowledgments

Finally, you can talk to me about my thesis again. You may be really glad that this thesis is now finished. You may be one of the people interested in what I actually do all the time at this university job. You may have been supporting this work in emotional and/or conceptual terms and now really deserve a copy. You may be a member of the thesis committee who is hereby greeted with utmost respect. You may be interested in this thesis for its scientific content. You may be a poor student who had to get ahold of this thesis and hope that at least these acknowledgments brighten up your day.

For whatever reason you might have picked up this thesis, please know that a thesis can never be the product of one person alone, even though it most often feels that way. Countless people somehow contributed to it in different ways and might not even know. May these acknowledgments inform some of these people about it.

First of all, I want to thank my supervisor Simone Strambach for deciding in September 2007 that this guy with the funny hat could be a good addition to her research group. In the last ten years, I have learned quite a bit about everything from her. This thesis would not have been possible without her support, ideas, and guidance, for which I am immensely grateful. I was lucky to have her as a supervisor, as she encouraged me to follow some crazy ideas.

During all these years I had the pleasure to work with and learn from many great people at the Philipps-Universität Marburg. Especially sharing the office and classrooms with Philipp Hein, Konstantin Schneider, Annika Surmeier, Florian Warburg, Thomas Brenner, Charlotte Schlump, Anja Dettmann, Tim Appelhans, Ansgar Dorenkamp, Martin Reiss, Martje Timmermann and Hannah Pinell made work a lot more fun than it usually is. Thanks for all the inspiring talks, comments on my work, discussions, and laughs! A special thank goes out to my office roommate Annika Surmeier for reminding me of many deadlines and that there are too many coffee mugs on my table.

The journey towards a Ph.D. is full of stops at conferences, workshops, and meetings. It has always been a pleasure to meet the people behind the literature that provides the foundation for this thesis. In particular, I want to thank Bjørn Asheim for being such an inspirational scholar who always keeps his ears open to the ideas of young researchers. I am also very fortunate that I could discuss my work and/or share a conference beer with Ron Boschma, Tom Brökel, Pierre-Alexandre Balland, Marte Cecilie Wilhelmsen Solheim, Johannes Glückler, Allan Watson, Brian Hracs, Christian Binz, and Roman Martin.

I have also met a lot of fellow travelers who are also pursuing this idea of becoming very knowledgeable in a very specific field. Unfortunately, it would take a bit long to mention every participant of the Ph.D. workshop in Utrecht 2014 or the YEGN meetings of 2016 and 2017, but be assured: even though you may have been junior researchers, your ideas, questions, and methodical support were already senior. Still, I want to thank especially Daniel Hain, Antoine Habersetzer, Marcin Rataj, Frank van der Wouden, Taylor Brydges (look what your Myspace paper made me do!) and Chris Esposito for all the debates at the Ph.D. table and exploring conference cities together.

At this point my closest friends may wonder, a) who all these people above are and b) when it is finally their turn to be acknowledged. Spoiler alert: Now is the time. I don't know who I would be if you weren't around. I want to thank all my friends for emotional support, proofreading and questioning everything I know. Someone has said that hard creative work is like breathing out – so you certainly need some quality time to breathe in. If this is true, then the friendships with Eike, Markus, Anne, Christian, Marco, Thomas, David, Anni, Katti, Manu, Kiki, the pub quiz team, Kathi, my bandmates (now there's something to google for you!) and many more have been my oxygen during the last years.

I want to end with the most important people in my life, my family, without nothing of this ever would have been possible. They deserve my deepest gratitude for providing me with love, support, genes, programming help (shoutout to my sister Laura!), patience, sympathy, and security. Finally, I want to thank my smart little nephew Anton for reminding me, especially in the last few days, that there are much more important things to do than "writing stuff", for instance, watching He-Man and Star Wars. Which I will be doing now that I have finished writing these acknowledgments. Now you, on the other hand, probably have to read this thesis. Enjoy.

vi. Abstract

English: This thesis addresses the question of how regions can adapt to technological and social changes. In the face of recent economic rises, disruptive digitalization, and the need to transition towards sustainability, processes of diversification, transformation, and renewal have become increasingly important to strengthen the dynamics development of regions. While the creation or the lock-in of regional development paths has received a lot of attention by economic geographers, studies on the transformation of existing paths are relatively scarce. Instead, in recent decades scientific, political, and economic actors alike have promoted a logic of specialization to support regional competitiveness. Yet the processes outlined above require that these specializations are combined with novel, external knowledge inputs.

In order to capture these processes of the accumulation and combination of knowledge, this thesis introduces and applies the concept of knowledge dynamics. It differentiates interaction processes by the degree of institutional and cognitive distance that actors have to bridge. In the theoretical framework of this thesis, these knowledge dynamics are brought together with path development research of the Evolutionary Economic Geography and Innovation Systems literature strands.

At the center of this thesis stand the questions of how different knowledge dynamics influence, and are influenced by, the elements and institutions of regional economic landscapes. In four papers based on empirical material from different contexts, these interfaces are explored. Thereby the focus is laid on knowledge dynamics in symbolic knowledge bases of music scenes, as the field of non-technological innovation is relatively underexplored despite its increasing economic significance. In order to quantitatively measure innovation and knowledge dynamics in this creative industry, this thesis employs so-called resonance indicators derived from digital social data.

The findings of this thesis show that the interplay of cumulative and combinatorial knowledge dynamics leads to processes of path modernization and branching. While cumulative knowledge dynamics guide the direction of potential diversification routes, combinatorial knowledge dynamics affect the creation and transformation of new organizations and institutions. In order to promote these dynamics, path plasticity and the openness to extralocal knowledge sources should be promoted.

vi. Abstract

Deutsch: Diese Dissertation untersucht, wie Regionen sich an sozialen und technologischen Wandel anpassen. Angesichts ökonomischer Krisen, einer disruptiven Digitalisierung und der Notwendigkeit einer Transition hin zu nachhaltigen Wirtschaftsformen werden Prozesse der Diversifizierung, Transformation und Erneuerung immer bedeutsamer für die Regionalentwicklung. Während die Wirtschaftsgeographie bisher eingehend untersuchte, wie regionale Entwicklungspfade durch Lock-In-Prozesse erstarren, ist die Zahl wirtschaftsgeographischer Studien zur Transformation von regionalen Entwicklungspfaden vergleichsweise gering. Stattdessen ist zu beobachten, dass in den letzten Jahrzehnten vor allem Logiken räumlicher Spezialisierung von wissenschaftlichen, politischen und wirtschaftlichen Akteuren ge- und befördert wurden, um regionale Wettbewerbsfähigkeit zu stärken. Die hier skizzierten Veränderungsprozesse erfordern jedoch, dass diese regionalen Spezialisierungen mit neuem, externen Wissen kombiniert werden.

Um die Prozesse der Akkumulation und Kombination von Wissen zu erfassen, führt diese Thesis das Konzept der Wissensdynamiken ein und demonstriert seine Anwendung. Wissensdynamiken differenzieren Interaktionsprozesse anhand der institutionellen und kognitiven Distanzen welche Akteure überbrücken müssen. Im theoretischen Rahmen dieser Arbeit wird das Konzept der Wissensdynamiken zusammengebracht mit der Forschung zu Pfadentwicklung in der Evolutorischen Wirtschaftsgeographie und Innovationssystemsanalyse.

Im Kern dieser Dissertation steht die Frage nach den Wechselwirkungen zwischen verschiedenen Wissensdynamiken und den Elementen und Institutionen regionaler wirtschaftlicher Landschaften. In vier wissenschaftlichen Zeitschriftenartikeln, welche auf empirischem Material aus verschiedenen Kontexten basieren, werden diese Schnittstellen zwischen Interaktionen, Elementen und Institutionen untersucht. Hierbei wird ein Schwerpunkt auf Wissensdynamiken in symbolischen Wissensbasen von Musikszenen gelegt, da nicht-technologische Innovationen trotz ihrer ökonomischen Bedeutung noch relativ unerforscht sind. Um Innovationen und Wissensdynamiken in der Kreativwirtschaft zu messen, werden in dieser Arbeit sogenannte Resonanzindikatoren auf Basis digitaler sozialer Daten entwickelt, gemessen und analysiert.

vii. Table of Contents

viii. List of Figures

ix. List of Tables

x. List of Abbreviations

ACM	Automated Content Management
ACM-box	A tool for →ACM, central innovation of the case study in chapter 5
AR	Average Relatedness
ASCS	Automotive Simulation Center Stuttgart
BeLCAR	Bench Learning in Cluster Management for the Automotive Sector in European Regions
BK	Benjamin Klement
bwcon	Baden-Württemberg: connected e.V.
CARS	Clusterinitiative Automotive Region Stuttgart
DKB	Differentiated Knowledge Bases
DKI	Distant Knowledge Interaction processes
DOI	Digital Object Identifier
EBM	Electronic Body Music
EEG	Evolutionary Economic Geography
ERDF	European Regional Development Fund
EU	European Union
EURODITE	Research project named "Regional Trajectories to the Knowledge Economy: A Dynamic Model" and funded by the European Union
GM	General Motors Company
GPS	Global Positioning System
HPCC	High Performance Computing Center Stuttgart
IBM	International Business Machines Corporation
ICT	Information and Communication Technologies
IDM	Intelligent Dance Music
IPC	International Patent Classification
IT	Information Technology

JAC	Jacobs externalities
KIBS	Knowledge-Intensive Business Services
KD	Knowledge Dynamics
MAR	Marshallian externalities
MEDIAKIBS	Central firm in the case study of chapter 5
MFG	Medien- und Filmgesellschaft Baden-Württemberg mbH
MKD	Micro-Knowledge Dynamics
NACE	Nomenclature statistique des Activités économiques dans la Communauté Européenne
NYHC	New York Hardcore
OEM	Original Equipment Manufacturer
PKI	Proximal Knowledge Interaction processes
R&D	Research & Development
RIS	Regional Innovation Systems
RV	Related Variety
SAS	Synthetic, Analytic, Symbolic Knowledge (see →DKB)
SC	Specialization Coefficient
SIC	Standard Industrial Classification
SiS	Simone Strambach
SRV	Semi-Related Variety
SUV	Sports Utility Vehicle
TIM	Territorial Innovation Model
TKD	Territorial Knowledge Dynamics
UK	United Kingdom
USA	United States of America
UV	Unrelated Variety
VDC	Virtual Dimension Center Fellbach

I INTRODUCTION

1 Introduction

“If we want things to stay as they are, things will have to change”

- Giuseppe Tomasi di Lampedusa (1958): Il Gattopardo -

My hometown Solms (Germany) was also home to a company whose products have achieved a legendary status amongst a worldwide community of consumers: Leica Camera. Since its foundation in nearby Wetzlar in 1869, Leica’s greatest invention was the 35mm film camera in 1914. The company continued to design and produce cameras that were cherished by professional photographers and amateurs alike (Storbeck 2008). Around the company, an optical industry cluster evolved in the region that employed over 5000 people at its peak (Moßig & Klein 2003). But in the late 1990s, a tidal wave of new technology threatened the company: Within seven years, from 1996 to 2003, the sales of digital cameras overtook the ones of film cameras (Lucas & Goh 2009). This did not stop Leica’s CEO Hanns-Peter Cohn from stating in 2004: “Digital technology is just an interlude. Of course, people will take pictures with other means in 20 years. But film photography will still be around then” (Kerbusk 2004: 82). As we know now, the digitalization of photography did continue, resulting in a downfall of Leica’s turnover of 40% between 2000 and 2005. Yet Leica, facing imminent bankruptcy, was saved by an Austrian investor who changed its strategy. In cooperation with the Japanese company Matsushita/Panasonic, Leica finally managed to introduce a fully digital model range by 2009 (Etscheit 2011). In 2014, the company moved from its nondescript factory building in Solms back to Wetzlar into a new headquarters featuring the so-called Leica World, a museum and gallery that celebrates the brand and its history (Obertreis 2014). A global network of 77 flagship stores was established, and in 2016, the smartphone market was entered by a co-engineering/licensing cooperation with the Chinese producer Huawei. Overall, this new strategy was so successful that the company’s turnover of the fiscal year 2015/16 set an all-time company record (DPA 2016).

1. Introduction

No, this thesis is not about Leica. Nevertheless, this short case study illustrates the processes that have motivated this thesis and gives a preview of themes recurring in it remainder.

First, the Leica case illustrates the rapid technological changes that occurred in recent years. It is one of the world's megatrends that the rate of technological change is accelerating (EEA 2015): While it took 16 years until computers were adopted by 25% of the US population (Kurzweil 2005), smartphones reached this degree of market penetration within 3 years after the first iPhone was released in 2007 (PewInternet 2011). Like many other examples, the shift from film photography to digital can be considered a so-called "disruptive innovation" (Christensen 1997; Lucas & Goh 2009). These are innovations that disrupt existing markets by providing new, often less complex, initially underperforming solutions to consumers' needs. It is discussed that many sectors are probably also about to fundamentally change as well, either because of the proliferation of digital information and communication technologies or because of the need to transition towards decarbonization (Coenen & Truffer 2012; Cooke 2013). Consequently, the need for adaptation and innovation has considerably increased. How to create and make use of knowledge has become one of the main sources of firms' competitiveness (Nonaka et al. 2000).

Second, the social dimension of innovation has gained in importance. For instance, the great disruption of photography by digital technology was not caused by technology alone. In fact, the quality of early digital cameras was quite low. But what was not expected by major players was the rapid change of social practices surrounding photography, especially due to the rise of smartphones (Lucas & Goh 2009). More and more, the success of companies is rooted in creating business model innovations (Markides 2006; Chesbrough 2007) that reconfigure how consumers interact with products and services. In many sectors, new forms of platform capitalism (Langley & Leyshon 2017) have emerged, because of which especially actors in creative industries have to reorient their business models towards creating new experiences and relations with consumers. Because of this turn towards an experience economy (Pine & Gilmore 2011), the significance of non-technological innovation that provides new aesthetic and user-oriented value added has risen considerably in recent years (Jeannerat & Crevoisier 2011; D'Ippolito & Timpano 2016). In addition to that, not all innovation has to be technologically superior: The transition towards a sustainable economy and society results in the emergence of new consumer segments that demand products and services to comply with certain social and environmental standards (Gilg et al. 2005). There are several examples of new social practices arising around new products and services, such as electromobility (Altenburg et al. 2016), craft beer (Elzinga et al. 2015), responsible tourism (Strambach & Surmeier 2013), or slow fashion (Leslie et al. 2015) that businesses in the respective industries cannot afford to miss. For businesses, this means that they have to find new ways to acquire, create, and use so-called symbolic knowledge (Asheim 2007) of socially constructed symbols, norms, values, habits, and culture required to understand and appeal to consumers.

Third, the strategy employed by Leica sketches ways to adapt to these changes mentioned above. It was not the local linkages to Wetzlar's optical cluster that were activated in order to find suitable solutions in this critical situation, but global networks with investors or cooperation partners (Obertreis 2014). In recent years it has been observed that border-crossing innovation processes become more prominent (Bruche 2009; Schmitz & Strambach 2009). A rising mobility of information and labor has resulted in global networks of knowledge exchange to which regional economies need to connect (Crevoisier & Jeannerat 2009; Asheim 2012). But this does not mean that existing activities and strengths have to be given up. The combination of external knowledge with existing competencies in optics and lens production enabled Leica to enter a co-engineering/licensing agreement with Huawei. The real value of external knowledge was only achieved by anchoring it with the accumulated knowledge base of the firm (Crevoisier & Jeannerat 2009). Furthermore, the example of Leica shows how symbolic knowledge can be leveraged by establishing attractively designed headquarters, flagship stores, and galleries with which connections to the community of professional photographers were strengthened. By doing so, the engineering-based synthetic knowledge (Asheim 2007) was infused with new meaning.

This increasing importance of border-crossing, intersectoral processes for innovation has been termed as a shift from cumulative to combinatorial knowledge dynamics (Crevoisier & Jeannerat 2009). And this is what this thesis is about. For today's world requires constant adaptation, a new focus on the symbolic meaning of products and services, new interactions between local and global knowledge, and new relationships between accumulated and external knowledge.

1.1 Objectives and Research Questions

In economic geography, the above-mentioned requirements of today's world have only recently entered the scholarly debate. The chalice of economic geography has filled to the brim with territorial innovation models (Moulaert & Sekia 2003) that explain economic development mainly by specialization, agglomeration economies and a focus on the mechanisms through which geographical and other forms of proximity (Boschma 2005) facilitate learning and innovation processes (Asheim et al. 2011a). These concepts and models were empirically informed by an abundance of successful regions, such as Silicon Valley or Baden-Württemberg, which prospered in the global economy because of the richness of local interactions within them. The concept of path dependence, imported from economics (David 1985; Arthur 1989), was used to explain the self-reinforcing mechanisms that favored economic development in some regions and resulted in the lock-in of unfavorable states in others (Martin & Sunley 2006).

But there was a lack of theories and research explaining adaptability and how successful regions could remain competitive and escape lock-in (Martin 2010). In the financial crisis of 2008, this became painfully evident. In the following years, the meaning of regional economic resilience for economic geography was debated and most scholars agreed that only an evolutionary understanding of resilience was valuable for regional economies. This understanding focuses not on the ability of economies to bounce back to previous states but to their ability to constantly adapt, in anticipation or reaction to sudden or gradual adverse, external effects (Simmie & Martin 2010; Bristow & Healy 2017).

Correspondingly, economic geographical research shifted to the analysis of transformation, adaptability, diversification, transition, and renewal of regional economies. Essentially, this body of research focuses on how new activities can enter a regional economy. (Martin 2010; Truffer & Coenen 2012; Tödtling & Trippl 2013; Boschma 2016; Boschma et al. 2017). Other than in the prevalent understanding of path dependence, existing economic structures were no longer understood as a burdensome legacy of the past that has to be overcome, but as a valuable resource which can be recombined, converted, and layered with new elements (Martin 2010). Evidently, the structure of existing economic activities affects the availability of opportunities for transformation and renewal greatly. It has been suggested that structures of regional economies that are characterized by so-called related variety (Frenken & Boschma 2007) provided best conditions for knowledge spillover and learning (Content & Frenken 2016).

1.1 Objectives and Research Questions

New regional development policies were developed, such as "Constructing Regional Advantage" (Asheim et al. 2011a) and "Smart Specialization" (Foray 2014) that aim at the transformation of regional economies by diversifying from the opportunities provided by existing regional economic structures and knowledge bases. Thus, this thesis contributes to this body of research by pursuing the following main objective:

1. **To analyze how regional economies can adapt to technological and social changes**

The existing body of research on this matter is not without gaps. These research gaps are shortly introduced here and are discussed at length in the theoretical and methodological sections. Most notably, the microfoundations for regional adaptation and transformation are lacking from the existing literature on knowledge creation (Hautala & Höyssä 2017), institutional evolution (Strambach 2010b), regional diversification (Boschma 2016) and regional innovation system transformation (Asheim 2016). Hence, this thesis takes the perspective that processes on the micro-level comprising the accumulation and combination of knowledge are important to achieve adaptability to technological and social changes. Accordingly, the second objective of this thesis is as follows.

2. **To explore how different knowledge dynamics on the micro-level contribute to forms of regional path development**

As mentioned above, the role of non-technological innovations for regional development has gained significance in recent years. While analyzing the combination of knowledge in the technological or scientific domain has made considerable advances in the last years (Antonelli et al. 2010; Uzzi et al. 2013; Boschma et al. 2015), the methodological tools available for the analysis of symbolic knowledge are underdeveloped, as they are limited to the use of employment and business data (Asheim & Hansen 2009; Boschma & Fritsch 2009; Florida & Jackson 2010). Thus, the nature of innovation in the creative economy, the underlying knowledge, and its evolution have been hidden, in particular, from the quantitative analysis of general mechanisms and patterns of development by statistical methods (Miles & Green 2008; Lee & Rodríguez-Pose 2014a). Consequently, the third objective of this thesis is:

3. **To capture knowledge dynamics and relatedness in symbolic knowledge bases**

To accomplish these objectives, several research questions are formulated and answered in the course of the thesis. Even though they are derived from the theoretical framework developed at a later stage of the thesis, they are listed here as well to give an overview. As indicated by the title and the above-mentioned objective, the main research question is formulated as

M — **Which role do cumulative and combinatorial dynamics play for continuity and change in regional path development?**

In order to tackle this main research question, the following four sub-questions are raised during the remainder of this thesis.

1 — **In what ways do cumulative and combinatorial knowledge dynamics differ on the micro-level?**

2 — **How do cumulative and combinatorial knowledge dynamics affect elements of economic landscapes and vice versa?**

3 — **How do cumulative and combinatorial knowledge dynamics affect institutions of economic landscapes and vice versa?**

4 — **How can knowledge dynamics in symbolic knowledge bases be differentiated by measures of relatedness?**

1.2 Outline

The thesis is structured in five parts, which are numbered by Roman numerals. As the attentive reader may have noticed, the first part provides an introduction to the motivation, objectives and research questions guiding this thesis.

In the second part, the two theoretical building blocks of this thesis are presented. First, the current state of the art in the analysis of knowledge bases and dynamics is discussed. A novel concept is presented that is used to differentiate knowledge dynamics into cumulative and combinatorial ones. Second, two perspectives on forms of regional path development are brought together. It shows how both literature strands on relatedness and regional innovation systems transformation have recently developed theoretical approaches and terminologies to grasp how continuity and change interplay in regional path development. The third section of this theoretical part ends with the development of a framework that links the micro-level knowledge dynamics to regional path development.

The third part displays the methodological background to the papers constituting the empirical part of this thesis. Each subsection elaborates upon methodological challenges for the analysis of different parts of the thesis and provides corresponding solutions, accompanied by their merits and limitations. The first subsection illustrates the qualitative innovation biography method and its use for the analysis of knowledge dynamics. It is followed by a section discussing the novel approach of quantitatively measuring knowledge relatedness, which has especially found application in evolutionary economic geography. The third subsection explains why relatedness metrics have not been transferred yet to the analysis of symbolic knowledge. It ends with the proposition to use digital social data from which crowdsourced classification systems can be derived.

These methods are employed in the articles presented in the fourth part. This part comprises four published and submitted papers, which are referred to as chapters in the context of this thesis to distinguish references to sections of the envelope from those to papers of this thesis. It is started by a depiction of the positions of the papers of this thesis in the framework. It has to be noted that this thesis does not have one common object of investigation, field of study, or geographical focus. This would have been difficult to attain, as the interaction between different levels and the differences between technological and non-technological knowledge are analyzed. Instead, the papers belonging to this thesis bring together research on different subjects in different geographical areas. While the first two papers employ research on knowledge dynamics in a variety of industries conducted in the context of the EURODITE project in Europe, the third and fourth papers explore the evolution of symbolic knowledge bases by the analysis of Northern American and European music scenes. Nevertheless, these papers share the objective to explore the roles of the accumulation and combination of knowledge for different forms of regional path development.

Finally, the fifth part provides the conclusions of this thesis. The findings of the papers of the fourth section are put into the context of the research questions. Furthermore, their implications for political actors are presented as well as the limitations of this thesis. In the end, potential avenues for further research are laid out. So, let’s begin.

II THEORY

2 Theoretical Building Blocks: Knowledge and Path Development

---

"The road in front of us is long and it is wide

We've got beginner's luck, we've got it on our side

If you are willing, well, I think I'm qualified

And with beginner's luck we've gotta take the ride"

(EELS, 2009)

In the following subsections, the theoretical building blocks of this thesis will be laid out as illustrated in Figure 2.1.

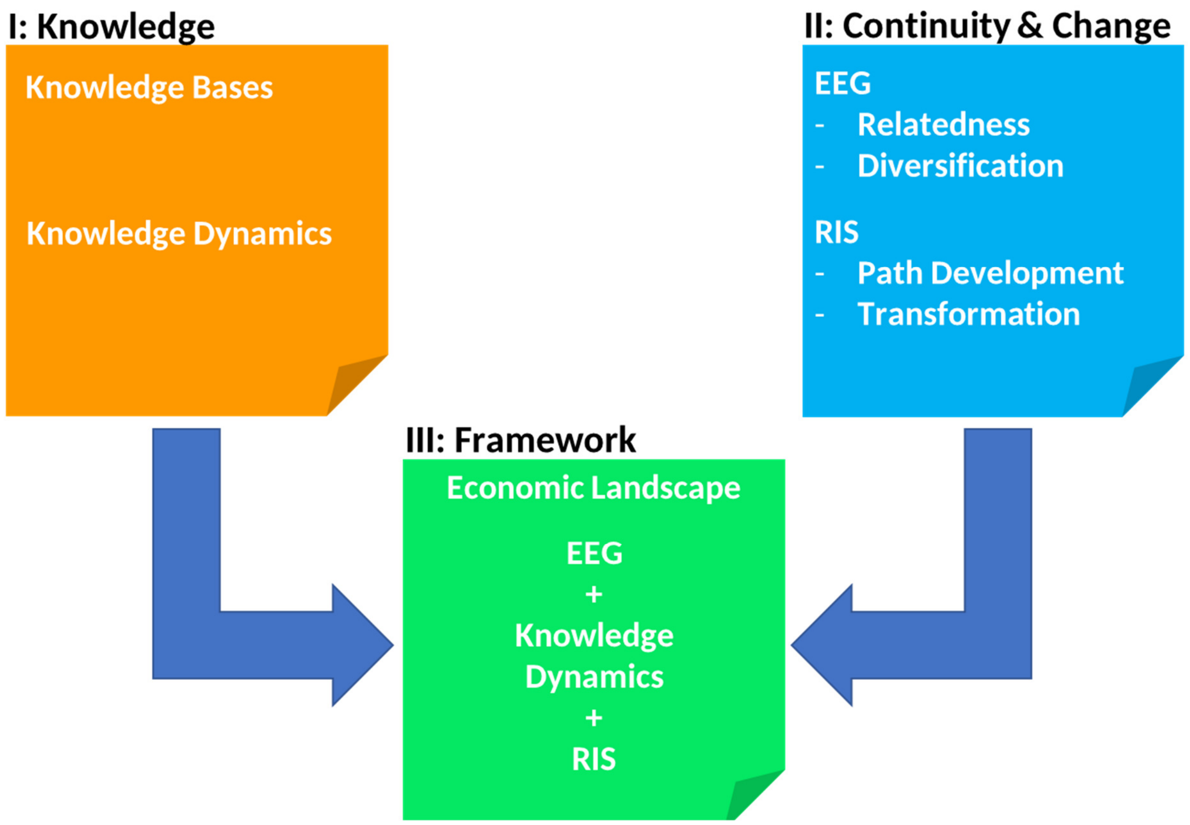


Figure 2.1: Theoretical building blocks of this thesis
Sources: Own figure

2.1 Knowledge **Bases and Dynamics**

First of all, section 2.1 will provide the basic understanding of knowledge for this thesis. In particular, the concepts of differentiated knowledge bases and knowledge dynamics are introduced. This section will set up the distinction of cumulative and combinatorial knowledge dynamics on the micro-level. Section 2.2 elaborates upon the role of continuity and change in regional path development. It will combine the research strands of evolutionary economic geography (EEG) on relatedness and diversification with current research on the transformation of regional innovation systems (RIS). Both building blocks are integrated into the framework of this thesis introduced in section 2.3. The framework offers a 3-level model of economic landscapes by integrating EEG, Knowledge Dynamics, and RIS research. At a later stage of this thesis (part IV), the four articles making up this cumulative dissertation are positioned within the framework.

2.1 Knowledge Bases and Dynamics

“A little knowledge is a dangerous thing”

(TOWER OF POWER, 1991)

It is one of the less contested axioms of modern economics that the global economy has turned towards becoming a “knowledge economy”, a term made popular several decades ago by Drucker (1969). Due to globalization and new information and communication technologies, great parts of the economy have become more dependent on intellectual capabilities than physical inputs or natural resources. Accordingly, the production of information, ideas, and knowledge has increased rapidly, as indicated, for instance, by the number of patents (Powell & Snellman 2004). Still, this trend shows no signs of deceleration: since 2004 alone, the number of worldwide patents has doubled (WIPO 2017).

Thus, in order to understand the modern economy – and its geography – it is essential to understand knowledge. Unfortunately, knowledge is so intangible that defining its nature has occupied scholars for millennia, e.g. see Aristotle in *De Anima* in ca. 350 BC (Aristoteles 2015). While antique considerations about knowledge were more concerned with the differences between the human and the animal mind, contemporary scholars are more interested in the differences between knowledge and information.

2.1 Knowledge **Bases and Dynamics**

Information is generally understood as structured data that are relevant and have a purpose (Hautala & Höyssä 2017). Information is often regarded as a commodity, whose acquisition does not imply elaborate cognitive requirements on behalf of the acquiring actor (Stehr 2001: 115f.). Knowledge, however, is understood as the "dynamic framework, from which information can be stored, processed and understood" (Howells 2012: 1003). Following Stehr (2001: 115), knowledge provides the 'ability to act'. To make use of knowledge, actors require cognitive capabilities to interpret it and command the context the knowledge is related to. This so-called context-dependency of knowledge considerably limits its transferability, especially compared to information (Stehr 2001: 58ff.). Thus, even though a tip on the glass surface of our smartphones enables us to retrieve information about nearly everything, knowledge remains relatively constrained in space (Howells 2012).

This has made knowledge an important factor for understanding the unevenness of economic development and innovative action in the face of the ongoing globalization of information (Feldman & Kogler 2010). As this thesis is situated in the field of economic geography, a closer look as to how knowledge is differentiated in this field is required. Two theoretical perspectives have evolved in the field: a rationalistic approach that treats knowledge as an object and a resource, and a performative, constructionist approach that emphasizes that knowing is situated in practice. While the former interprets knowledge as a quantifiable object that exists outside of individuals, applications, and social contexts, and can be circulated, exchanged, shared or lost, the latter understands knowledge as being inextricably connected to social actions of collectives (Ibert 2007)[1]. The most studies in economic geography treat knowledge as an object. This is an "economic rationale", in which knowledge is portrayed as a resource that has certain merits, such as the promotion of economic growth. Less pronounced in economic geography, but increasingly popular is the "methodological rationale" of understanding knowledge as being situated in and constructed by social interaction (Hautala & Höyssä 2017).

Especially those studies that follow an economic rationale often use taxonomies (e.g. tacit and codified knowledge) to distinguish pieces of knowledge (Ibert 2007). The most prominent distinction is the one between tacit and codified knowledge (Polanyi 1966). The term tacitness refers to knowledge which cannot, or is difficult to be articulated in

[1] While there is a semantic difference between "knowledge" and "knowing" in the English language, in German the noun and verb are the same: "Wissen" (knowledge) and "wissen" (knowing)

form of symbolic representations such as writings, formulas or even natural speech. It exists because people "know more than they can tell", so they are often not aware of the knowledge they possess and consequently have difficulties in making it explicit (Polanyi 1966: 4). Hence, tacit knowledge cannot be transmitted or communicated without considerable efforts. The degree of tacitness decreases the extent of knowledge exchange between actors which are spatially separated and act in different spatial and social contexts (Dicken & Malmberg 2001), are associated with different organizations (Kogut & Zander 2003), do not share the same cognitive backgrounds (Nooteboom 2010) or do not possess sufficient amounts of similar knowledge (Cohen & Levinthal 1990). Even knowledge which is highly codified (e.g., in the form of patent descriptions) comprises tacit parts which prevent third parties from fully appropriating the knowledge and putting it to use (Nightingale 1998). In fact, as all knowledge is bound to specific contexts, all knowledge has a certain tacit dimension (Johnson 2002; Antonelli 2006). That the boundaries of tacit and codified knowledge are blurry, is also shown by Nonaka et al. (2000) who described how tacit knowledge can be converted into explicit knowledge and vice versa through socialization, externalization, combination, and internalization.

2.1.1 The Typology of Differentiated Knowledge Bases

One of the more recent approaches to distinguish types of knowledge is the one of "differentiated knowledge bases" (DKB) (Asheim 2007). It was developed in the 2000s, at the Centre for Innovation, Research and Competence in the Learning Economy in Lund (Sweden) by Bjørn Asheim, Lars Coenen, and colleagues. At its core, this approach argues that differences in the spatial organization of knowledge creation between industries/sectors result from the different nature of knowledge inputs (Asheim 2007; 2012). The corresponding typology distinguishes between analytical, synthetic, and symbolic knowledge bases (Asheim 2007).

This typology has become a vital part of the regional systems of innovation literature (Asheim 2016) and provided a building block of a platform-based regional innovation policy to construct regional advantages (Asheim et al. 2011a). The DKB approach has been applied in empirical studies (Boschma 2017) on the spatial nature of innovation and learning processes (Coenen et al. 2004; Moodysson et al. 2008; Moodysson 2008; Martin & Moodysson 2011; Martin & Moodysson 2013; Herstad et al. 2014; van Tuijl & Carvalho 2014; Rekers 2016; Davids & Frenken 2017), the geography of industrial specialization

(Asheim & Hansen 2009; Martin 2012), the role of institutional contexts for knowledge creation (Asheim & Coenen 2006; Zukauskaite & Moodysson 2015; Moodysson et al. 2017), economic resilience (Sedita et al. 2016), and the combination of different knowledge types (Manniche & Larsen 2013; Plum & Hassink 2013; Tödtling & Grillitsch 2015; Albors-Garrigós et al. 2017; Davids & Frenken 2017; Fitjar & Timmermans 2017)

The origins of the DKB approach are slightly blurred. First references to analytical and synthetic knowledge in the literature can be found in Laestadius (1998, 2000) in studies on the pulp and paper industry. Yet to a certain degree these terms abruptly arise from the texts and little explanation is given about their origin and etymology. The synthetic, engineering-based mode of knowledge formation in the pulp and paper industry is described as a way to "build systems", while the analytical mode of knowledge formation in biotechnology is supposed to be more concerned with "breaking down" the systems of nature (Laestadius 2000). This distinction resembles the ancient, Aristotelian distinction of knowledge into universal, theoretical *epistèmè* and instrumental, context-specific, and practice-related *technè*, which was mentioned in a footnote of Johnson (2002) that was taken up explicitly only in later texts of the DKB literature (Asheim 2012).

Nevertheless, these origins illustrate two central vantage points of the DKB approach: first, while most of Economic Geographers in the 1990s often focused on industries considered "high-tech", Scandinavian scholars were in need of approaches that explained the economic success of traditional, "low-tech" sectors, such as pulp/paper, forestry, furniture, or machinery in the high-cost economies of Northern Europe. They arrived at knowledge and learning being at the core of all activities of the economy, even the ones considered as "low-tech" (Lundvall & Johnson 1994). Scholars developing and applying the DKB approach did not only focus on industries characterized by high expenditures for Research & Development or patenting activity, but rather turned to unravel the knowledge inputs and sources of industries, whose leaders themselves did not think they were that innovative.

Second, in the early 2000s, the distinction of knowledge according to its codifiability was a major line of reasoning to explain why some economic activities did not globalize as much as others did. It was argued that the importance of tacit knowledge (Polanyi 1966; Nonaka et al. 2000) for some activities required them to happen largely in close interaction over short distances within common institutional contexts and thus tended to be "spatially sticky" (Gertler 2003: 79). Even though this still remains a valuable distinction of knowledge, disentangling codified from tacit knowledge proved to be impractical (Johnson 2002). While early works of the DKB approach were strongly informed by this distinction, its authors stated that the simple dichotomy of tacit vs. codified knowledge had to be transcended (Asheim & Coenen 2005; Asheim & Gertler 2005; Asheim 2007).

Instead of distinguishing knowledge by its intensity or codifiability, the DKB approach, certainly inspired by the above-mentioned Aristotelian thoughts on knowledge, puts the epistemological characteristics of knowledge center stage (Asheim 2012; Manniche 2012) by differentiating knowledge by their distinct rationales of knowledge creation, development, evaluation, use, transmission, absorption, and diffusion (Asheim et al. 2011a; Asheim 2012; Manniche & Larsen 2013).

While the analytical knowledge base is present in "theoretically understanding" natural principles, synthetic knowledge is aimed at "instrumentally solving problems", and symbolic knowledge is required to "culturally create meanings" (Manniche 2012). In the following, the three knowledge types are described as presented in the literature and summarized in *Table 2.1*.

An analytical knowledge base predominates in practices in the natural sciences, and industries such as chemicals, pharmaceuticals, biotechnology, nanotechnology or so-called life sciences (Asheim 2007). Analytical knowledge is required to understand and explain features and empirical phenomena of the natural world by discovering and applying scientific laws (Moodysson et al. 2008; Davids & Frenken 2017). To reveal mechanisms underlying natural systems, interference of any context-related influences has to be limited, or even better, excluded (Asheim & Coenen 2005; Moodysson 2008). Thus, the analytical mode of knowledge creation is based on formalized models, deductive reasoning, and rational search processes (Asheim 2007; Hassink et al. 2014). Spatially, it takes place in controlled, dedicated environments, such as laboratories or R&D departments of universities and firms, in which people with a high level of formal qualifications work (Asheim & Coenen 2005). It is suggested that the high level of formalization results in a high level of codification of analytical knowledge in the form of reports, research publications, files, or patents, thereby making it less sensitive to distance-decay effects (Asheim 2007). As discovery is the main mode of analytical knowledge creation, its economic use often entails the emergence of new products and new processes that can be considered radical innovations, often marketed by start-ups and university spin-offs (Asheim 2007; Asheim et al. 2011a).

A synthetic knowledge base, however, is required to create and transform human-made systems designed to meet human needs and solve human problems (Asheim & Coenen 2005). As noted by Laestadius (2000), the intellectual work underlying engineering can be termed as „synthetic“, in that they are aimed at building systems composed of multiple smaller systems and technologies. Thus, a synthetic knowledge base predominates in industries such as machinery, automotive, plant engineering, and other engineering-based manufacturing industries (Asheim 2007; Asheim et al. 2011a). The synthetic mode of knowledge creation can be described as an inductive process of understanding human problems and applying existing natural phenomena to their solution (Arthur 2009; Asheim et al. 2011a). While understanding problems requires in-depth interaction with clients or suppliers, finding practical, suitable solutions involves learning-by-doing, testing, experimentation, computer-based simulation, or practical work (Asheim 2007; Manniche 2012). In contrast to analytical knowledge creation, the spatial or social context is not a potentially compromising source of interference, but an indispensable source of information for the needs of clients and consumers. Thus, controlled environments such as R&D departments or laboratories are less important (Asheim et al. 2011a). Knowledge about existing solutions is rarely codified but tacitly embedded in expertise accrued preferably over long periods of learning-by-doing (Asheim 2007; Mattes 2012; Hatch 2013). Furthermore, the use of synthetic knowledge mostly results in the incremental modification and optimization of existing solutions. Hence, long-term organizational and institutional settings that provide stable employer relations, organizational routines, and continual on-the-job training are ideal environments for the buildup of synthetic knowledge (Asheim et al. 2011a; Hatch 2014; Ingstrup et al. 2017).

Even though not included in early works of the DKB approach, the symbolic knowledge base has become an essential element of this typology. Symbolic knowledge is required to attribute products and services with meaning, aesthetic content and affect so that they trigger “reactions in the mind of consumers” (Asheim 2007; Martin & Moodysson 2011: 1188; Manniche 2012). In order to do so, socially constructed symbols, ideas, habits, and norms have to be understood, interpreted, and created. Consequently, symbolic knowledge is especially significant for the cultural and creative industries that create, for instance, films, books, media, music, art, advertising, design, fashion, or video games

(Asheim 2007; Asheim 2016). More recent contributions to this approach have also identified symbolic knowledge as an equally important source of innovation outside creative/cultural industries (Jeannerat & Crevoisier 2011; Manniche & Larsen 2013; van Tuijl & Carvalho 2014; D'Ippolito & Timpano 2016; Fassio & Grilli 2016), as it is associated with the creation of desire for products and services through the assignment of sign-value (Asheim & Hansen 2009; Asheim et al. 2011a). As the meaning of symbols is socially constructed by and within social groups, being highly embedded in these groups is essential to gain and apply symbolic knowledge (Asheim 2007; Manniche 2012; Asheim 2016). Consequently, symbolic knowledge is rarely codified and less attainable by formal qualification (Asheim 2007). As cultural meanings can vary strongly between social contexts, symbolic knowledge is very context- and place-specific (Asheim et al. 2011b; Manniche 2012). Whereas natural laws and human needs – the subject-matter of analytical and synthetic knowledge – are comparably more universal and independent of social or geographic context, the meaning and value of symbolic knowledge varies strongly between places (Martin & Moodysson 2011). For knowledge-creating actors, it is essential to tap into the localized habits, norms and the 'everyday culture' of social groups (Asheim & Hansen 2009). In contrast to the other types of knowledge, the value of new symbolic knowledge is strongly tied to consumers' interpretations and understanding, meaning that new symbols that are not understood or even disregarded, hold little value for their producers (Martin & Moodysson 2011; Rekers 2016).

It has been criticized that this distinction lacks precise definitions (Manniche et al. 2017). In fact, the original definition fails to explicitly mention a common defining element along which knowledge bases are distinguished. For this reason, the differentiated knowledge bases approach has often been criticized as being too imprecise for its application in empirical research (Boschma 2017; Manniche et al. 2017). Thus, in this thesis, the original distinction is extended by the addition of a common defining element.

This common defining element that distinguishes these three knowledge types, is the subject matter of which knowledge is gained. The subject matter to which knowledge refers can be characterized as "worlds". In this understanding, there is a natural world with universal laws and regularities and a social world, whose function and mechanisms are humanly devised. While analytical knowledge refers to the understanding and explanation of features of the natural world by discovering and applying scientific laws (Moodysson et al. 2008), symbolic knowledge refers to the understanding, interpretation, and creation of symbols that are constructed by and within social contexts (Asheim & Hansen 2009). Both worlds blend together in the domain of synthetic knowledge that is used to harness features of the natural world to solve human problems, mostly by the help of technologies (Asheim & Coenen 2005; Arthur 2009). Hence, the knowledge bases could be arranged along a continuum ranging from the understanding of the natural world to the understanding of the social world, as displayed in *Table 2.1*.

Table 2.1: Overview of differentiated knowledge bases

Knowledge	**Analytical**	**Synthetic**	**Symbolic**
Subject matter	Natural world	Making use of the natural world to solve human problems	Social world
Purpose of knowledge creation	Understand natural systems	Attain functional goals of systems	Creating meaning & sign-value
Requires understanding of	Scientific knowledge and models	Natural phenomena and human needs	Everyday culture of social groups
Knowledge creation process	Deductive; highly formalized	Inductive; custom problem-solving	Creative process; challenging and creating existing conventions
Learning processes are situated in	Collaboration within and between R&D units	Interactive learning with customers and suppliers	Experimentation in studios and project teams; Embeddedness in cultural groups
Codifiability	Strongly codified knowledge content, often documented, highly abstract, universal	Partially codified knowledge, strong tacit component, more context specific	Rarely codified; Importance of interpretation, cultural knowledge, implies strong context-specificity
Relation of meaning to context	Meaning relatively constant between places	Varies substantially between places	Highly variable between places and social contexts
Examples	Drug development	Mechanical engineering	Cultural production, design, brands

Sources: Adapted and modified from Asheim (2007), Asheim (2012), and Manniche (2012)

Understanding the distinction of knowledge bases along these lines helps to avoid mixing descriptive elements, such as the codifiability, spatial implications, or requirements for education or labor relations (Boschma 2017; Manniche et al. 2017) into the definition of knowledge bases. In general, it has to be kept in mind that these knowledge bases refer to ideal types: in reality, most activities comprise a certain mixture of knowledge bases (Asheim 2007). This has led to uncertainty about the appropriate level on which the DKB typology of knowledge bases should be applied and resulted in a variety of methods to determine activities as analytical, synthetic, or symbolic. While early contributions of this approach tended to classify whole industries, sectors, or firms to distinct knowledge bases, more recent contributions apply the typology on the level of individual actors and processes to identify and describe the nature of knowledge creation processes (Boschma 2017; Manniche et al. 2017). They take an explicitly combinatorial approach to the analysis of knowledge bases, which has led Manniche et al. (2017) to regard these new contributions as part of a "Combinatorial Knowledge Base 1.0" approach, while from Boschma's (2017) perspective, a novel literature strand of "DKB 2.0" is emerging.[2] These studies mostly emerged in the research project EURODITE, in which the concept of "knowledge dynamics", another main theoretical pillar of this thesis, emerged (Manniche et al. 2017). In the following section, the notion of knowledge dynamics and the foundation for its distinction in cumulative and combinatorial ones will be elaborated.

2.1.2 Knowledge Dynamics

A search for the term "knowledge dynamics" on Google Books Ngram Viewer (Google Books 2017) reveals that it has been used as early as 1964[3] (Engineering Institute of Canada 1964) and in the following decades in a variety of separate contexts but without a common, widespread definition. Only at the end of the 1990s, the term entered economics and innovation studies in a systematic way. In the following section, it will be clarified which understanding of knowledge dynamics inform this thesis.

The term first appeared in the literature introducing the conceptual framework of the knowledge-based view of the firm, in which it is argued that the capability to create and utilize knowledge is the most important source of a firm's sustainable competitive

[2] In this work, the term "DKB 2.0" will be used in the following, as it emphasizes the continuity between both perspectives and is less mistakable with the term "combinatorial knowledge dynamics".
[3] Knowledge dynamics are there defined as "the growth of scientific journals, scientists and universities"

advantage and its main raison d'être (Nonaka et al. 2000: 1). In general, the literature on the knowledge-based firm acknowledges the procedural nature of knowledge and emphasizes that firms are more than just containers holding the resource knowledge, e.g. in the form of human resources, databases, or patents, but are institutional contexts for the process of individual and collective knowledge creation through interaction (Turvani 2010). Here knowledge dynamics are one layer of the multi-layered knowledge constituting organizational capabilities of firms (Kusunoki et al. 1998). In contrast to the other structure-oriented layers, coined knowledge frames and knowledge bases, knowledge dynamics provide process capabilities. An example for knowledge dynamics in this view is communication and coordination across functional groups of the firm, in which units of knowledge are combined and transformed (Kusunoki et al. 1998: 700; Nonaka et al. 2000).

In a more resource-based literature strand focused on the identification of knowledge bases, however, the notion is used to describe and explain the evolution of knowledge bases of firms and industries (Nesta & Dibiaggio 2003; Ahrweiler et al. 2004; Saviotti et al. 2005). These studies have in common that they use the term in the title of publications, but do not explain the term explicitly in the body of their texts. Instead, the term knowledge dynamics is used loosely to describe how knowledge stocks of firms change and transform over time, e.g. in the case of mergers (Saviotti et al. 2005), technological shifts in industries (Nesta & Dibiaggio 2003), or in agent-based models simulating knowledge applied in innovation processes (Ahrweiler et al. 2004).

These resource-based and process-based interpretations of the term provided the background when, in the middle of the 2000s, the term "knowledge dynamics" was taken up in the context of the research project EURODITE (Jeannerat & Crevoisier 2015). The project follows the procedural perspective on knowledge by defining knowledge dynamics as "interactions of individual actors or groups of actors that learn, search for, or diffuse new knowledge" (Halkier et al. 2010: 6). Thus, the focus of the knowledge dynamics approach does not lie on innovations per se, but on the "processes of creation, using, transforming, moving and diffusion of knowledge" (Strambach 2008: 154) that underlie innovations in products and services. Like crime investigators "follow the money"[4], knowledge dynamics follow the origins, types, and transformations of knowledge inputs of an innovation. Therefore, knowledge dynamics do not stop at the borders of study regions but follow the trails laid out by the knowledge involved in an innovation. This is a necessary adaptation of research to reality, as the mobility of knowledge has increased in recent decades (Crevoisier & Jeannerat 2009; Butzin & Widmaier 2015).

This approach to knowledge dynamics is also taken in this thesis, as its use has several merits. First of all, one value added of the knowledge dynamics approach is that it is closely linked to the above-mentioned differentiated knowledge bases perspective (Asheim 2007). There is a lot of complementarity between both approaches: while knowledge dynamics put above-mentioned processes of knowledge creation, diffusion, transformation and use center stage, the DKB approach illustrates why rationales for these processes differ between industries and knowledge types. Furthermore, the DKB approach provides a broader view on innovation and acknowledges the increasing importance of arts-based, symbolic knowledge for innovation in particular (Jeannerat & Crevoisier 2011; Manniche & Larsen 2013; James et al. 2015). This suits the aim of the knowledge dynamics approach to move beyond technological innovation and study socio-cultural dynamics and service innovations (Crevoisier & Jeannerat 2009). Using DKB allows to theoretically and empirically pursue the question as to how and why the spatiality of learning and innovation processes of non-technological innovations differs to technological ones (Asheim & Hansen 2009; Martin & Moodysson 2011; Rekers 2016). Furthermore, it illustrates how non-technological, symbolic knowledge is interwoven with other types of knowledge, e.g. in the cases of food retailing (D'Ippolito & Timpano 2016), 3D printing (Fassio & Grilli 2016), furniture manufacturing (Hatch 2014), car design (van Tuijl & Carvalho 2014) or watchmaking (Jeannerat & Crevoisier 2011).

Second, by leaving behind the constraints of administrative borders for innovation studies, knowledge dynamics are especially suited to acknowledge the increased mobility of knowledge (Strambach 2008; Crevoisier & Jeannerat 2009). The notion of "anchoring" has been developed to capture the interaction processes of mobile knowledge with local knowledge by analyzing the contexts in which knowledge emerges, how it travels

[4] This quote from the TV-series „The Wire" illustrates this analogy: "You follow drugs, you get drug addicts and drug dealers. But you start to follow the money, and you don't know where the f*** it's gonna take you" (The Wire, S01E09: "Game Day")

between contexts, and how it arrives in new territorial settings. Anchoring mobile knowledge that originated in different contexts to another regional context does not happen everywhere: some regions are better at this than others. This concept turns away the reasoning for the mobility of knowledge from the classification of knowledge (e.g. as tacit) towards the regional capacity at the receiving context to appropriate and contextualize extralocal knowledge (Crevoisier & Jeannerat 2009; James et al. 2015; Crevoisier 2016). This capacity is regarded as more than local, spontaneous "buzz" (Bathelt et al. 2004), but dependent on strategic connections between extralocal and local networks of knowledge circulation (Jeannerat & Crevoisier 2015). The notion of anchoring has been applied for instance in studies on the emergence of greentech industries in China (Binz et al. 2015; Binz & Anadon 2016), medical technology in Sweden (Hermelin et al. 2014), or Portuguese biotechnology (Vale & Carvalho 2013).

Third, following the knowledge implies that knowledge dynamics offer a suitable approach to analyze cross-sectoral innovation processes. Processes of modularization, externalization, and standardization have led to a wider distribution of knowledge onto actors from different sectors and domains (Strambach 2008; Manniche et al. 2017). Sectors have lost their coherency as there has been a tendency of the emergence of cross-sectoral fields, e.g. in health, communication or tourism (Crevoisier & Jeannerat 2009; Butzin & Widmaier 2015). It has not only become more valuable for firms to build composite knowledge stocks (Antonelli & Calderini 2008) but also for regions. Instead of further specialization within cluster-based policy frameworks, they are increasingly inclined to establish innovation platforms (Asheim et al. 2011a; Cooke 2012) that provide the foundations to bundle local strengths. As section 4 illustrates, knowledge dynamics are especially suited to analyze the combination of knowledge created in diverse sectoral contexts.

A fourth advantage of the knowledge dynamics approach is that it is applicable on several levels. Thus, within the EURODITE project, knowledge dynamics were further differentiated between "territorial knowledge dynamics" as "the geographical patterns of knowledge exchange, networks and interactions between different actors" that affect the development of a particular region (Halkier & Cooke 2010: 20) and "firm-level knowledge dynamics" that "concern the way that knowledge is developed and transferred at a micro level: within a firm or an organisation, or within a network of firms or organisations" (Halkier et al. 2010: 7; Hermelin et al. 2014). This way, the relationships and interdependencies between industrial, regional, territorial, and firm-specific contexts of knowledge creation could be analyzed (Kaiser & Liecke 2009; Halkier et al. 2010). In the following, the distinction between territorial and firm-level knowledge dynamics is further illustrated.

Territorial knowledge dynamics (TKD) are situated at the meso-level of regions. They were introduced originally as a multi-location paradigm in contrast to the "proximity paradigm" of so-called territorial innovation models (TIM), such as regional innovation systems, innovative milieus, clusters, or industrial districts (Moulaert & Sekia 2003). In contrast to these models of endogenous regional growth that emphasize the merits of localized specialization along cumulative trajectories, the TKD paradigm suggests that in times of hypermobile knowledge and production factors, the ability of regional actors to insert themselves in so-called combinatorial knowledge dynamics developing across regions, sectors, and firms is essential for regional economic development (Crevoisier & Jeannerat 2009; Jeannerat & Crevoisier 2015). The "combinatorial" aspect in this regard refers to the multi-scalar, multi-locational ways in which knowledge circulates and is eventually anchored in local contexts, while cumulativeness refers to innovations building on existing regional stocks of knowledge (Butzin & Widmaier 2015). The approach of TKDs focused on extending the analysis of knowledge-based regional development to multi-location systems, instead of just regarding extralocal knowledge sources as "from elsewhere" (Crespo & Vicente 2015).

Complementing the regional perspective are firm-level knowledge dynamics on the micro-level of individual organizations that evaluate how firms govern their specific knowledge flows and how they develop organizational capabilities to absorb external knowledge (Kaiser & Liecke 2009). Studying knowledge dynamics on the micro-level is important, as individual groups and actors are those who actually hold, create, and transfer knowledge. Despite their central function in knowledge creation, they have received little attention in Economic Geography so far (Hautala & Höyssä 2017). Recently, micro-level knowledge dynamics have been recognized as microfoundations for the transformation of industries (Bugge & Øiestad 2014) and regional innovation systems (Asheim 2016).

Also, several studies have identified the increasing relevance of making unconventional combinations of knowledge for different reasons on the micro-level: apparently, the combination of more distant technological fields is more probable to result in radical innovations (Schoenmakers & Duysters 2010). For the creation of scientific knowledge, Uzzi et al. (2013) identify atypical combinations of existing knowledge in journal articles as being linked to their scientific impact. Furthermore, the transition towards sustainability is thought to entail bringing together knowledge from separate domains (Coenen et al. 2012; Cooke 2012). Apparently, the above-mentioned shift from cumulative to combinatorial knowledge dynamics is effective on the micro-level as well.

To understand the implications of the shift from cumulative to combinatorial knowledge dynamics on the micro-level, first, it is necessary to determine how cumulative knowledge dynamics differ from combinatorial ones on the micro-level. It can be suggested that cumulative, respectively combinatorial knowledge dynamics pose different challenges for the spatial organization of learning and innovation processes. Thus, the first research question of this thesis is:

1 **In what ways do cumulative and combinatorial knowledge dynamics differ on the micro-level?**

There are many aspects as to how different knowledge dynamics differ. For instance, how do firms organize different knowledge dynamics? How do they access external knowledge and how do they combine it with their internal, accumulated knowledge? Which actors are involved in different knowledge dynamics and which types of knowledge do they contribute at which point in time? How do different micro-dynamics of knowledge relate to regional institutional contexts? How do territories shape firm-level knowledge dynamics and vice versa? (Strambach 2010b).

In the course of this thesis, the publications in part IV will illustrate the distinction between cumulative and combinatorial knowledge dynamics on the micro-level, and illustrate how different knowledge dynamics are linked to continuity and change of development paths. But first, the next section shows how different forms of path development are distinguished in the literature.

2.2 Continuity and Change in Path Development

"Yes, there are two paths you can go by
But in the long run
There's still time to change the road you're on"
(LED ZEPPELIN, 1971)

The continuity and change of regional economies belong to the core topics of Economic Geography, as they can be used to explain the unevenness of economic activity in space. Thus, the model of path dependence, which originated in economics (David 1985; Arthur 1989) was quickly introduced to economic geography/regional studies in the early 1990s. The central idea behind path-dependence is that small chance events can have long-term, irreversible effects on economic structures. They can become starting points of development paths that are reinforced by increasing returns caused by network externalities, learning effects, institutional hysteresis and sunk costs up to the point where economic structures lock in to a rigid state that can only be disrupted by external shocks (Martin & Sunley 2006; Sydow et al. 2009; Henning et al. 2013). In its original form, it was used to explain suboptimal phenomena, e.g. the QWERTY keyboard, that defied the logic of neoclassical economics by historical events (David 1985). While in neoclassical thinking economic systems are ergodic, i.e. can return to an equilibrium independent of their current state, path-dependent processes and systems are non-ergodic. Non-ergodicity means that a system cannot return to a previous state, as the sequence of events that has led to its current state cannot be repeated or reversed (Henning et al. 2013).

In economic geography, this perspective was especially suitable to explain agglomeration processes and why some regions were not able to react accordingly to structural changes (Grabher 1993b). Furthermore, several of the above-mentioned mechanisms leading to path dependence, such as increasing returns, network externalities, learning effects or institutions have a strong spatial dimension and are considered place-dependent (Martin & Sunley 2006; MacKinnon et al. 2009; Henning et al. 2013). It has become the theoretical cornerstone of the field of EEG, which understands the "current distribution of economic activity (…) as an outcome of largely contingent, yet path-dependent, historical processes" (Boschma & Frenken 2011b: 296).

The concept of path dependence has since been applied in several studies in economic geography, despite continuing uncertainty on how to properly define a regional path. Most studies (like this thesis) regard a regional path as the development of a particular, locally dominant industry in a particular region (Henning et al. 2013). This industry is accompanied by institutional and other self-reinforcing mechanisms, which narrow down the scope of action to a certain degree so that actors in the region cannot or will not use the full variety of choices. Spoken metaphorically, the positive feedback of the path develops a "pull" which attracts actions towards it (Sydow et al. 2009).

However, there is certainly room for the existence of multiple paths and path-interdependence within a region due to its composition of several industries (Cooke 2012) or even multiple path developments within local industries due to the heterogeneity of firms (Zukauskaite & Moodysson 2015; Moodysson & Sack 2016). While the path metaphor is especially suitable to understand the history of regional trajectories, it does not provide an unambiguous way of determining starting and end points of paths (Henning et al. 2013). It is difficult to take just the establishment of an industry as a starting point of paths, since the self-reinforcing dynamics that limit the scope of choices available to local actors have to develop as well (Sydow et al. 2009). Consequently, the difficult part of defining a path lies in finding the 'paths not taken' (Schneiberg 2007), that is the alternative realities that actors were not able to enter because their scope of action was already narrowed down by the path.

With further usage, another major shortcoming of its application became apparent. While path dependence provides a valid explanation for the direction of trajectories and their rigidity, there appeared to remain little room for the agency of actors to form new paths and prevent lock-ins from happening (Garud et al. 2010; Martin 2010; Bathelt et al. 2013; Dawley 2013). The canonical model of path-dependent, ironically, had been locked in the description and explanation of continuity (Martin 2010). Hence, Martin (2010) offered an alternative path dependence model which provided a way to understand paths as dynamic processes that through layering, conversion and recombination can lead to the adaptation of local industries and technologies. It was based on the recognition of composability of industries and institutions: unlike the textbook example for path dependence, the QWERTY keyboard, these systems are composite entities, whose parts can be incrementally changed without destroying the whole system (Strambach & Storz 2008: 149; Martin 2010: 13). In EEG, Frenken & Boschma (2007) developed a model of evolutionary regional growth in which diversification is understood as a branching process in which the modification and recombination of existing routines provide the basis for new routines. These approaches entail that "history matters", but is not necessarily a force of ossification, but a source of change.

Nevertheless, especially the financial crisis of 2008 showed that the path dependence model could not really explain the resilience of regions to crises, or lack thereof. In the discussion on the meaning of the newly imported buzzword "resilience" for economic geography in the early 2010s, it became clearer that an evolutionary understanding of regional economies had to emphasize adaption, renewal, and reorientation of regional economies, not just their bounce back to old structures and functionality. Thus, the introduction of new activities into regional economies was identified as highly relevant to ensure that regional economies resist and recover easily from crises (Hassink 2010b; Simmie & Martin 2010; Martin & Sunley 2014; Boschma 2015; Strambach & Klement 2016).

In the following years, an array of alternative forms of path development emerged within two major literature strands: first, the relatedness school around Ron Boschma and Koen Frenken offers terms centered around the relatedness of new activities to old ones to describe regional diversification processes, mostly on an industrial level. Second, a Scandinavian school originating from CIRCLE, concerned with the transformation of regional innovation systems, differentiates forms of path development according to the direction and stability of paths. Both terminologies can, however, be distinguished by how they depict the relationship between existing and new activities in regional economies along the lines of continuity and change, as illustrated in Figure 2.2. As can be seen in this Figure, some terms are comparable, have similar meanings or are sometimes used as superordinate categories. In the following sub-sections, three general types of path development are differentiated due to their treatment of the relationship of old and new activities of regional economies.

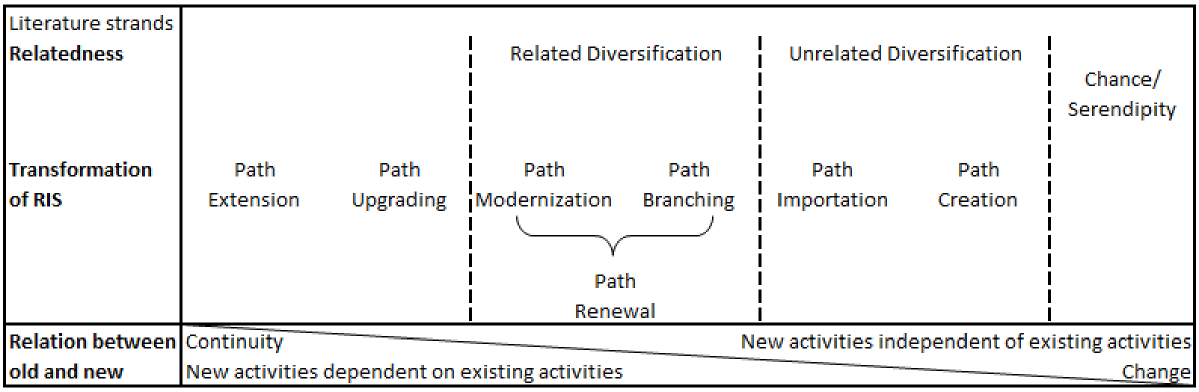


Figure 2.2: Overview of different forms of path development
Sources: Own figure

2.2.1 Continuity in Forms of Path Development

The form of path development identified In the RIS literature that is characterized by a high degree of continuity is the so-called **path extension.** In this form of path development, path-dependent processes act strongly. Actors still innovate, but along prevailing paths. Established networks and institutions are used to improve products and processes incrementally. Although this strategy can be very successful, it can also lead to stagnation and gradual decline, a negative lock-in process that is also called path exhaustion (Isaksen 2015; Grillitsch & Trippl 2016). Especially those regions are in danger to be trapped in this kind of path development, which are considered organizationally thin: they are characterized by SMEs who show little signs of local knowledge exchange and are accompanied by weak or little organizational support. Often they are found in rural, peripheral areas (Tödtling & Trippl 2005). As most firms in these regions are self-contained and exploit their well-endowed internal knowledge base, they continue to do things their well-established ways. There are only few resources that can be redeployed to develop new or updated paths (Isaksen 2015). But also, organizationally thick, specialized economies mostly found in old industrialized regions face several challenges when trying to escape path extension. Supporting capabilities or institutional and organizational infrastructures are often equipped to promote the continuity of existing activities (Grillitsch & Trippl 2016; Moodysson et al. 2017).

Another form of path development, **path upgrading**, refers to the improvement of the regional position in global production networks (Ernst & Kim 2002; Henderson et al. 2002). It has been introduced recently to acknowledge that great parts of regional economies are affected by economic players outside the region. Even though path upgrading can imply great improvements for economic prosperity and social conditions, it is rather associated with continuity of existing activities. Regional capabilities and skills are improved or enhanced, but essentially remain within the same industry or value chains (Grillitsch & Trippl 2016)[5]. Especially in organizationally thin regions, path upgrading remains one of few viable policy options and should accompany any efforts to attract subsidiaries of external firms to the region. Strengthening local competencies can be achieved through education, (vocational) training and the establishment of local networks and support organizations (Grillitsch & Trippl 2016; Isaksen & Trippl 2016). In some cases, subsidiaries voluntarily strengthen local capabilities through the establishment of networks to local firms and universities in order to strengthen their own autonomy and position in innovation networks of multinational corporations (Strambach & Klement 2012b).

2.2.2 Change in Forms of Path Development

At the other end of the spectrum between continuity and change, there are forms of path development emphasizing that new activities entering a regional economy can be very dissimilar to existing activities. In the original works of path dependence, **chance and serendipity** can play a large role in the emergence of locked-in patterns in the adoption of technologies (Arthur 1989). Chance has indeed played a great role in regional path development. For instance, the emergence of the Wetzlar optics cluster in the 1850s, which eventually led to the invention of the 35mm film cameras (the Leica I), was a result of several unpredictable family-related decisions of a small number of highly innovative individuals (Moßig & Klein 2003). This is a perfect example for 'windows of locational opportunity' (Storper & Walker 1989) opening up at the beginning of an industrial lifecycle: since the optimal location and required location factors are unknown (or even unknowable) at the starting point of new industries or technologies, the random location of entrepreneurs and inventors can set in motion long-term agglomeration patterns of economic activity. Nevertheless, trusting chance does not appear to be a practical approach to promote and coordinate path development.

[5] The typology of forms of path development proposed by Grillitsch and Trippl (2016) does apparently not account for the form of "inter-sectoral upgrading" proposed by Humphrey and Schmitz (2002). This form of upgrading would rather be associated with forms of branching or diversification.

2.2.2 Change in Forms of Path Development

Another form of path development is **path importation.** Similar to the previously mentioned path upgrading, it is linked to extra-regional linkages, which become increasingly relevant for avoiding lock-in (Asheim 2012). Importation occurs by industries established elsewhere being transplanted into a region by the attraction of external investments or the migration of highly qualified personnel and entrepreneurs (Binz & Anadon 2016; Grillitsch & Trippl 2016; Isaksen & Trippl 2016). Yet it is questionable whether entire paths can be imported, as self-reinforcing dynamics are often bound to spatially delimited contexts (Henning et al. 2013). Thus, the attraction of outside firms or research institutes has to be accompanied by the establishment of supporting networks, organizations, and institutions (Isaksen & Trippl 2016). Even though this is no small feat, it often remains one of the more viable policy strategies of organizationally thin regions to avoid path extension (Martin & Sunley 2006: 422; Grillitsch & Trippl 2016).

Yet new paths do not necessarily require external actors, they can also emerge by actions of local actors. Thus, the term **path creation** was created to introduce a more systematic form of agency than what was originally inherent to the concept of path dependence (Martin & Sunley 2006). Garud et al. (2010) emphasize that initial conditions and self-reinforcing mechanisms are constructed by the actions of agents that do not necessarily follow the alleged automatisms of paths. Instead, especially entrepreneurs purposefully and mindfully deviate from paths by mobilizing resources and people in order to break institutional, social and cognitive barriers (Simmie 2012; Binz et al. 2015; Sotarauta 2016). However, also non-firm actors such as research organizations, civic organizations or public policy are important actors attempting to promote path creation, especially in peripheral regions (Simmie 2012; Dawley 2013; Martin & Martin 2016). As a form of path development, path creation is often associated with the most radical form of regional structural change. It refers to the emergence of completely new paths in a region that are unconnected to existing economic activities and bring about a wide-ranging transformation of regional organizational and institutional configurations (Grillitsch & Trippl 2016; Moodysson et al. 2017).

In the terms of the relatedness literature, path creation is understood as **unrelated diversification** (Boschma 2016). This literature strand is based on the measurement (see section 3.2) of the relatedness between economic activities (Breschi et al. 2003; Frenken et al. 2007; Boschma & Frenken 2011a). Relatedness provides a possibility to describe regional economies not only by the shares of distinct activities therein but by the distances and similarities of these activities. It is argued that differences in relatedness between activities are associated with different possibilities for the nature and scope of knowledge spillovers, knowledge combination, learning, spin-offs, or diversification (Breschi et al. 2003; Boschma & Frenken 2011a). Consequently, the notion of unrelated diversification describes situations in which new activities are unrelated to the existing portfolio of industries of a region. However, to make confusion even worse, it is also used for processes in which previously unrelated activities are combined (Boschma 2016; Boschma et al. 2017). Often these 'leaps' in the industrial structure of countries and regions, in which unconnected activities become connected, are associated with radical innovations, which have the potential to provide starting points of new paths (Schoenmakers & Duysters 2010; Castaldi et al. 2015). Apparently, liberal market economies provide a better institutional environment to make these jumps than coordinated market economies (Boschma & Capone 2015). In general, however, unrelated diversification processes are less frequently observed than their counterparts, related diversification processes (Neffke et al. 2011; Castaldi et al. 2015).

2.2.3 Continuity and Change in Forms of Path Development

Related diversification belongs to the forms of path development that are associated with continuity *and* change. These forms of path development have in common that existing activities are not regarded as a hindering factor of regional development, but as a valuable resource which can be leveraged to promote the emergence of new activities and paths. Thereby, paths are not given up or broken, but renewed (Martin 2010; Neffke & Henning 2013; Boschma 2015; Coenen et al. 2015).

Amongst these forms of path development, **related diversification** describes processes, in which regions diversify into new activities that are similar to those already present in the region. It is also coined as 'regional branching', as the resulting industrial structure develops along trajectories resembling branches of a tree. In general, it is based on Penrose's (1959) resource-based view on the diversification of firms: she suggests that firms have an excess of unexploited resources that they preferentially use to expand their range of operations.

Regarding the diversification of economies, the relevance of related diversification was first identified on the national level on the basis of export portfolios: countries tend to develop new comparative advantages in exporting products that are similar to the existing export portfolio (Hidalgo et al. 2007). This suggests that especially for developing countries, policy efforts should be targeted at supporting the most viable diversification processes resulting from existing country-specific export portfolios (Hidalgo & Hausmann 2013). Several studies applied this concept to the sub-national level and found its importance in different contexts despite varying methods of measuring relatedness and different spatial contexts (Boschma et al. 2017).

Regarding the change of regional industrial structures, Neffke et al. (2011) find that industries that are related to the existing regional industrial mix have a higher probability to enter the region, while industries with little relatedness to the rest of the industrial structure have a high probability to exit the region, which results in a tendency of regions to become industrially cohesive. According to Boschma et al. (2013), the emergence of industries can be better predicted by regional industrial structures than national ones, emphasizing the local nature of diversification. Industry-specific studies, such as the laser industry in Western Germany (Buenstorf et al. 2012) or the fuel cell industry in Europe (Tanner 2014) show that the existence of existing related patents, producers, and research organizations are a valuable foundation for the emergence of new industries. As the case of the development of a steel technology cluster in Pittsburgh (Treado 2010) shows, new clusters can arise from the legacy of old, allegedly outdated ones.

Also in science and technology, this mode of diversification prevails: the emergence and adoption of new scientific topics (Boschma et al. 2014; Heimeriks & Boschma 2014) and methods (Feldman et al. 2015) appear to be associated with the cognitive proximity (Boschma 2005) of local research activities. In addition to that, the technological knowledge base of regions and cities affects the scope and direction of technological change. Regions and cities tend to diversify into technologies that are close to their existing technological capabilities, mostly measured by patent data (Colombelli et al. 2014; Boschma et al. 2015; Essletzbichler 2015; Rigby 2015; Tanner 2016).

Despite the vast empirical evidence for related diversification, there is still uncertainty about the actual mechanisms underlying this process and causing the spatial dimension of diversification, as existing studies mostly identify the phenomenon itself, not its causes. From a theoretical standpoint, EEG suggests that localized routine replication plays a great role. Routines are replicated and thereby gradually transformed in a localized manner for several reasons. Most spinoffs locate in the vicinity to their parent firms

(Klepper 2007), and firms diversify into new activities in existing plants (Breschi et al. 2003; Neffke & Henning 2013) or along their value chains (Buenstorf et al. 2012; Tanner 2014). Furthermore, most employees remain in the same labor market area while switching between industries, and social networks through which knowledge spillovers occur tend to be local (Boschma & Frenken 2011a; Boschma & Frenken 2011b).

However, the actual mechanisms underlying branching have only been analyzed explicitly in a few studies (Bugge & Øiestad 2014; Tanner 2014) and especially qualitative studies appear necessary to further investigate branching. The blind side of existing studies [see also section 3.2) that mostly follow a knowledge/product space logic (Hidalgo et al. 2007) is the role of user industries, non-firm actors and extralocal connections (Dawley 2013; Tanner 2014; Binz et al. 2015; Miörner & Trippl 2016). Furthermore, activities that are difficult to attribute to individual industries or that are based on symbolic knowledge that is rarely codified (e.g. as patents) (Asheim 2007) have not yet been subject to the scrutiny of the related diversification literature.

In the RIS transformation literature, related diversification has been coined **path branching** (Dawley 2013; Grillitsch & Trippl 2016). While this literature strand has not yet made many empirical contributions to path branching in particular, it provides a way to contribute much-needed "geographical wisdom" into the diversification debate (Boschma 2016). The well-established approach of regional innovation systems provides several tools to complement cognitive-historical studies branching with a spatial context, which is especially useful to translate above-mentioned findings into public policy (Coenen et al. 2017). Due to the lack of slack resources in organizationally thin regions, these regions face a lot of challenges when attempting to achieve related diversification. Organizationally thick regions, however, may have the best disposition to follow a branching approach (Grillitsch & Trippl 2016).

Recent contributions to the path development literature emphasize that not only the diversification but the transformation of existing economic activities lead to successful regional development. They propose that there are **path modernization** processes, in which existing industrial structures need not expand, but existing paths are retained, transformed, and advanced in a new direction (Grillitsch & Trippl 2016). Intra-path changes that avoid path extension are for instance sparked by the application of new technologies or organizational innovations in an established path (Butzin & Rehfeld 2013; Coenen et al. 2015; Grillitsch & Trippl 2016; Moodysson & Sack 2016). While the line between branching and modernization is blurry, it is important to differentiate between these forms of path development. These dynamics in which firms remain within the same industry and adopt technologies would be hidden from the mostly quantitative studies of industrial or technological diversification (Bugge & Øiestad 2014; Tanner 2014). Then again, the case of Kodak's handling of the digitization of photography also shows that even though firms invent (Kodak invented the first megapixel sensor in 1986) and diversify their operations, they are not able to adapt to technological and social changes (Lucas & Goh 2009).

Several case studies show the roles of key actors from the public and private sector for the reapplication and recombination of existing knowledge to new contexts (Bugge & Øiestad 2014; Miörner & Trippl 2016). Furthermore, extralocal knowledge sources apparently provide important impulses for modernization, as regions try to get "on the map" of wide-ranging, global trends (Crevoisier & Jeannerat 2009; Hatch 2013; Coenen et al. 2015). Especially, organizationally thick regions should attempt the policy strategy of path modernization (Grillitsch & Trippl 2016), as even successful innovation systems such as Baden-Württemberg require path modernization efforts in order to face challenges brought about by new forms of mobility or digitalization (Stahlecker & Zenker 2017: 6). A promising policy approach would be to complement evidently strong knowledge exploitation capabilities with novel knowledge exploration organizations (Grillitsch & Trippl 2016).

For present purposes, both the path branching/related diversification and path modernization forms of path development are understood as **path renewal**, as is done in some texts (Isaksen & Trippl 2014; Coenen et al. 2015; Moodysson et al. 2017). In several earlier texts, the usage of the term has referred to all forms of path developments between path creation and path extension but was mostly defined in terms of the relatedness literature (Isaksen 2015; Asheim 2016; Coenen et al. 2017). However, when differentiating path modernization from path branching/related diversification, it makes sense to use path renewal as a superordinate category for both.

Especially for studies of path modernization, the concept of path plasticity (Strambach & Storz 2008; Strambach 2010c) provides a suitable theoretical foundation, as it provides a third perspective between path creation and dependency (Isaksen & Trippl 2014). Path plasticity does not refer to another form of path development but provides a vantage point for understanding the institutional dimension of intra-path changes. It emphasizes that despite the constraining and guiding function of institutional systems, creative, adaptive agents are able to deviate from established paths without breaking with the established institutional system by exploring its scope for variation (Strambach 2010c; Strambach & Halkier 2013). Path plasticity results from the numerical and functional plasticity of institutional systems: numerical plasticity refers to institutional systems that accompany paths as being incoherent in themselves, since they are decomposable into individual elements. These elements may belong to the center or the periphery of the system. Especially peripheral elements of institutional systems (e.g. exceptions for particular actor groups) can be exploited to promote dynamics within paths. On the other hand, functional plasticity implies that agents can change the meaning, usage, functions, and aims of individual elements, e.g., in order to adapt them to new contexts. Especially informal institutions have a high interpretative flexibility, and allow actors to deviate from the path by reinterpreting them to their benefits (Strambach & Storz 2008; Strambach 2010c).

Research explicitly following a path plasticity perspective is still scarce, but mostly attempts to identify ways in which actors explored path plasticity in order to achieve change within paths, mostly in incremental ways. On a sectoral level, it can illustrate how paths emerged despite constraining institutional arrangements of national innovation systems, such as the customized business software industry in Germany (Strambach & Storz 2008). By the example of path plasticity in the German construction industry, Butzin & Rehfeld (2013) illustrate how industries cope with changing environments by implementing routines from other industries. Regarding local tourism destinations, path plasticity is a valuable approach to rededicate existing infrastructure and organizations to promote competitiveness in new forms of tourism (Halkier & Therkelsen 2013; Clavé & Wilson 2016). In the case of seaport governance in Belgium and Netherlands, Notteboom et al. (2013) display how port authorities were able to reform restrictive century-old institutions tied to Hanseatic traditions by circumventing and stretching institutional arrangements in creative ways. Evidently, the strengths of this approach lie in emphasizing the gradual, institutional work (Sotarauta 2016) of creative agents that are, for some reasons, not capable of or interested in breaking paths.

2.3 The Role of Knowledge Dynamics for Path development: A Framework

“I've been waiting for a guide to come and take me by the hand”
(JOY DIVISION, 1979)

After providing the theoretical foundations for this thesis, in the following a framework is developed that links both approaches, since, as mentioned in section 1, finding how knowledge dynamics on the micro-level relate to different forms of path development, is at the heart of this study. This framework is created by integrating the literature strands of evolutionary economic geography, regional innovation systems and the knowledge dynamics approach. The framework can be understood as a model of the economic landscape (Boschma & Martin 2010a), which is enhanced by the dimensions of regional innovation systems (Edquist 2005).

To some degree, EEG and RIS approaches are complementary: while EEG provides a historical-cognitive perspective to explaining the unevenness and evolution of the economic landscape (Martin & Sunley 2006; Boschma & Martin 2010a), the RIS approach offers a spatial contextualization perspective by putting knowledge and institutions center stage (Coenen et al. 2017). Bringing both perspectives together can compensate for each perspective’s weaknesses: while EEG has downplayed the role of institutions and non-firm actors (Dawley 2013: 91; Binz et al. 2015), analyzing the evolution and transformation of regional innovation systems remains one of the biggest research gap in RIS literature (Tödtling & Trippl 2013; Asheim 2016; Doloreux & Porto Gomez 2016).

In the framework for this thesis, the constituents of regional innovation systems – elements, interactions, and institutions – are used as levels. This was inspired by the literature on regional innovation systems (Cooke 1992; Cooke et al. 1997; Asheim & Isaksen 2002; Asheim & Gertler 2005; Edquist 2005) and their transformation (Tödtling & Trippl 2013), as well as Boschma ‘s (2015) framing of the evolutionary perspective on resilience. Of course, these three levels are closely interrelated. An analytical separation can, however, help to understand different aspects of path development, and furthermore foster an understanding of how these levels relate to each other (Tödtling & Trippl 2013).

Regional innovation systems comprise of components (organizations and institutions) and their interactions, which form a system that is delimitable from the outside world or other systems and fulfills the function of promoting innovation (Edquist 2005). In order to integrate RIS with the EEG literature – and similar to Tödtling & Trippl (2013) and Boschma (2015) – this study's framework (see Figure 2.3) comprises of the elements (organizations, actors, and groups of actors), interactions (networks, communications, connections), and institutions (the rules that shape actors' actions and interactions) of economic landscapes.

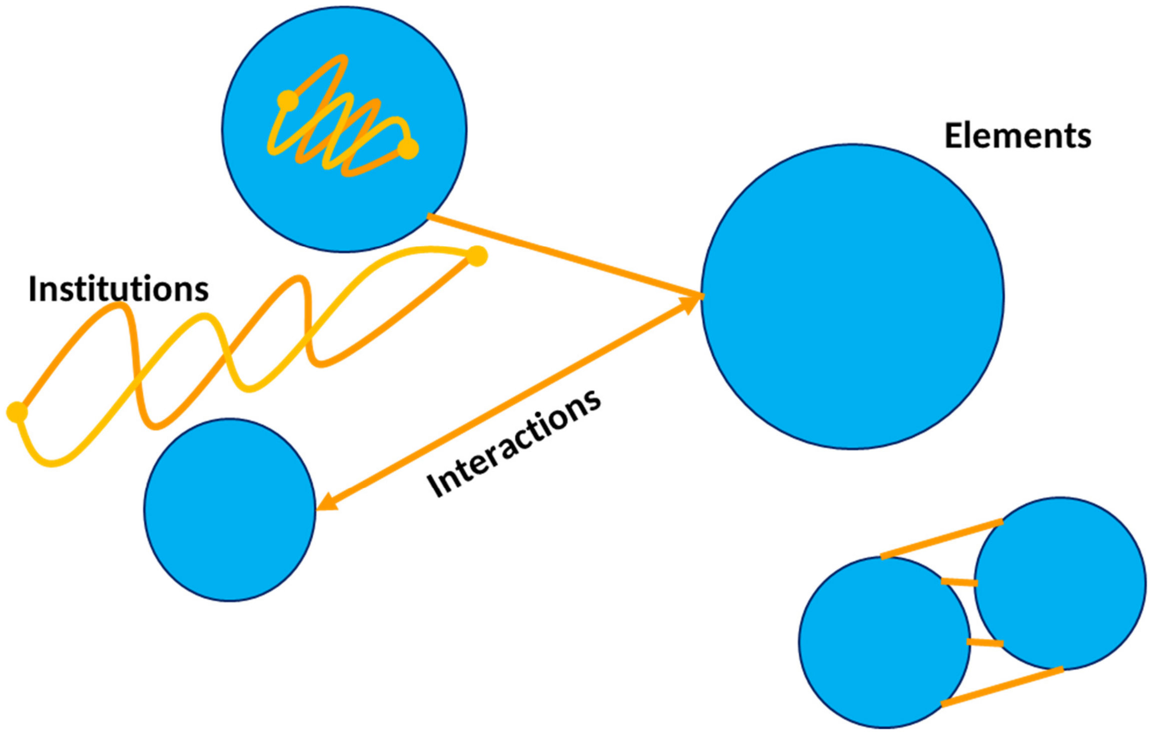


Figure 2.3: Components of the framework
Sources: Own figure

In the following, all three levels of the framework are introduced and visualized to present possible processes on these levels. The level of elements (see Figure 2.4) comprises actors, organizations, and groups thereof who can carry out actions and are locatable in space. By this definition, both firm and non-firm actors are included. To avoid visual clutter, the visualization in this study does not use different symbols for both types. Groups of actors or organizations can, for instance, be subsumed as industries. In network theory, these elements could best be described as nodes (Newman 2013). This level comes closest to the metaphor of economic landscapes – the spatial patterns of local and regional economic differentiation and organization – whose evolution lies at the center of evolutionary economic geography (Martin & Sunley 2006; Boschma & Martin 2010a). Elements can be regarded as the visible parts of the economic landscape that are physically manifested. Even though elements are physically manifested, their characteristics can be intangible (e.g. knowledge). These intangible characteristics can also be located in space via the location of the possessors of said characteristics. Elements can not only be arranged by their physical location but according to their relative similarity/relatedness (Hidalgo et al. 2007; Boschma & Frenken 2011a; Rigby 2015) or proximity (Boschma 2005; Balland et al. 2015) to each other. This arrangement of groups of elements can be understood as network-based "spaces" (Hidalgo et al. 2007. The composition of these spaces can be characterized by different measures of density, (related) variety, or specialization (Frenken et al. 2007; Beaudry & Schiffauerova 2009; Boschma & Iammarino 2009). Elements are not static, but can change over time, e.g. by shrinkage, growth, loss, emergence, or branching (Boschma & Frenken 2011a).

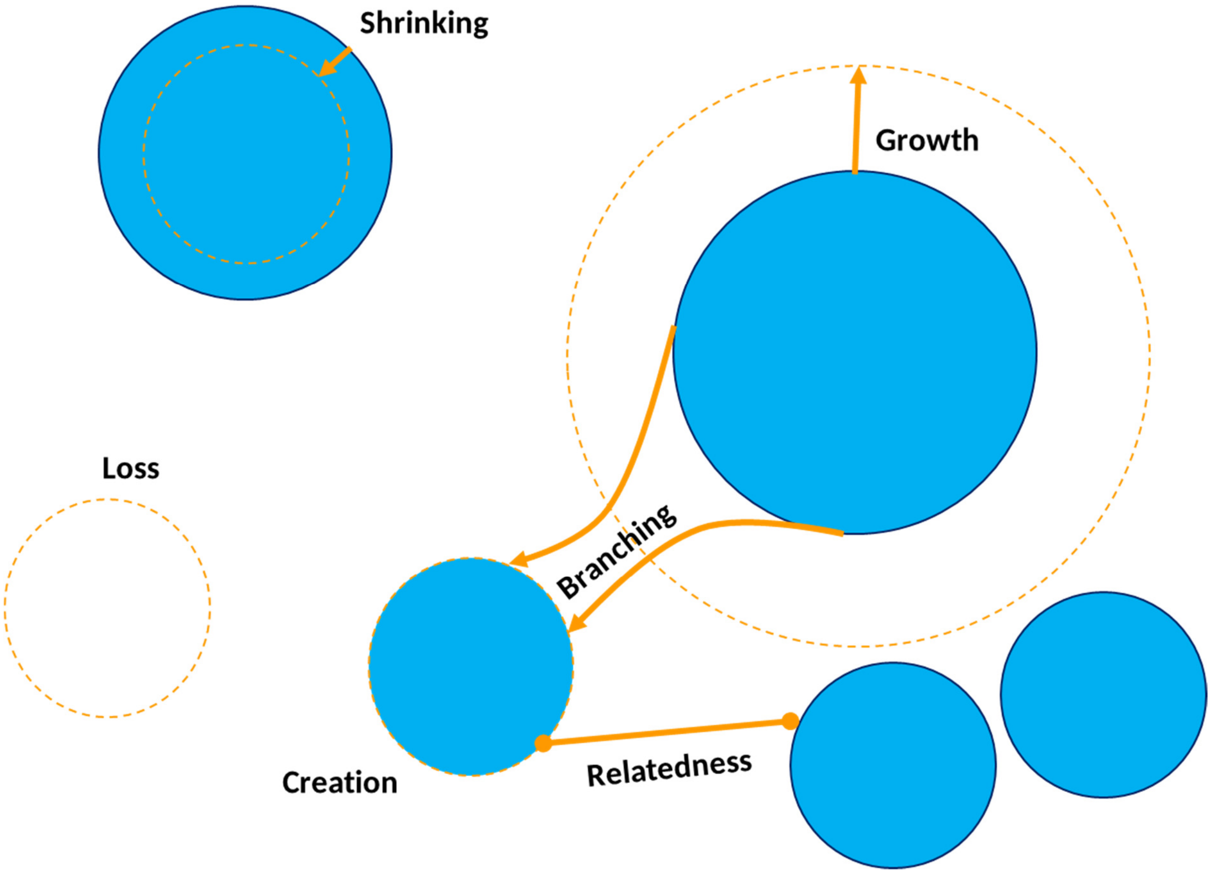


Figure 2.4: Elements of the economic landscape and their dynamics
Sources: Own figure

The interactional level of the framework (see Figure 2.5) comprises all direct and indirect interactions, in which two or more elements have an effect on each other. These can be social or economic relationships, in which tangible (e.g. goods, capital, money) or intangible entities (e.g. knowledge) are set in motion. In networks theory, this level would refer to the ties or edges between nodes (Newman 2013). Of course, these interactions are also dynamic as they can intensify or diminish, new ties can be made or there can be decoupling between elements. Most importantly to this thesis, knowledge dynamics are located on this level, as they are defined as "interactions of individual actors or groups of actors that learn, search for, or diffuse new knowledge" (Halkier et al. 2010: 6) in which knowledge is created, used, transformed, moved, and diffused (Strambach 2008: 154).

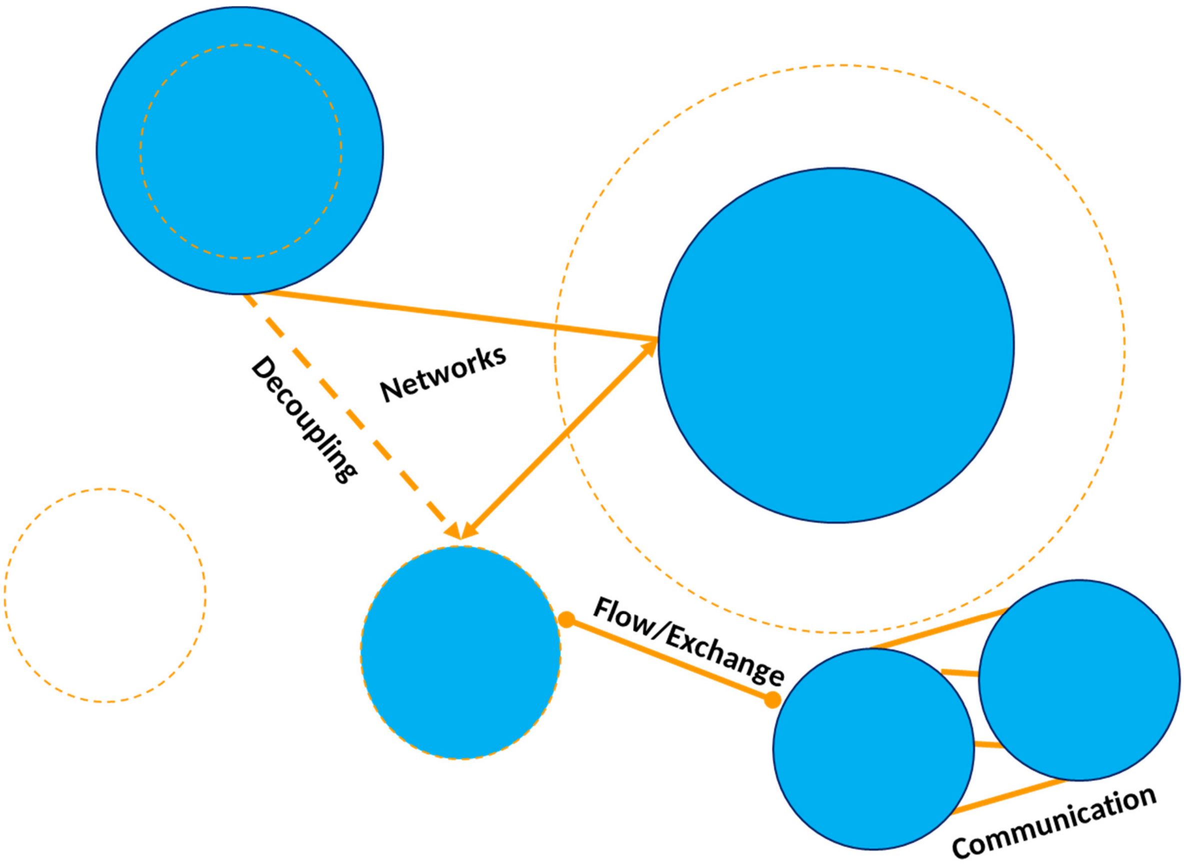


Figure 2.5: Interactions of economic landscapes
Sources: Own figure

The third level of this framework is made up of the institutional dimension (see Figure 2.6). Institutions are an essential constituent of regional innovation systems, whose role for affecting the nature and scope of institutions is strongly emphasized in the corresponding literature (Edquist 2005; Asheim 2016; Doloreux & Porto Gomez 2016). This study follows the understanding of institutions as "the humanly devised constraints that structure political, economic and social interaction. They consist of both informal constraints (sanctions, taboos, customs, traditions, and codes of conduct), and formal rules (constitutions, laws, property rights)" (North 1991: 97)[6]. Thus, institutions "comprise regulative, normative, and cultural-cognitive elements that, together with associated activities and resources, provide stability and meaning to social life" (Scott 2013: 56).

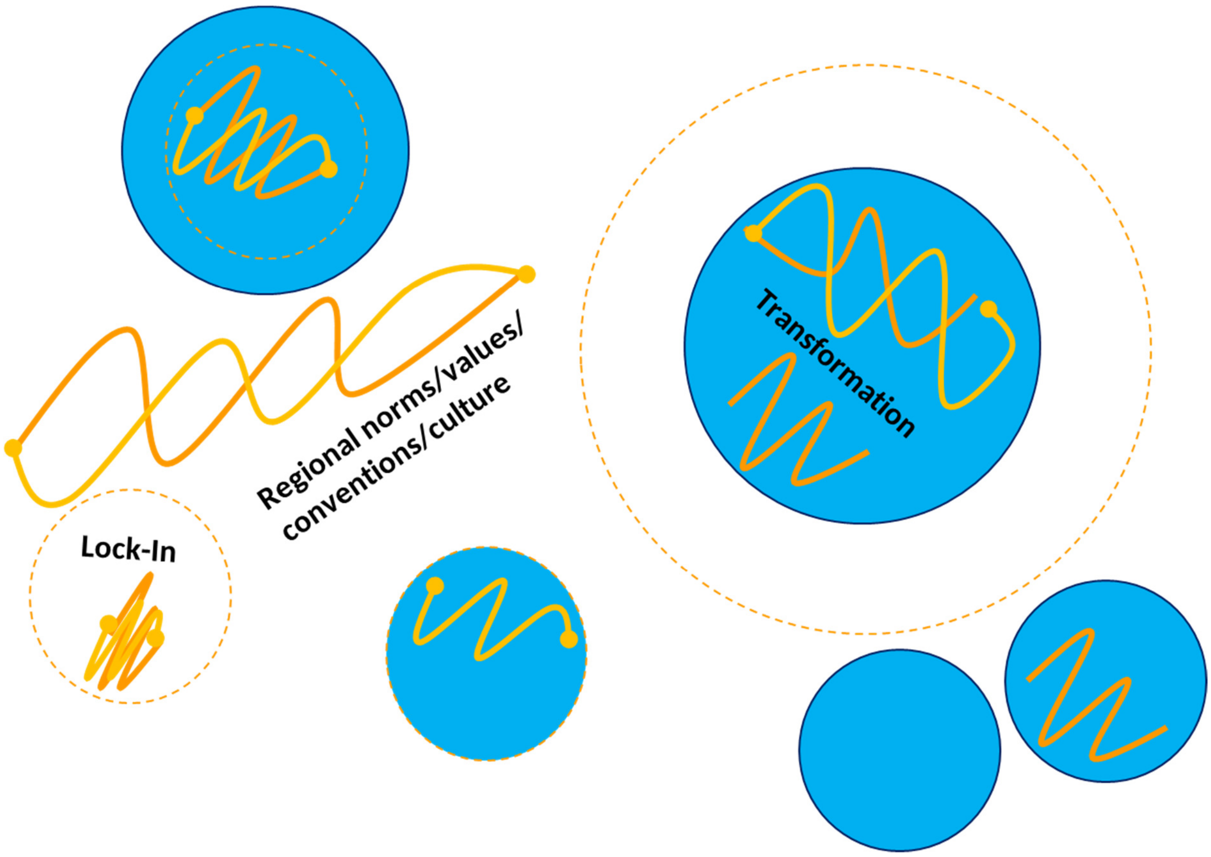


Figure 2.6: Institutions of the economic landscape

Sources: Own figure

From this definition, it is clear that first of all, institutions shape interactions between elements. But they can also be important mechanisms shaping behavior and human interaction within elements. Within organizations, Nelson & Winter (1982: 14) have termed these "regular and predictable behavioral patterns" as organizational routines.

[6] Some authors claim that Douglass North's understanding of institutions did not comprise informal institutions (e.g. norms, unwritten rules) or overemphasized the regulative aspect of institutions. This may be true for the first page of his seminal book "Institutions, Institutional Change and Economic Performance". On page 4, however, North (1990: 4) clearly states: "Are institutions formal or informal? They can be either, and I am interested both in formal constraints – such as rules that human beings devise – and in informal constraints – such as conventions and codes of behavior"

These different procedures within organizations have a clear institutional dimension in that they constrain and stabilize (inter)action. As organizational routines are compared by Nelson & Winter (1982) with genes, this study's visualization of institutions resembles a DNA helix. In the broadest sense, both DNA and institutions provide replicable, decomposable guidelines for pattern and behavior formation. Hence, even though there are a lot of differences between institutions and genes, genes provide a suitable visual allegory. Even though institutional arrangements provide stability for human interaction, they can also be subject to change. Institutional change does not imply that rules have to be radically removed and displaced. It can also happen gradually by processes of layering (introduction of new rules on top or alongside existing ones), drift (changing impact of existing rules due to the changing environments) or conversion (reinterpretation of existing rules towards new goals, functions, and purposes) (Streeck & Thelen 2005; Mahoney & Thelen 2010). Furthermore, as mentioned before, path-dependent processes can result in lock-in of institutions (MacKinnon et al. 2009).

Combining these three levels results in the following framework, as depicted in Figure 2.7. It integrates the elements of economic landscapes, the interaction between them and the underlying institutions shaping interaction within and between these elements. As mentioned before, knowledge dynamics are positioned at the level of interactions. As was mentioned in section 2.2, in economic geography a regional path refers to locally dominant industries which are accompanied by institutional and other self-reinforcing mechanisms. Hence, a regional path cuts all levels of the framework vertically. The regional path is then understood as locally dominant elements of the economic landscape that are reinforced by institutions narrowing down the scope of actions available to local actors towards the path. For visual clarity, the borders of the path are clearly delineated around a particular element. In reality, however, the borders between the regional path and the rest of the economic landscape are much fuzzier and blurred. For instance, the automotive industry acts as the core of the regional path of Baden-Württemberg's innovation system. But the path itself affects several non-firm and firm actors outside the automotive industry, as the path affects the curricula of the education systems, other industries and services that act as suppliers, or political decision (Heidenreich & Krauss 1998).

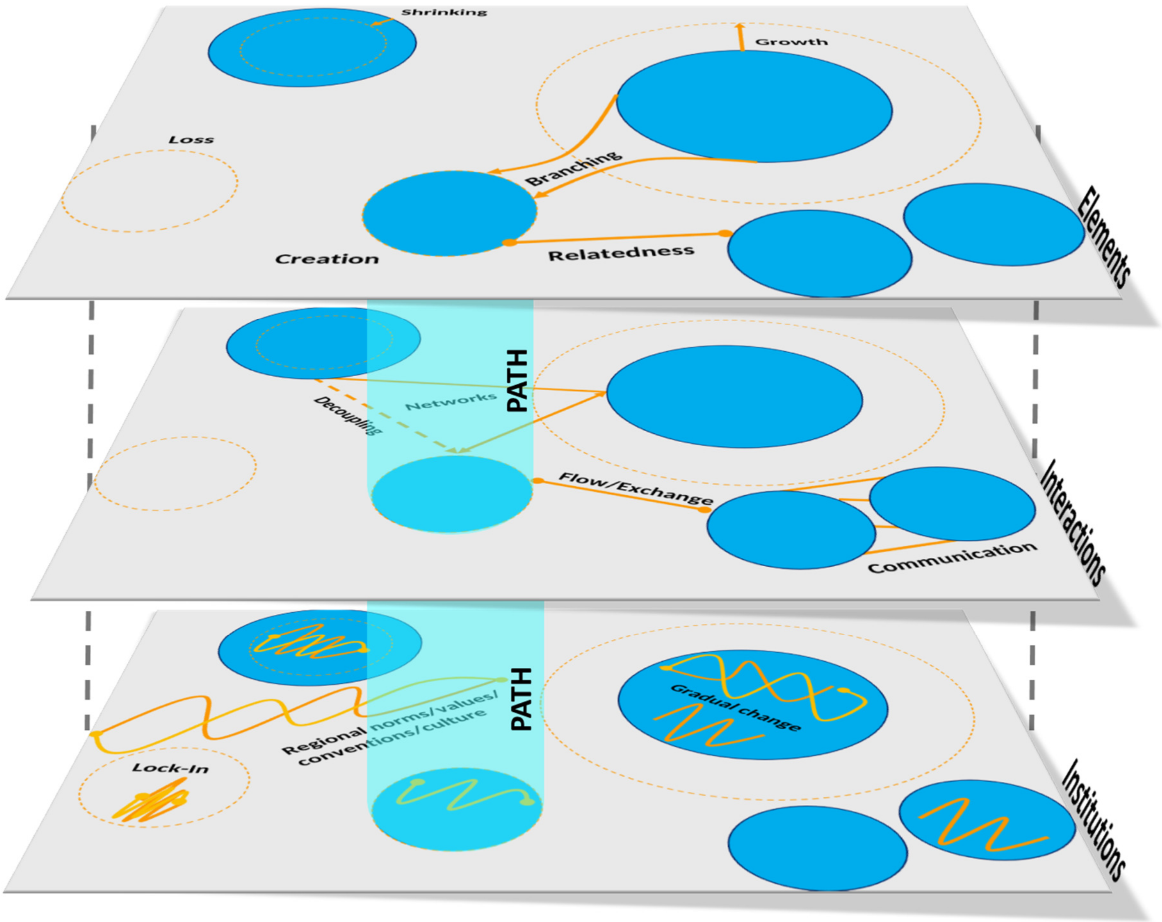


Figure 2.7: Illustration of the analytical framework of economic landscapes
Sources: Own figure

This analytical framework makes clear that in order to link knowledge dynamics with forms of regional path development, it is necessary to analyze the processes at the interfaces of the levels of the framework. Consequently, the research questions of this thesis are positioned at these interfaces. Not only can it be assumed that the interactional level affects the level elements and institutions, but there can also be effects in the other direction. Thus, the 2nd and 3rd research questions of this thesis are formulated as follows.

2 **How do cumulative and combinatorial knowledge dynamics affect elements of economic landscapes and vice versa?**

3 **How do cumulative and combinatorial knowledge dynamics affect institutions of economic landscapes and vice versa?**

Figure 2.8 shows how these research questions are positioned at the interfaces of the interactional level with the other levels, while the first research question is located the level of interactions.

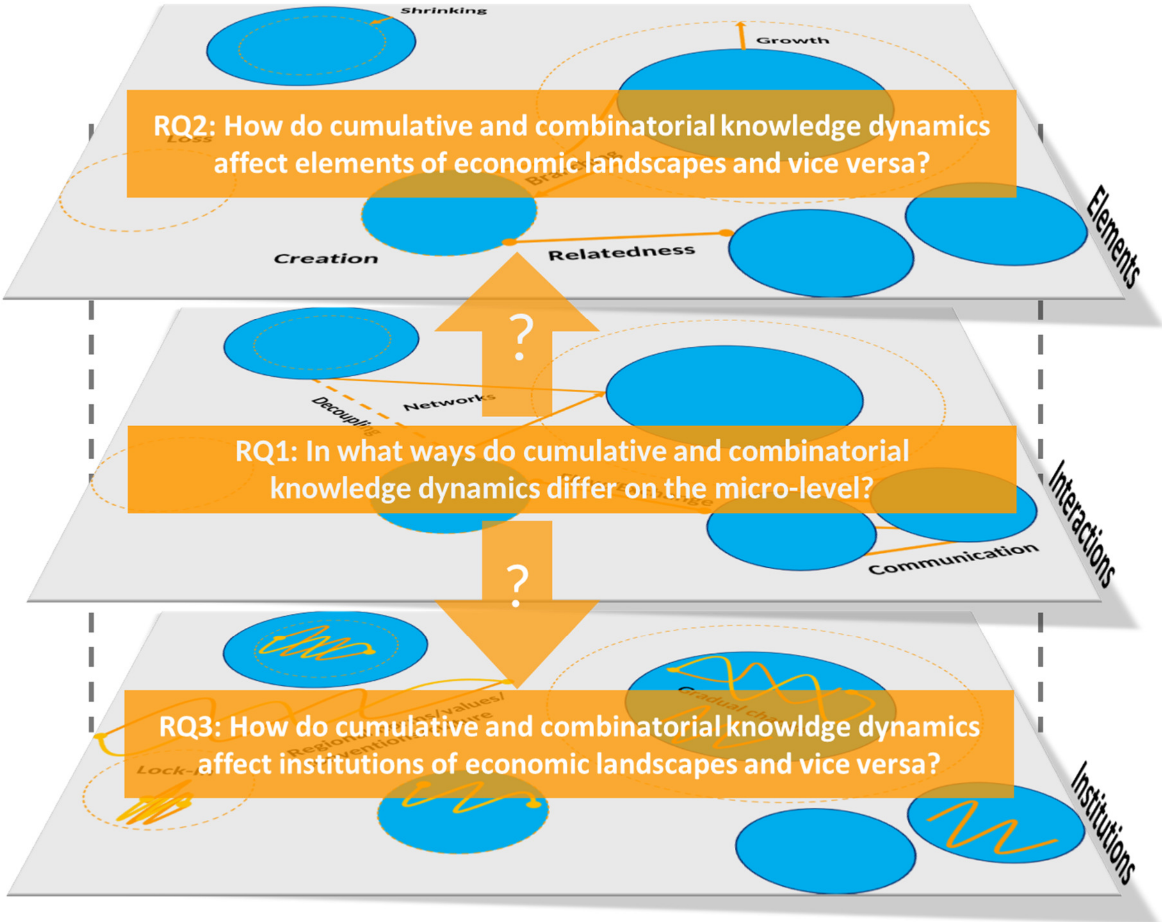


Figure 2.8: Positioning of research questions in the framework
Sources: Own figure

How the papers of this thesis are positioned within this framework, is shown in part IV.

III METHODS

3 Methods

"This is how we do it"

(MONTELL JORDAN, 1995)

As shown in the previous section, in this thesis processes on the different levels of elements, interactions, and institution are analyzed and the interactions between levels are at the heart of the research questions. Due to different subject matters, it makes sense to integrate qualitative and quantitative methods into one research design by applying the methodological approaches most suitable for each level (Kelle 2007). In the end, the results from these different approaches are triangulated, thereby being treated as equally valuable sources of information (Flick 2014).

For present purposes this means that qualitative methods from the research on knowledge dynamics and bases are combined with quantitative methods usually used in research on the evolution of economic landscapes. While the former, innovation biographies, are especially suited to provide information on the processes on the interactional and institutional level of the framework (Butzin & Widmaier 2015), the latter, technological relatedness, has been proven to reveal structural patterns of elements of economic landscapes (Frenken et al. 2007.

In this study, a third approach is introduced in order to enable the study of knowledge relatedness and dynamics in symbolic knowledge bases. Usually, symbolic knowledge eludes standardized classification and thus, was hidden from research on relatedness which only analyzed technological knowledge (Content & Frenken 2016). In this thesis the use digital social data (Poorthuis et al. 2016) in form of tagging data from the social music platform last.fm (Lamere 2008) is suggested. These tagging data provide a way to construct a folksonomy (Trant 2008), a crowdsourced taxonomy which provides the classification system necessary to transfer methods of relatedness measurement to symbolic knowledge.

While the first method, innovation biographies, is employed especially in the first two papers of this thesis (see sections 4 and 5), knowledge relatedness and user-generated content are employed in 7th and 8th sections of this thesis (see sections 6 and 7).

3.1 Innovation Biographies: A Process-based Method

As introduced in section 2.1, identifying and characterizing knowledge dynamics requires tracing the knowledge underlying an innovation. This implies the nature of knowledge inputs, relevant actors contributing knowledge, and the type of interactions in which knowledge was created, transformed, or used, regardless of their geographical location (Butzin 2009; Manniche & Larsen 2013; Butzin & Widmaier 2015). In regional studies and economic geography, the actual processes leading to innovation are often treated as a black box: situated mostly on the meso-level of regions, the most easily available indicators of innovations are patents whose relational data (Breschi & Lissoni 2005) cannot provide in-depth accounts of innovation processes (Butzin 2009): Even though they can reveal constellations of inventors involved in an innovation (Balconi et al. 2004; Ter Wal & Boschma 2009), the forms of individual involvement, the actors' relevance for different phases of the innovation process, and the actual forms of interaction between inventors, remain hidden from relational patent analysis (Bergek & Bruzelius 2010).

Hence, the methodical instrument „innovation biography" was developed in the course of the EURODITE project. It should be acknowledged that the notion innovation biography was used before (Butzin 2012), most notably by Rammert (2000) to investigate the creation of technological diversity, but this thesis will follow the understanding developed by authors associated with the EURODITE project. In the following, this instrument and ways to conduct research with it are further elaborated upon.

The central object of investigation of an innovation biography is not a region or firm, but an innovation. Identifying its biography entails finding a clear picture of all actors involved and the types of knowledge they contributed from the initial idea formation to the introduction of an innovation on the market (Butzin 2009: 2–3). As in biographical research of individuals, the main dimension of analysis is time. Following entire innovation processes over time allows capturing processes of learning, development, and knowledge transformation (e.g. during its contextualization) (Manniche & Larsen 2013; Butzin & Widmaier 2015).

As innovation biographies were developed in a geographical context, naturally the spatial dimension receives much more attention than in sociological biography research. The location of every actor and event along the timeline is recorded, so that the fabrication of the time-space path of innovation processes is made possible. Thereby the analysis does not stop at administrative borders but is especially helpful to reveal the multi-locational configurations involved in an innovation process (Butzin 2009: 10; Butzin & Widmaier 2015).

The procedure for applying the innovation biography method entails conducting narrative interviews, collecting spatio-temporal data of relevant actors and processes through interviews and document analysis, triangulating from these data sources, and finally reconstructing the innovation biography as a thick narrative accompanied by egocentric network analysis and time-space paths (Butzin 2009, 2012; Butzin & Widmaier 2015).

The research starts off with selecting a relevant innovation as a case. This can result from the identification of an interesting firm/non-firm actor or an interesting innovation beforehand. A major advantage of the innovation biography method is that it can be applied to any kind of innovation, whether it is a product, process, organizational, social innovation or even failed ones. Establishing the first contact with the respective firm/organization should result in a first appointment with an individual directly involved or responsible for an innovation process, which can provide a majority of the relevant information. The researcher should not enter the interview without previous knowledge but should form a basic idea of the innovation before the first interview to be able to have an informed conversation with the interviewee (Butzin & Widmaier 2015).

The first interview with a central actor should be understood as narrative interviews, in which a relatively open initial question instigates an open narration of the process in question (Flick 2014: 263ff.). However, in the case of innovation biographies it is the researcher's responsibility to establish a "narrative corridor" to gain relevant information and insights into relevant actors, the time of their involvement, their locations, the form of interactions, and the type of knowledge that they brought in, as these are not necessarily bits of information that interviewees provide by themselves (Butzin 2009, 2012; Butzin & Widmaier 2015). An innovation biography, however, should not consist of information from just one interview. The first interview helps to identify further relevant actors within or outside the innovating organization, which the researcher contacts to conduct further interviews. This snowball sampling method is used to enrich and verify/test the information gathered in the first interview. Finally, document analysis on sectoral, organizational, and geographical contexts of the innovation should be conducted to enrich the picture provided by the interviewees (Butzin & Widmaier 2015; James et al. 2015).

From these different data sources, the innovation biography is triangulated from (Flick 2014) and a time-oriented egocentric network is formed with the innovation as “ego” and all identified involved actors and organizations as “alters”. This enables the researcher to enhance the thick narration of the innovation process with visual aids that include a timeline and localization of relevant events and actors involved (Butzin & Widmaier 2015).

Examples of innovation biographies can be found especially in literature emerging from the EURODITE project in which 62 case studies/biographies were conducted in a variety of contexts (Kaiser & Liecke 2009; Halkier et al. 2010; Cooke & Kaiser 2012; Halkier & Therkelsen 2013; Manniche & Larsen 2013; Hermelin et al. 2014; James et al. 2015) It has, however, been adopted in other research contexts as well. Thereby the relatively open method has inspired a certain variety of ways to document the biographies. Davids & Frenken (2017) have provided insights into the historical case of the development of Unilever’s diet margarine Becel and were able to access the firm’s archives to enrich the narrative interviews. Ibert (2010) combined the innovation biography of a sensor system for biotechnological applications with a participatory observation and ethnographic interviews. In comparing cases from biotechnology firms with those in legal services, Ibert & Müller (2015) illustrated the relational dynamics (such as rivalry, mentorship, competition) at different stages of the innovation process. Strambach (2017) has applied the method to transnational, sustainability innovations, proving the method’s merits, especially for border-crossing innovation projects. Last but not least, without referencing the original innovation biography and knowledge dynamics literature, Scaringella (2016) reconstructed the knowledge dynamics around the internationalization process of a semiconductor firm.

All the above-mentioned studies make use of the primary advantage of innovation biographies: Knowledge, whether considered a classifiable object or as situated in social interaction (Ibert 2007), is the main object of investigation and is traced along the progress of innovation projects. Thereby the multi-scalar scope of its origin and transformation comes to the fore, especially since the analysis is not limited to predefined conceptions of regions, sectors or technological fields (Butzin & Widmaier 2015). Furthermore, due to the emphasis on time, innovation biographies are especially well-suited to draw attention to changes of organizations, ideas, knowledge inputs, proximity and contexts over time (Plum & Hassink 2013; Balland et al. 2015). From a technical perspective, innovation biographies provide a standardized set of instruments (narrative interviews, ego-centered network analysis, and triangulation) that can easily be adapted to the requirements of different research contexts, enabling its use in large research projects (Butzin & Widmaier 2015).

Like every method though, innovation biographies are not without limitations. First of all, there is a major practical challenge of gaining all relevant information from narrators. The quality of interviews is dependent on the cooperation of interviewees and their openness. It may not be possible to apply this method in sectors in which details of innovation projects are kept under strict secrecy. Interviewees may also not speak freely of failures and acts that throw a shade on the company's narrative or themselves (Butzin & Widmaier 2015; James et al. 2015). By illustrating the case of the Zara myth of domestic production, Tokatli (2015) shows how researchers tended to follow established corporate narratives without consulting other sources such as bank analysts, consultants, journalists or competitors. It is also problematic to find clear starting and end points of the biographies as well as a comparable set of phases with which the biographies can be structured (Manniche et al. 2017). Last but not least, innovation biographies, like case studies in general, provide suitable means to access the everyday knowledge of experts, but do not provide representative evidence. Especially in the case of innovation processes, the biographies may differ so clearly that aggregating the findings on the micro-level is not recommendable. Thus, innovation biographies can be extremely helpful to inductively generate theories grounded in empirical data (Glaser & Strauss 1967) but are not usable to test theories deductively and make generalizing claims (Butzin & Widmaier 2015).

3.2 Relatedness: A Structure-based Method

Innovation biographies are most suitable to analyze how knowledge creation, transformation, and use unfolds. In the course of innovation biographies, knowledge inputs are identified and characterized by their content. Yet the differentiation of knowledge dynamics calls for a way to measure the commonalities and dissimilarities between knowledge bits so that cognitive and institutional distances are determined (Boschma 2005). As Boschma (2017: 9) points out, both the knowledge base literature and EEG literature have developed a research program around "the search for commonalities and differences between activities in terms of knowledge and innovation". While the DKB literature focused on the different rationales in activities associated with knowledge generation and is thus closer to the process-oriented focus of knowledge dynamics and innovation biographies, the EEG literature has developed the instrument of relatedness to explore "which pieces of knowledge can and which cannot be effectively combined" (Boschma 2017: 9) from a more quantitative, structure-oriented perspective.

This relatedness can be employed to characterize knowledge dynamics as cumulative or combinatorial ones. Thus, this section will explore the method of determining the relatedness between bits of knowledge and its application in the network-based visualizations of knowledge spaces and the description of regional economic structure by related variety (Frenken et al. 2007) in order to complement the qualitative, process-based innovation biography method.

There is a long history of regional structural analysis in economic geography in which official statistics on employment, firm population or patents were utilized to identify the shares of economic activities present in a region, e.g. in order to determine the degree of specialization of regional economies. Using shares of economic activities, however, ignores the fact that some activities are more similar to each other than others (Essletzbichler 2015). Consequently, ignoring different degrees of similarity would impede studying processes such as knowledge spillovers (Verspagen 1997), diversification (Breschi et al. 2003; Hidalgo et al. 2007), industrial variety (Frenken et al. 2007), labor mobility (Neffke & Henning 2013; Otto et al. 2014), or routine branching (Frenken & Boschma 2007), in which a higher degree of interaction between similar activities is assumed. As this study, in particular, is most interested in finding relatedness between bits of knowledge to illustrate knowledge combination, it will focus on metrics of relatedness regarding knowledge.

Theoretically, the relatedness of knowledge affects knowledge transfer and spillover processes due to the cognitive dimension of proximity (Boschma 2005; Nooteboom 2010). It is suggested that a certain degree of similarity between the existing knowledge base of actors and external knowledge has to be present in order for actors to absorb it. Hence, actors have different levels of "absorptive capacity" that allows or prevents them from learning from external sources (Cohen & Levinthal 1990). As Nooteboom (2010) illustrates, the relationship between the propensity of learning between actors and their cognitive proximity follows an inverted U-shape: Put simply, two actors who know the same, cannot learn from each other, while actors with no overlap in their knowledge bases also face difficulties, as finding common ground and mutual understanding is too costly, e.g. in terms of communication or transaction costs.

As knowledge has been first and foremost studied in the context of science and technology, many studies use the term "technological relatedness" (Boschma & Frenken 2011a). There are three mechanisms through which technological relatedness may be constituted. First, technologies can have a common ancestor, from which several technological subfields spawned (Boschma & Frenken 2011a). Second, knowledge may stem from the joint use of resources: For instance, similar economic activities employ human capital from the same labor markets (Neffke & Henning 2013). Third, the complementarity of technological components in technological systems, such as the car, the spinning wheel, or computer hardware (Arthur 2009) results in high relatedness of knowledge required to produce components that are used together in products and processes (Essletzbichler 2015). Correspondingly, there are three general ways to measure technological relatedness: Classification-based methods that utilize pre-defined categories of knowledge, resource-based methods analyzing resource flow patterns, and co-occurrence analysis which investigates the complementarity of knowledge bits by the frequency of their combination in portfolios of economic entities (Neffke & Henning 2013).

Classification-based methods employ the hierarchical information in classification systems on industries (SIC, NACE) or patents (IPC) used by official authorities. Activities which belong to the same groups on distinct hierarchical levels of the classification systems are supposed to be related. This method is especially in use in the measurement of related variety by entropy metrics (Frenken et al. 2007; Castaldi et al. 2015). The cosine index applied by Breschi et al. (2003) to measure knowledge relatedness uses the similarity of distributions of co-occurrence patterns in the classification system. While this method is comparatively easy to apply and benefits from experts' decisions on grouping economic activities together, it has to be kept in mind that there is no corresponding theory with which these classification systems were initially established (Content & Frenken 2016). McNamee (2013) demonstrates by the example of Linnaean taxonomy that the distinction of similarity of animals entirely depends on the hierarchical level chosen and masks a lot of information. Furthermore, classification systems remain highly static and when they change, change only in discrete steps, sometimes grouping previously unrelated activities together or vice versa (Neffke & Henning 2013).

Resource-based methods, however, use actual economic activities to find similarities. The idea behind this approach is that similar industries or activities should use similar resources. It is theoretically linked to resource-based views on the firm which explain diversification or branching processes by the exploitation of underutilized economies of scope (Penrose 1959; Frenken & Boschma 2007; Neffke & Henning 2013). Information about the use of resources is provided by input-output tables that show which industries use similar inputs of resources and thus can be considered related (Los 2000; Essletzbichler 2015). Another possibility is given by measuring labor mobility flows between industries. It is assumed that industries are similar when they tap human capital from the same labor markets, as they evidently require similar skills (Neffke & Henning 2013; Otto et al. 2014; Fitjar & Timmermans 2016, 2017). One major problem of this method is that especially workers at the upper and bottom end of the qualification scale rarely have industry-specific skills and thus have to be excluded from the analysis (Neffke & Henning 2013). Furthermore, there may be a lot of interference by locational and structural characteristics of labor markets that affect labor mobility.

Especially regarding science and technology, the similarity of inputs provides little information on the similarity of outputs. Groups of equally skilled professionals, such as professors, scientists, or engineers, hold distinct sets of knowledge even when they belong to the same discipline, which leads to an ever-diversifying "tree of knowledge" with highly-specialized, fragmented branches (Howells 2012). Thus, co-occurrence analysis attempts to capture the complementarity of knowledge bits by evidence of its combination (Weitzman 1998). The central idea behind this method is that the more often knowledge bits are combined, the more related they are. There are several studies utilizing the information given by the co-classification of patents with technological classes (Antonelli et al. 2010; Quatraro 2010; Colombelli et al. 2014; Feldman et al. 2015) or the citation patterns of patents (Rigby 2015). Other studies analyze publications related to science & technology and identify the co-occurrences of words in title of scientific articles (Boschma et al. 2014; Heimeriks & Boschma 2014), scientific journals cited in the same articles (Uzzi et al. 2013; Mukherjee et al. 2016), or words used in tweets about upcoming technological fields (Jurowetzki & Hain 2014).

As not all economic activities can be traced back to scientific publications and patents, several studies utilize the co-occurrence of products in the portfolios of different economic entities. One of the most prominent examples is the “proximity” indicator of Hidalgo et al. (2007) in which those goods of which countries display a joint comparative advantage (indicated by their export intensity) are considered related. This can be considered a mixture of the resource-based and co-occurrence approach, as relatedness can stem from both complementarity and the dependence on joint resources. This approach was transferred to the regional level by Boschma et al. (2013) and Colombelli et al. (2014). The correlation of employment in different industries has also been employed by Porter (2010), resulting in a list of related industries that form clusters in the USA. On the most detailed level, Neffke et al. (2011) identified relatedness from the product portfolios of manufacturing plants in Sweden. A major disadvantage of co-occurrence approaches is the underlying assumption that portfolios are coherent and activities within them related. Even though they can illustrate working combinations that evidently benefit from economies of scope, they cannot reveal the underlying sources and mechanisms leading to their combination (Neffke & Henning 2013).

Howsoever measured, relatedness has enriched regional structural analysis. Most striking are the network-based visualizations stemming from resource flow and co-occurrence analysis that characterize economies not only by the shares of activities but by their interrelations. These networks can reveal diversification routes, structural holes, weak and strong ties, and illustrate a dynamic view of economic development over time. Depending on the subject of analysis, these visualizations are called product spaces (Hidalgo et al. 2007; Hidalgo & Hausmann 2013), industry spaces (Neffke et al. 2011; Otto et al. 2014: 139; Fitjar & Timmermans 2016), technology spaces (Jurowetzki & Hain 2014; Feldman et al. 2015; Balland & Rigby 2016) or knowledge spaces (Kogler et al. 2013; Feldman et al. 2015; Rigby 2015). Despite using the word “space”, the locations of and the ties between the networks’ nodes do not show spatial information, but the relatedness between nodes. However, they are not only visualization tools but can be analyzed by methods of social network analysis. On the one hand, these can be used to determine metrics of the network’s structure, such as density, coherence, or inclusiveness. On the other hand, the centrality of certain knowledge bits can be illustrated by calculating their degree, closeness, betweenness, or eigenvector centrality (Krafft & Quatraro 2011).

Furthermore, the concept of relatedness has informed the literature on different forms of variety found in regional economic structures. In the debate on whether the specialization or diversity of regional economies promotes their economic growth (Beaudry & Schiffauerova 2009; Caragliu et al. 2015), related variety provides a new perspective that is able to separate the positive knowledge spillover effects arising from related variety and portfolio effects originating from unrelated variety (Frenken et al. 2007; Boschma 2015). The related variety of economies is calculable by using the within and between entropy of employment, patents or similar data on different levels of corresponding hierarchical classification systems. Another way to determine the relatedness in regional economies is calculating weighted average relatedness measures that can refer to the coherence of the analyzed regional economic structure (Kogler et al. 2013; Krafft et al. 2014; Feldman et al. 2015).

The concept of related variety has been employed in many studies (of which Content & Frenken (2016) provide an extensive overview). Its association with several indicators of economic performance has been proven in multiple instances. Evidently, related variety is linked to economic growth (Boschma & Iammarino 2009; Boschma et al. 2011; Cortinovis & van Oort 2015), employment growth (Frenken et al. 2007), the growth of creative industries (Lazzeretti et al. 2017), regional economic resilience (Sedita et al. 2016), and the innovativeness of regions (Tavassoli & Carbonara 2014; Castaldi et al. 2015).

What studies on relatedness and related variety fail to analyze is, however, the mechanism through which relatedness gains these powerful effects. It is still unclear whether relatedness promotes knowledge spillovers via labor mobility, spin-offs, similarity, complementarity, or knowledge networks (Boschma et al. 2011; Desrochers & Leppala 2011; Boschma 2016). Furthermore, the measurement of relatedness is still a source of many problems: The many asymmetrical relationships in the modern economy may also imply asymmetrical forms of relatedness which have not yet been taken up by measurement methods (Boschma 2016). In addition to that, relatedness studies do not differentiate between the activities of firm and non-firm actors, often resulting in downplaying the contributions of universities, research institutes, or public policy, e.g. in the diversification of regional economies (Binz et al. 2015; Coenen et al. 2017).

Another shortcoming is that relatedness measures, being dependent in some ways on classification systems remain static while they measure very dynamics processes (Bugge & Øiestad 2014). There is good reason to believe that breakthrough innovations can turn unrelated knowledge bits into related ones, thereby also changing the (related) variety of economies (Castaldi et al. 2015; Boschma 2016).

Last but not least, the overview on existing measurement methods and applications of relatedness has illustrated one major shortcoming of the existing relatedness literature: To date, only the relatedness of manufacturing goods and technological relatedness has been measured due to the availability of extensive databases (Content & Frenken 2016). Tanner (2014) shows that market knowledge is insufficiently acknowledged by the relatedness literature. For instance, it is much easier for a window manufacturer to apply novel nanotechnology to their products than suggested by the technological relatedness of both products. She proposes that not only technological, but market relatedness exists, which can have different effects on diversification and growth processes.

This market relatedness may not be incorporated in technological knowledge, but in symbolic knowledge (Asheim 2007). To date, no measurements of relatedness of symbolic knowledge (or creative industries in general) have been undertaken (Berg & Hassink 2014) despite it being a valuable resource of a considerably large part of the economy (Boix et al. 2016). Services and the creative economy, for instance, are very dependent on their symbolic knowledge base (Strambach 2008; Asheim & Hansen 2009).

Hence, knowledge dynamics in symbolic knowledge are difficult to differentiate by measures of relatedness. To close this gap in the literature, the final research question of this study is as follows.

4

How can knowledge dynamics in symbolic knowledge bases be differentiated by measures of relatedness?

The next section illustrates which challenges arise when symbolic knowledge relatedness is measured and how these can be met.

3.3 Utilizing User-generated Data: A Resonance-based Method

“Everything counts in large amounts”

(DEPECHE MODE, 1983)

In summary, three conditions have to be satisfied in order to transfer methods of measuring relatedness and related variety to the context of symbolic knowledge: classification, hierarchy, and novelty. First, the knowledge that is analyzed has to be disaggregated into knowledge bits (Antonelli 2006) by classification systems. Only then can the relatedness between bits of knowledge bits be analyzed by their co-occurrence in portfolios (Quatraro 2010) or resource flow patterns (Neffke & Henning 2013). Second, these classification systems should contain a hierarchical element. The measurement of related variety requires grouping knowledge bits at different hierarchical levels, as the information entropy on different levels of the classification systems has to be calculated (Frenken et al. 2007). Third, measuring knowledge relatedness should naturally take place by using data associated with novelties, such as patents or scientific articles (Krafft & Quatraro 2011; Heimeriks & Boschma 2014).

Regarding symbolic knowledge, fulfilling these conditions is a challenge. First of all, the classification of symbolic knowledge is difficult. Of course, there are different industries or product categories to which creative industries belong, but these can give only rudimentary information on what is produced and invented. While the knowledge of scientists and engineers is reflected in detail by the different technologies and inventions that they produce, existing classification systems, at best, only reveal the medium in which artists are active, e.g. music, film, books, etc. But there are no central authorities that classify these products of creative industries into the distinct categories called genres that are usually used to sort pieces of art (DiMaggio 1987; Sordo et al. 2008). This is not possible to do by a central authority, as it is commonly understood that genres are socially constructed categories that “imbue artworks with significance beyond their thematic content and are, in turn, responsive to structurally generated demand for cultural information and affiliation” (DiMaggio 1987: 441). Genres are less linked to objective characteristics but linked to social practices and conventions regarding jargon, ideals, performance, use of technology, dress, drugs, and boundary work towards other genres (Lena & Peterson 2008). For instance, some music genres such as “riot grrrl” or “indie rock" are virtually indistinguishable from similar genres by musical content, while following a set of conventions that demarcate the borders of the genres and the corresponding scenes (Schilt 2004; Hibbett 2005). The classification of art into genres is constantly negotiated by fans, musicians, tastemakers, media, industrial actors, and outside spectators (Lena & Peterson 2008). Thus, self-classifications, expert-based classifications, or commercial classifications can hardly reflect the true nature of a piece of art (Sordo et al. 2008).

Obviously, the lack of central classification systems prevents the creation of a hierarchy of genres similar to the hierarchy of industrial classification systems that allows the calculation of related variety metrics. Instead, hierarchy in artistic classification systems is often linked to the social prestige and status of listeners and creators of art, often sorting art into categories such as "high vs. popular art", "high culture vs. mass culture" or "ernste vs. Unterhaltungsmusik" (germ.= serious vs. entertainment music) (Horkheimer & Adorno 1944; Bourdieu 1984; DiMaggio 1987). This sort of hierarchical classification is irrelevant for present purposes, not only because it completely neglects the creative energy of artists outside bourgeoise elites, but also because this way of grouping art is useless for calculating the relatedness between pieces of art.

Last but not least, determining the novelty of symbolic knowledge has been proven difficult, as the scarcity of studies on innovation in creative industries shows (Miles & Green 2008; Lee & Rodríguez-Pose 2014a). The value, content, and novelty of products incorporating symbolic knowledge are intrinsically interwoven with subjective responses of consumers instead of objective parameters (Asheim 2007; Brandellero & Kloosterman 2010: 63; Martin & Moodysson 2011). In general, innovation in creative industries based on symbolic knowledge creation is hidden from traditional innovation indicators for four reasons: 1. Any research done by creative firms is rarely situated in R&D departments, 2. Business model and organizational innovations that are very relevant for creative industries are not reflected in patents or R&D statistics, 3. Very often, innovation is achieved by novel recombination of existing knowledge, 4. many innovations are one-offs that are or should not be replicated (e.g. movies, albums, books, video games) (Miles & Green 2008). Innovations mostly entail changes in aesthetic content or meaning of products and less changes or improvements of their functionality, which is why innovations in creative industries are also called "soft innovations" (Stoneman 2010). Stoneman (2010) concludes that the creative significance of these innovations can only be measured by consumers responses indicated by market success. However, there are arguably a lot of reasons for market success being a poor indicator of innovative creative and cultural goods: Some of the greatest pieces of art remained unnoticed during the lifetime of their creators, while now-forgotten artists succeeded financially (Eltham 2013). Furthermore, the creation of novel, radical ideas in creative industries often takes place in spaces and communities detached from commercial interests (Brandellero & Kloosterman 2010; Cohendet et al. 2014). Miles & Green (2008) suggest that measuring and assessing the uptake of an innovation may be a better indicator of creative significance and novelty, but also remark that researchers are not the ones able to make these aesthetic judgments themselves.

Discussed at such length, the obstacles of measuring symbolic knowledge relatedness appear insurmountable. So, how can these challenges in measuring symbolic knowledge be met? The reason for the lack of classifications is also part of the solution for developing a classification system usable to calculate relatedness. As the previous discussion points out, the nature of products embodied with symbolic knowledge eludes standardized classification because of it being socially constructed. It is sensible to make use of this process of social construction (Berger & Luckmann 1966) also in a methodological sense. Hence, the solution proposed by this study is based on the resonance of pieces of art with consumers. Ultimately, the aim of symbolic knowledge creators is to 'trig reactions in the mind of consumers' (Martin & Moodysson 2011: 1188); to create and communicate the meaning of products so that some response from consumers is elicited. Consequently, consumers' responses become a valuable source for unveiling the symbolic knowledge embodied in products.

Originally, how pieces of art resonated with consumers was hidden from researchers and could only be revealed by intensive qualitative research or fieldwork. But this has changed due to the advent of social media. On social media, users build a presence and identity, establish and maintain relationships, gain reputation, form communities, converse with each other, and share original or third-party content (Kietzmann et al. 2011: 243). To some degree, all these main functionalities of social media can be linked to consumers reacting to products of creative industries. Users of social media are not merely recipients of cultural goods, but have become active participants in their creation, evaluation, and curation (van Dijck 2009).

For present purposes, this study will, however, focus on one functionality that is available on many social media pages today: Social tagging. Tagging refers to the act of users voluntarily applying an unlimited number of (mostly) short pieces of texts, to online content. The motivation of taggers can be classified in respectively two dimensions of functionality (organization or communication) and sociality (for oneself or for others) (Ames & Naaman 2007). The term social or collaborative tagging refers to the aggregation of the tags of many individuals so that a rich description of the tagged items emerges. Content is not only described by the most prominent tag but a word cloud of frequently used tags. Most websites enable users to click on tags in order to find other items tagged with these keywords or finding other users using the tags (Lamere 2008).

In aggregated form, tags can form a so-called folksonomy, a collective vocabulary in form of a crowdsourced taxonomy arising from the individual actions of a diverse and large user base, in which every opinion is treated equally (Shepitsen et al. 2008; Sordo et al. 2008; Trant 2008; Hollenstein & Purves 2010). These taxonomies benefit from the wisdom of the crowd, not the dominating view of self-proclaimed or employed experts or the content creators themselves. Thus, they are able to change quickly and react to new trends as quickly as users find them (Shepitsen et al. 2008). Non-experts are not necessarily worse at classifying works of art than experts. As a study of the understanding and perception of the music genre black metal by Hantschel & Bullerjahn (2016) shows, there are inter-subjectively shared concepts and cognitive prototypes of music genres, even of rather obscure ones. Consequently, the identification and classification of non-experts and experts overlap to a great degree.

Folksonomies can provide a classification system usable to disaggregate symbolic knowledge into knowledge bits that co-occur in the descriptions of creative and cultural goods. It classifies the symbolic knowledge of content creators indirectly by utilizing the subjective classification effort of an anonymous crowd. Regarding technological knowledge, this would not make a lot of sense, but in the context of symbolic knowledge, it has a beneficial side effect. It directly records the meaning of products that symbolic knowledge creators have produced and were able to convey. The social construction of symbols becomes visible, as the data themselves are socially constructed.

Concerning the second requirement, hierarchy, it has to be noted that folksonomies are, by definition, non-hierarchical taxonomies. Nevertheless, the frequency of tag usage and co-occurrence of tags can be utilized, as Lamere (2008: 108) demonstrates by building a hierarchy of metal music genres by using the popularity of tags as an indicator of hierarchy.

Concerning the third requirement, novelty, folksonomies can be used either by analyzing when new tags have emerged or by identifying the history of cultural/creative goods that were tagged with distinct tags. While in the case of music, objective, quantitative measures of acoustic properties have been used to identify innovations (Mauch et al. 2015), they cannot provide such detailed insights into the social classification of items.

In summary, the resonance-based method proposed here differs in some respects from the typical measurement of technological relatedness, as illustrated in Figure 3.1. Measuring symbolic knowledge may appear more indirect, but ultimately it only differs in the way the classification of products embodying symbolic knowledge is achieved by user-generated content instead of experts' actions. Note that in this thesis, the method of calculating relatedness from co-location (Hidalgo et al. 2007) is not employed for the measurement of symbolic knowledge relatedness.

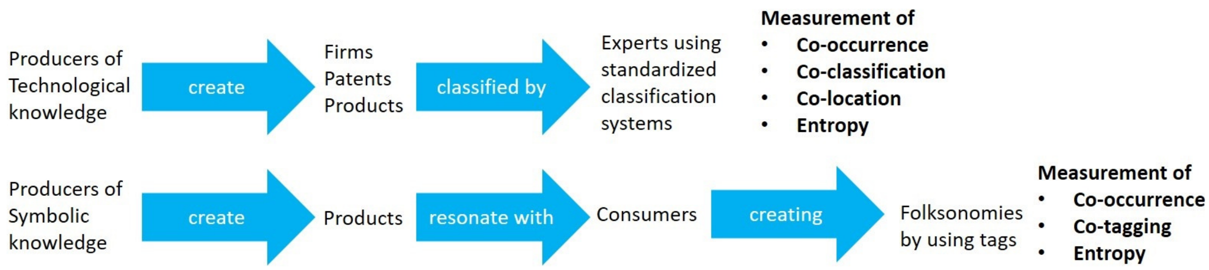


Figure 3.1: Measuring relatedness for technological and symbolic knowledge
Sources: Own figure

3.3.1 Digital Social Data in Human Geography

Even though the use of user-generated content in economic geography is a quite novel approach, in general, the use of user-generated data in geographical research has gained traction within the last ten years and has found its way into hand- and textbooks (Capineri et al. 2016; Poorthuis et al. 2016). The first geographical research on user-generated content was conducted on volunteered geographic information, that is cartographical data collected by the general public (Goodchild 2007; Coleman et al. 2009; Elwood et al. 2012). As the proliferation of social media, location-based services, applications, and devices has continued, the research field has widened as well. New opportunities for acquiring data have arisen for research, as people leave more and more digital traces of their lives. Social processes and interaction have been put into numbers and texts that can be harvested for research purposes (Crampton et al. 2013; Stefanidis et al. 2013; Crang 2015). There is a new wealth of data amassed through users' articulations of "interests, intentions, perceptions and needs that may enrich traditional institutional and other commercial data sources" (Campagna 2016: 16).

Poorthuis et al. (2016) propose the term "digital social data" for this new type of data, which is a) digital, as it is collected and stored by improved means of computing capacity, hard disk storage and the availability of low-cost sensors in desktop and mobile environments, and b) is social, as it increasingly represents mundane, significant, habitual, and relational (inter)actions of people, may it be with close family/friends, but also with perfect strangers. These data are sometimes purposefully shared, sometimes reflexively distributed, but sometimes simply amount automatically from users' actions.

In human geography, digital social data have been used mostly in studies of urbanism. For instance, mobile GPS sensor data have been applied to monitor mobility in urban areas (Ahas et al. 2015). Image and text data from Flickr or Instagram have been put to use in studying urban landscapes, and the interaction of different social groups with them (Hollenstein & Purves 2010; Boy & Uitermark 2016). Modern practices of place-making by the use of different hashtags have been explored (Reithmeier et al. 2016), while patterns of social inequality by mapping the usage of the word "ghetto" in parts of the city could also be revealed (Shelton et al. 2015). Social data can also be employed at the interface of human and physical geography, as the study of the "data shadow" of Hurricane Sandy by Shelton et al. (2014) illustrates.

To the knowledge of this author, digital social data in economic geography research has not been applied except for a few notable exceptions: For instance, Zook & Poorthuis (2014) have analyzed regional preferences and patterns of consumption of beer. In order to identify and map emerging technological fields and the epistemic communities surrounding them, Jurowetzki & Hain (2014) used Twitter data. Last but not least, self-classification data of fans and artists on Myspace was employed by Brydges et al. (2013) in order to characterize urban music scenes of US cities. The latter study has also inspired this author greatly to analyze music scenes by the folksonomies emerging from the social music platform last.fm.

3.3.2 Using Last.fm as a Data Source

Last.fm was established in London (UK) in 2002 and possesses about 50 million users (Mauch et al. 2015). The central idea behind last.fm is that users allow the site to automatically track what they listen to on digital devices, music players or streaming platforms via a small application that reads out MP3 metadata. On the site, the process of listening to a song and tracking it on last.fm is called a "scrobble". In June 2016, the site recorded the 100 Billionth scrobble. Not surprisingly, The Beatles are the most listened artists with 497 million plays (Last.fm 2016). The primary service of the site is to create user profiles that display users' musical preferences and provide radio stations and recommendations to users based on what they have listened to. One major advantage of using last.fm as a data source is that artist profiles are created automatically on the site as soon as a single user has listened to any song of the artist, resulting in a comprehensive data source, which is virtually unaffected by selection bias resulting from commercial or artistic interests. Furthermore, users are encouraged to contribute biographical information to the artist profiles, such as their place of origin or their years of activity (Lamere 2008; Haupt 2009; Pontello et al. 2016).

Most important to this analysis, users are encouraged to describe artists, albums, or songs with as many tags as they please, of which the six tags most frequently used are displayed publicly on the website. Last.fm was one of the first websites on which tagging was used. Already in 2007, last.fm users tagged musical content 2 million times per month. Users did not only use genres as tags, but also indicators for mood, technical description, and most valuable to the papers of this thesis, geographical references. Of the 500 most frequently applied tags, only 68% of tags refer to genres, followed by 12% referring to locations (Lamere 2008), which makes it a valuable source of geographical information on music.

The use of digital social data for the proposed resonance-based method certainly comes with some limitations. Distinctive consumption (Bourdieu 1984) can be a blessing and a curse for the use of social media data and especially tags. On the one hand, distinction and signaling of taste can motivate users to codify their reaction to a piece of art online (Ahas et al. 2015). On the other hand, socially undesired consumption may be hidden from the internet. In the case of last.fm it has been observed that some users engage in "profile work", sometimes by actively omitting traces of them consuming a piece of music from the database. At the same time, some users, however, strive for a certain eclecticism of their recorded taste (Uski & Lampinen 2016).

Furthermore, the population producing digital social data is certainly not representative of the general population, resulting in tagger bias (Lamere 2008). In a publicly available dataset of 583,000 anonymized last.fm users, the mean age is 25.4 years, the median is 24, and the mode is 22. There is also a male bias, as only 23.4 of the users in this dataset declare themselves as female (18.4 did not declare their gender). While the audience is spread over the globe, users from Africa and Asia are underrepresented on last.fm. The greatest penetration levels are found in Northern Europe, the UK, and Australia. It is notable that countries in South America and Eastern Europe have higher penetration levels than Mediterranean countries (Vigliensoni & Fujinaga 2017). Nevertheless, this is still a better sample of opinions on music than could ever have been achieved by a survey or qualitative interviews.

In some rare cases, tag hacking or vandalism was observed. For instance, 90% of the tags used to describe Paris Hilton are malicious, hostile, or humorous misclassifications: of the 3500 users tagging Paris Hilton, 558 people used the tag “brutal death metal” (Lamere 2008). Unfortunately, last.fm no longer reveals data on the number of taggers and the frequency of tags applied to an artist. Hence, as on other websites, it is not possible to trace whether tagging information has indeed been generated by a large number of users. This calls for carefulness when analyzing unpopular artists. Thus, in the papers of this thesis, only artists with at least 1000 listeners on last.fm were included in the analysis.

Finally, using last.fm tagging data for classification of artists active before the establishment of last.fm means that people use today’s terms to describe yesterday’s music. Genres are dynamic and tend to progress through lifecycle-like phases so that the understanding of what constitutes a genre can change over time (Lena & Peterson 2008). But that does not necessarily mean that contemporary witnesses had a better understanding of the pieces of art of their time than observers of today. For instance, the band Black Sabbath, which is commonly understood as one of the founding fathers of Heavy Metal, was described by contemporary music critics as bad copies of the blues acts of the time (Weinstein 2014). As this study intends to reconstruct the evolution of music and music scenes, an example from evolutionary biology can also illustrate how evolution is invisible to the contemporary observer: The emergence of a species from an ancestral species simply cannot be observed by contemporary witnesses, as the changes from generation to generation are too small (Dawkins 2009). Of course, evolution in the arts progresses much faster than in the natural world, but this shows that the observers of the past are not necessarily worse than the observers of the present.

IV PAPERS

To summarize, this thesis sets out to answer four research questions. First, it addresses the more theoretical question of how to differentiate cumulative and combinatorial knowledge dynamics. Second, in order to link knowledge dynamics to forms of path development, it is also necessary to show the relationships of knowledge dynamics on the interactional level of the framework to elements and institutions of economic landscapes. Third, this thesis has a methodological contribution by searching for ways to quantify symbolic knowledge so that knowledge dynamics can be further differentiated.

As shown before (Figure 2.8, page 42), these questions are positioned at different levels of a theoretical framework. Since the different papers of this thesis focus on different research questions, they can also be positioned in the framework according to Figure 4.1. Of course, this does not mean that the papers exclusively deal with these research questions, but depicts their major contribution in the context of this thesis.

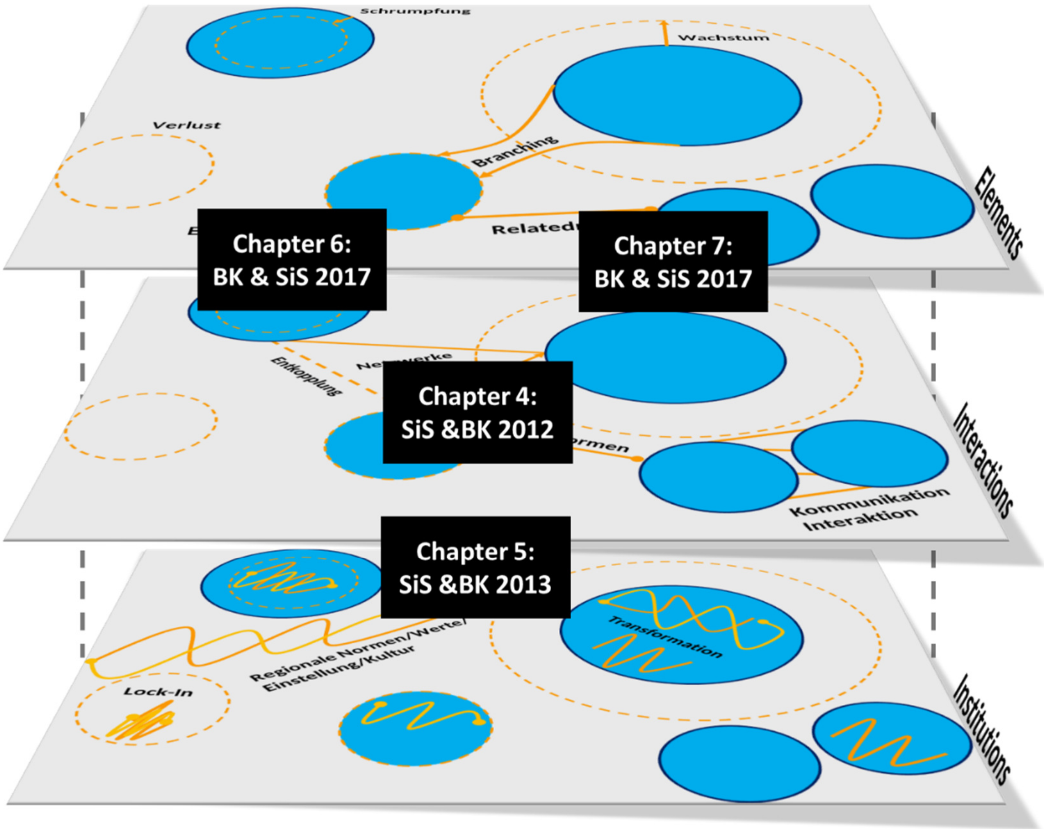


Figure 4.1: Position of the papers in the theoretical framework
Sources: Own figure

Chapter 4, "*Cumulative and Combinatorial Micro-Dynamics of Knowledge: The Role of Space and Place in Knowledge Integration"*, focuses on the differentiation of knowledge dynamics and on their relationship to different types of proximity, and thus is clearly positioned on the interactional level. Thus, it contributes to answering research question 1 on how knowledge dynamics on the micro-level are differentiated. It provides an analysis of 62 case studies conducted in the EURODITE project and explores the geography of different knowledge dynamics. Thereby it shows the interaction of space and place with different knowledge dynamics.

The other papers are positioned at the interfaces of the framework's levels. Chapter 5, "*Exploring plasticity in the development path of the automotive industry in Baden-Württemberg: the role of combinatorial knowledge dynamics"*, focuses on research question 3 and thus takes a more institutional approach, which positions it at the interface of interactions and institutions in the framework. The paper links combinatorial knowledge dynamics to the concept of path plasticity and explores how these knowledge dynamics, in particular, contribute to the dynamics within the path of the automotive industry in Baden-Württemberg. By showing the innovation biography of a media KIBS (knowledge-intensive business service) from the Stuttgart region, it illustrates how organizational routines are transformed by combinatorial knowledge dynamics.

Chapter 6 and chapter 7, however, are both positioned at the interface of elements and interactions of the framework. Here, knowledge dynamics and the evolution of elements of economic landscapes are linked, in different directions respectively. While chapter 6 addresses the question of how the structure of knowledge bases affects knowledge dynamics, chapter 7 analyzes how knowledge dynamics contribute to the creation and change of elements of the economic landscapes. As chapters 6 and 7 analyze symbolic knowledge by the example of music, both contribute to answering research question 4 by using the relatedness approach in the context of symbolic knowledge.

Chapter 6, "*Innovation in Creative Industries: Does (Related) Variety matter for the Creativity of Urban Music Scenes?"*, analyzes the structure of urban music scenes by measures of specialization, average relatedness and folksonomy-based measures of (related) variety. It also provides measures of innovation in music, among others the creation of new combinations of music genres. The study then explores the relationship between the structure and innovativeness of urban music scenes.

Chapter 7, "*How do new Music Genres emerge? Diversification Processes in Symbolic Knowledge Bases*", shows, by the example of new music genres, how new elements in symbolic knowledge bases are created. It does so by exploring how the emergence of new music genres unfolds from processes of accumulation and combination of symbolic knowledge. Furthermore, the study provides insights into the role of local or extralocal knowledge sources for the creation of symbolic knowledge.

As can be seen from these short summaries, these following chapters explore the relationship between knowledge dynamics and path development in different ways. On the one hand, the differentiation of knowledge dynamics is done differently. On the other hand, the empirical material of the papers comes from different sources and contexts. Hence, Table 3.1 gives an overview of the content of four papers that are reprinted, with the kind permission of the respective copyright holders, in the next part IV.

Table 3.1: Overview of the content of chapters 4-7

Chapter	Title	Understanding of knowledge dynamics		Other variables of interests	Empirical Material
		Cumulative KD	Combinatorial KD		
4	Cumulative and Combinatorial Micro-Dynamics of Knowledge: The Role of Space and Place in Knowledge Integration	Knowledge interaction processes involving one knowledge base	Knowledge interaction processes involving two or more knowledge bases	Geography of knowledge dynamics (proximity)	62 qualitative case studies in different industries in different european countries
5	Exploring plasticity in the development path of the automotive industry in Baden-Württemberg: the role of combinatorial knowledge dynamics	Knowledge interaction processes involving one knowledge base	Knowledge interaction processes involving two or more knowledge bases	Organizational and institutional change, path plasticity	2 case studies at the interface between digital media and the automotive industry in Baden-Württemberg
6	Innovation in Creative Industries: Does (Related) Variety matter for the Creativity of Urban Music Scenes?	Accumulation of symbolic knowledge in urban music scenes	Combination of previously separated symbolic knowledge bits	Different forms of Related Variety of symbolic knowlege bases	Database of 8769 artists in the music scenes of 33 cities in North America and Europe
7	How do new Music Genres emerge? Diversification Processes in Symbolic Knowledge Bases	New symbolic knowledge created from accumulated symbolic knowledge in urban music scenes	New symbolic knowledge created from the integration of external, unrelated symbolic knowledge	Related and unrelated diversification in symbolic knowledge bases	Database of 8769 artists in the music scenes of 33 cities in North America and Europe

4 Cumulative and Combinatorial Micro-Dynamics of Knowledge: The Role of Space and Place in Knowledge Integration

SIMONE STRAMBACH & BENJAMIN KLEMENT

(published in: European Planning Studies, volume 20, issue 11, pages 1843-1866, DOI:[10.1080/09654313.2012.723424](https://doi.org/10.1080/09654313.2012.723424)*)*[7]

ABSTRACT. The changing nature of innovation processes is a significant feature of the global structural transformation towards knowledge economies. Much more than in the past, innovation processes require the integration of highly specialized knowledge bases distributed over heterogeneous actors. Hence, we claim that there is a hidden qualitative shift in knowledge dynamics towards combinatorial knowledge. The geography of these knowledge dynamics on the micro-level is at the center of this article. It explores the ways in which space and place shape cumulative and combinatorial knowledge dynamics by proximity economies and the institutional embeddedness of actors and in turn reshape territory and territorial configurations of actors. Knowing more about these interrelations may provide an improved basis for regional policy-making regarding the reform of established institutions and practices.

4.1 Introduction

The changing nature of innovation processes is a significant feature of the global structural transformation towards knowledge economies and knowledge societies. What is widely acknowledged about innovation processes is the growing importance of external knowledge which requires the collaboration of a variety of actors outside the focal firm, located in different technological, sectoral, regional and national contexts. In order to solve complex problems, it is increasingly necessary to integrate highly specialized and distributed knowledge bases. Even though several innovation approaches such as distributed innovation (Coombs 2003), open innovation (Cooke 2005; Chesbrough et al. 2006) and the organizational decomposition of innovation (Schmitz & Strambach 2009)

[7] To improve readability, numbering of sections, tables, and figures has been harmonized with the rest of the thesis. The spelling has been adapted to the American spelling used in the rest of this thesis.

put emphasis on the increasing significance of external knowledge, the underlying knowledge dynamics which form the basis for innovation have so far received little attention. While technology-driven innovation, the growing importance of user involvement (Hippel 2010) and the co-creation of values with customers indicate the increase of non-technological knowledge as a driving force for innovation, the hidden qualitative shift in knowledge dynamics towards "combinatorial knowledge" (Strambach 2011) has not been reflected in more detail in innovation research.

Micro-dynamics of knowledge emerge through the interactions of actors within firms and other organizations or between networks of firms and organizations. Hence, interaction processes among actors are central to the use and creation of knowledge and its transformation into innovation with economic value added. Taking knowledge as the key resource for innovation shifts the focus from the innovation itself to the processes of knowledge creation, using transformation and diffusion—defined as knowledge dynamics (Strambach 2008; Crevoisier & Jeannerat 2009; Halkier et al. 2010). Even though innovation is often an intangible artifact, it can be regarded as the visible result of knowledge dynamics underlying it.

At the center of this article is the geography of micro-knowledge dynamics (MKDs). The production of knowledge is fundamentally grounded in complex social processes, which in turn are embedded and shaped by institutional contexts. Compared with information, knowledge does not flow easily due to its inherent tacit dimension, its process character and context dependency as identified by the theory of knowledge economics (Polanyi 1985; Foray 2004; Nooteboom 2010). The ways in which space and place shape combinatorial knowledge dynamics by proximity economies and the institutional embeddedness of actors and in turn reshape territory and territorial configurations of actors, as a part of the social process, are explored in this article. This is the territorial dimension.

This article aims to deepen the understanding of the modes in which different forms of knowledge dynamics are connected and unfold in time and space in conceptual and empirical terms. Knowing more about these issues may build an improved basis for policy-making. The article is structured in three parts. The first part specifies, from a theory-led perspective, the general understanding of knowledge dynamics, discusses the role of space and place in MKDs and suggests a conceptual distinction between different forms of cumulative and combinatorial dynamics. The second part presents empirical results based on quantitative and qualitative meta-analyses of the European case studies from the Eurodite project, obtained through the construction of knowledge biographies. First, the spatial organization of micro-dynamics of knowledge will be explored; subsequently, the analysis will focus on the ways in which cumulative knowledge bases and place-specific institutional endowments are used in innovative change processes by firms and other economic actors and combined with different types of external and distant knowledge resources.

In section 4.4, these conceptual and empirical results are reflected upon, particularly dealing with policy implications. What do the results regarding the micro-dynamics of combinatorial knowledge imply for policy challenges in terms of reforming established institutions and practices? Can policy make a difference by actively and professionally supporting these complex labor divisions of knowledge production?

4.2 Cumulative and Combinatorial Knowledge Dynamics

The term "knowledge dynamics" is increasingly used in the field of research focusing on "knowledge economics". The concept is applied to the micro-level as well as to the macro-level, focusing on the transformation and shift of knowledge as one of the driving forces for innovations. Knowledge dynamics unfold from processes of the creation, use, transformation and diffusion of knowledge. Even though knowledge is increasingly generated in a more systematic way and transformed into a kind of commodity that can be traded and priced, the production of knowledge is fundamentally grounded in complex social processes. Meeus & Hage (2006) define new knowledge as a function of an existing stock of knowledge plus collective learning. The dynamics of knowledge unfold at the micro-level of actors and through learning, which is by its nature situated within a geographical, social and economic context (Howells 2002: 873).

The Eurodite project investigated knowledge interaction processes related to the creation of innovations in products, services, and processes, which are considered to be the visible results of knowledge dynamics. Drawing on the scientific debate in economic geography, two questions frame this section: How does geography shape knowledge dynamics in general? What can be identified as central characteristics of cumulative and combinatorial knowledge dynamics?

4.2.1 The Role of Space and Place Micro-dynamics of Knowledge

Research on the geography of innovation over the last few decades underlines that innovations are still very unevenly distributed in space, despite the growing international integration of economic activities and the greater mobility of knowledge. Even though there is no comprehensive conceptualization of the ways in which geography influences, and in turn, is influenced by, knowledge and knowledge activities, some useful approaches, especially in the field of economic geography, provide important insights.

Drawing on these strands of literature, two different ways can be identified in which the territorial dimension does play an essential role in knowledge interaction processes: through the mechanism of proximity and through the localized socio-institutional environments built over time in a path-dependent way, often named as “place”. Place and space are the main dimensions that shape micro-dynamics of knowledge lying behind innovation. As Feldman & Kogler (2010) point out, places are not equal and are defined by evolutionary processes. For a long time, it has been stressed that external economies resulting from the concentration of economic activities in space are important mechanisms for the generation of place-specific advantages. In particular, agglomeration economies such as urbanization, location and diversity economies are emphasized. In the case of urbanization economies, it is argued that diversity and variety foster cross-fertilization of knowledge and technology between diverse industrial sectors, leading to differentiation and transformation and inequalities of places. In the case of localization economies, it is stressed that firms belonging to the same industry can benefit from being concentrated in space through supplier linkages and a pool of skilled labor force (Capello 2009; Feldman & Kogler 2010). The high degree of specialization facilitates knowledge spillovers and technological learning among firms. The analytical unit of these approaches is the macro-level of the economic landscape, and even though it is still an open question whether diversity or specialization matters more for place-specific advantages, these approaches underline the importance of proximity for learning processes.

Particularly with regard to interactive learning processes and knowledge exchange, the social and institutional context can be considered as an enabling and supportive factor (Lundvall 1992; Edquist 2005). Several approaches, such as the concept of “embeddedness” and the localized learning approach (Malmberg & Maskell 2006) as well as territorial innovation models (Moulaert & Sekia 2003), argue that the institutional characteristics of a territory, which have formed over time, provide place-specific resources for firms and organizations. The local institutional environment is considered to be an important determinant of innovation and knowledge processes. Scholars argue for the significance of being situated in a common institutional setting that is necessary to benefit from localized knowledge bases and localized capabilities. As Gertler (2003) stresses, the geography of tacit knowledge, in particular, cannot be understood without considering the institutional foundation of economic activities. By "being there" actors embedded in these specific geographical contexts can exploit and use localized knowledge. Furthermore, the local presence enables firms to participate and benefit from local "buzz", understood as localized, highly specialized and tacit knowledge by the means of frequent opportunities for face-to-face interactions and unanticipated encounters (Bathelt et al. 2004; Storper & Venables 2004). Processes of assimilating and exploiting external localized knowledge are heavily determined on both the individual and the organizational levels by prior knowledge and the absorptive capacity of the respective actors (Cohen & Levinthal 1990). Additionally, recent research provides more detailed evidence that the importance of participating in the local buzz in learning and innovation also varies at the level of industries, differentiated by the predominating knowledge bases of the industry (Asheim et al. 2007).

Recent debates question whether local knowledge interaction is the only source of innovative dynamism for firms (Bathelt et al. 2004; Gertler & Levitte 2005; Torre 2008) and put emphasis on the non-local and international networks and relationships as critically important sources. The establishment of global "pipelines" (Bathelt et al. 2004) to international knowledge bases offers firms the opportunity to tap spatially distributed competencies. Access to extralocal knowledge requires long-distance learning, which appears to be more difficult to achieve. Research findings point to the existence of trade-offs and a distance decay effect in knowledge transfer (Howells 2002; Malmberg & Maskell 2006). Under what conditions learning and joint knowledge production by distanciated actors is facilitated or hindered is not fully explored.

In economic geography, it is widely acknowledged that spatial proximity facilitates knowledge spillovers and knowledge exchange, in particular when the knowledge being produced and exchanged is highly specialized and has a strong tacit component or is highly novel and economically very valuable (Howells 2002; Gertler 2003). However, it is not the physical proximity per se which is necessary for interactive learning and knowledge sharing among actors. It is the intersection with other forms of non-geographical proximities, such as cognitive, organizational, social and institutional proximities, which is crucial to reduce uncertainty and foster interactive learning (Boschma 2005). Understanding knowledge as a socially constructed outcome of interactive learning processes, communication and mutual understanding among the actors plays a decisive role in new knowledge generation. Actors in geographical proximity often share the same culture, the same institutional environment and social practices which create a certain degree of cognitive proximity, the basis for effective communication and mutual understanding. Malmberg & Maskell (2006: 11) point to neighborhood effects that will always, in an almost automatic way, create a degree of overlap between spatial proximity and other forms of proximity.

In summary, the impact of geographical proximity is not always direct, but often indirect, subtle and varied (Howells 2002: 874). It is the interconnectedness of spatial and non-spatial forms of proximity that provide a rich source of what Gertler (2008) named "social affinities" which essentially affects interactive learning and knowledge integration. Actors located in the same national or regional institutional context or working in the same industry or organization share institutions such as conventions, norms, and values that reduce cognitive distance (Nooteboom 2010) and in turn facilitate the building of a common understanding—the basis for new knowledge creation. Geographical proximity alone seems to be an insufficient basis for supporting knowledge dynamics.

4.2.2 The Characteristics of Cumulative and Combinatorial Knowledge Dynamics

Drawing on the literature on knowledge economics, three factors that affect knowledge dynamics in a generic way become obvious: the specific knowledge base of agents, their competencies or capabilities (Malerba & Orsenigo 2000; Dosi et al. 2008) and the context in which these processes take place (Strambach 2008). However, by arguing that a qualitative shift in modes of knowledge dynamics is underway (Crevoisier & Jeannerat 2009; Halkier et al. 2010), we suggest that a more detailed conceptual differentiation of cumulative and combinatorial knowledge dynamics is required in order to facilitate the empirical investigation.

The cumulativeness of knowledge means the degree to which the generation of new knowledge builds upon current and existing knowledge (Malerba & Orsenigo 2000: 290;

Antonelli 2005: 230). It is pointed out on several analytical levels — ranging from the individual to nation states — that cumulativeness determines knowledge production. The time dimension and path-dependent developments are important for the specific profile of cumulative knowledge bases. At the micro-level of firms, substantial research based on organizational theories or industrial dynamics has shown that cumulative knowledge provides options to expand in new but uncertain markets in the future. What an organization has done before tends to predict the type and direction of innovation processes as well as the ability to absorb new knowledge (Cohen & Levinthal 1990; Kogut & Zander 1992; Patel & Pavitt 1997). Knowledge creation and firms' modes of innovation are strongly shaped by their specific cumulative knowledge base(s). Furthermore, recent research using the SAS (synthetic, analytical and symbolic) typology of knowledge bases shows that they shape modes of knowledge creation processes significantly (Asheim & Gertler 2005; Asheim 2007, 2007; Manniche 2012).

"Cumulative knowledge dynamics" are characterized by a certain continuity caused by the co-evolution of institutions and complementary institutional arrangements. The selective and stabilizing functions of institutions reduce uncertainty for actors involved in innovative learning processes and, by definition, uncertain situations regarding the outcome. They contribute to competence-building and knowledge accumulation over time. Substantial theoretical and empirical insights exist in cumulative knowledge dynamics and their mechanisms and processes of path dependency. Organizational routines and organizational capabilities are essential institutions that coordinate and integrate knowledge use and exploration processes among individuals and communities at the firm level (Nelson & Winter 1982; Dosi et al. 2008; Teece 2010).

Organizational routines and competencies reflect territorial forces that shape firms' routines and competencies. The knowledge- and competence-based theory of the firm (Kogut & Zander 1992; Nonaka & Takeuchi 1995; Teece et al. 1997) recognizes the weight of path dependencies of knowledge and organizational practice inherited from the past. Economic geography points in the same direction by showing the interaction between firms and territory through the institutional and relational embeddedness of firms over time. Apart from the market, the corporate environment plays an essential role in knowledge production. The importance of time and historicity in economic decision-making is deeply embedded in the knowledge- and competence-based view of the firm, as reflected in the idea of organizational paths. Organizational routines are based on localized learning processes, which can explain why they cannot easily be replicated and transferred to other contexts (Teece 2010).

Based on the changing nature of innovation processes in the emerging knowledge economies, the EURODITE project assumed an ongoing qualitative shift in modes of knowledge dynamics characterized by an increase in combinatorial forms (Crevoisier & Jeannerat 2009; Halkier et al. 2010; Strambach 2010a). "Combinatorial knowledge dynamics" come into existence by the unification of originally separated knowledge bases located in distinct institutional environments (Table 4.1). Apart from technological developments, the driver of an increasingly important role for combinatorial knowledge dynamics at the level of the firm seems to be the ongoing restructuring of global value chains, accompanied by modifications in the organization of innovation. There has been a shift to more open innovation environments (Chesbrough 2006) and the importance of knowledge external to the firm in innovation processes has become more obvious in recent years.

While the vertical disintegration of production has been going on for a long time, leading to pronounced global production networks (Coe et al. 2008), more recent developments are the outsourcing and offshoring of intangible business processes and knowledge-intensive service activities (Miozzo & Grimshaw 2005). As the internationalization of R&D activities proves (Guinet et al. 2008), the process of knowledge production itself is affected by shifts towards modularization, standardization, and externalization.

Table 4.1: Characteristics of cumulative and combinatorial knowledge dynamics

Dimension	Cumulative knowledge dynamics	Combinatorial knowledge dynamics
Actors		
Heterogeneity in actor constellation	Low	High
Cognitive distance	Low	High
Institutional overlaps	High	Low
Interaction process		
Existing knowledge base(s)	Broaden/deepen	Unification with others
Variety of contexts to be integrated	Low	High
Investment in mutual understanding	Low	High
Bridging of organizational, technological and sectoral interfaces	Low	High
Time		
Expected outcome	Nearer in time	Distant in time

Sources: Own draft

4.2.2 The Characteristics of Cumulative and Combinatorial Knowledge Dynamics

These processes have led to the further fragmentation and expansion of value chains affecting sector-specific knowledge, as well as generic knowledge about business functions such as marketing, human resource management, and sales. The restructuring of value chains is increasing the complexity of vertical and horizontal knowledge domains related to sectors and business functions. It generates new distance – proximity relations in both organizational and spatial terms. The dynamic growth of knowledge-intensive business services (KIBS) appears to be closely connected with the rising need for combinatorial knowledge. Research on KIBS has provided substantial theoretical and empirical evidence that the knowledge products of these firms contribute in an essential way to knowledge dynamics in firms, sectors and territorial contexts (Strambach, 2008).

Having defined the unification of originally separated knowledge bases located in distinct institutional environments as a key feature of the emergence of combinatorial knowledge creation processes, it follows that both a high degree of cognitive diversity and a low level of common knowledge between the actors are characteristic attributes of combinatorial knowledge production (Table 4.1). Such constellations make it difficult for firms to develop organizational routines. As research on the knowledge-based theory of the firm points out, the efficiency of knowledge integration is influenced by the level of common knowledge and the frequency and variability of the activity and the structure, which economizes on communication (Kogut & Zander 1992; Grant 1996). The wider the span of knowledge being integrated, the more complex the creation and management of organizational capabilities. Knowledge integration and the development of governance structures are much more complex in combinatorial knowledge production crossing several organizational, technological, sectoral and value chain interfaces.

While overlapping institutional contexts, present in cumulative knowledge production, facilitate the integration of knowledge by providing a level of common knowledge based on the intersection of different types of proximities such as organizational, technological and sectoral, combinatorial knowledge production to a large extent lacks such focusing mechanisms. Actors coming from a variety of backgrounds have to cope with many different technological, organizational and institutional interfaces in order to explore complementarities of originally separated knowledge stocks. The plasticity of institutions, that is, their interpretive flexibility (Strambach 2010c), and a low degree of institutional coherence open up a wide space for interpretations and perceptions. In turn, the need for complex communication processes to convert the variety of different actors' meanings into shared views is generated. In order to bridge the diverse interfaces and develop a common knowledge base that supports decision-making and choice in the course of the innovation process, actors must invest in establishing mutual understanding, for example, by rearranging organizational routines and practices, transferring institutions to different contexts and reinterpreting these for new purposes. Hence, we assume, based on the theoretical reasoning given above, that dynamic institutional transformation and changes are some less obvious features of combinatorial knowledge production.

4.3 Micro-Dynamics of Knowledge: Empirical Insights into Their Spatial Organization

4.3.1 Methodology

The EURODITE project followed the methodological approach of the grounded theory (Glaser & Strauss 1967) in its qualitative research by gaining, in an inductive way, new insights into knowledge dynamics of innovation. It was intended to derive theory from the empirical material rather than from testing existing theories. The methodological instrument of knowledge biographies was developed and used throughout the project to explore how complex knowledge dynamics of innovative change processes unfold in space and time. One of the main advantages of this biographical method is to grasp the dynamism without being limited to a certain territory (for detailed information on the instrument of knowledge biographies, see Butzin & Widmaier 2010). Knowledge interactions can be mapped regardless of geographical or sectoral scales. By tracing back an innovation event in its biographical development, the instrument concentrates on the distributed knowledge activities and tries to understand how the internal knowledge of actors is related to the various sources of external knowledge located at different scales and their evolution over time. It uses secondary research and a combination of different types of qualitative interviews connected with a snowball sampling strategy to investigate the sequences and distributed knowledge activities of innovation events.

In total, 62 case studies (comprising one innovation event, respectively) were analyzed using the empirical instrument of knowledge biographies. "EURODITE" investigated innovation events at the firm level in seven sectors: food & drink; automotive; biotechnology; information and communication technology (ICT); KIBS; new media and tourism in 22 European regions. In summary, 693 knowledge interaction processes form the foundation of the empirical findings reported here. Knowledge interaction processes are hereby defined as knowledge-using, -transforming and -creating processes occurring in the interactions of several actors during an innovation event.

The empirical meta-analysis reported in this article has an explorative nature and uses quantitative and qualitative methods. The data sources comprise the written reports on the firm-level case studies and the quantitative data of the timeline reports which were generated within EURODITE. The latter contain basic information on the knowledge interaction processes in the course of every innovation event. The actors, including their spatial and sectoral locations, and the knowledge types were noted in a systematic manner by each of the different research teams. These data were modified and supplemented for data processing. Additionally, the written knowledge biographies were analyzed in depth by means of a qualitative content analysis. The main objective of such a method is to keep the advantages of quantitative content analysis and to transfer and further develop them to qualitative – interpretative steps of analysis (Mayring 2000: 1). Central to the qualitative analysis is the use of categories deductively or inductively built to identify text passages that are relevant to the analysis. While the material was examined mainly by deductive theory-led coding, it was supplemented by inductive codes, formulated directly out of the material. Such a proceeding increased the openness and flexibility to grasp and discover new aspects which had not been considered theoretically previously.

There are, of course, also drawbacks to approaching innovation processes by qualitative analysis. First of all, the empirical findings may be of limited representativeness due to the relatively small number of analyzed cases, the idiosyncrasy of innovation processes and the limited, possibly arbitrary selection of cases. The international nature of the research project means that empirical material from many cultural contexts was collected by several researcher teams from a variety of (research) cultures and disciplines. Even though the cultural distance between researchers and interview partners was rather low, the transfer of empirical material throughout the research consortium across language barriers and cultural contexts was subject to individual interpretations of the researchers (cf. Zalan & Lewis 2004).

In the following empirical analysis, we will try to shed some light on the role of space and place in cumulative and combinatorial knowledge dynamics by addressing two questions: How are knowledge dynamics of both types spatially organized in the labor division of knowledge production? How do both types of knowledge dynamics shape place specificities or vice versa by relating to institutional change to different extents?

4.3.2 Multi-scalarity and Proximity in Knowledge Dynamics

Regarding the spatial organization of knowledge dynamics, economic geographers have emphasized the significance of local and regional relations and interactions in the last 20 years. However, as Amin (1998) and Dicken & Malmberg (2001) pointed out, focusing on one spatial scale cannot sufficiently describe and explain innovation processes. Similarly, our analysis found that the debate on the global-local dichotomy falls short of the complexity of knowledge interactions over time in innovative change. It is rarely the case that knowledge dynamics unfold exclusively at one spatial scale. Instead, knowledge interactions involve local, regional, national and international actors in mixed patterns of interactions at close and great distances, which cannot be assigned to a particular phase of the innovation process. Hence, they can be described as “multi-scalar” (see Crevoisier & Jeannerat 2009). In the following sections, we analyze interaction processes related to knowledge creation in innovation events.

In order to shed light on the significance of spatial proximity in innovation processes, Table 4.2 provides an overview of all 693 knowledge interactions analyzed in the case studies of the Eurodite project. They are assigned, on the one hand, to the sector in which the corresponding innovation event took place and, on the other hand, to the type(s) of knowledge involved. Furthermore, in

Table 4.3, we distinguish between proximal knowledge interaction (PKI) processes at the regional and national scales and distant knowledge interaction (DKI) processes crossing national borders. While PKI processes represent knowledge integration processes within the same institutional context, DKI processes stand for distanciated learning processes. For instance, in the automotive sector, of all the knowledge interaction processes concerning synthetic knowledge, 91% took place as PKI processes (second row and third column). To distinguish knowledge types, we applied the SAS typology used throughout the whole Eurodite project. The SAS typology states that analytical knowledge, synthetic knowledge, and symbolic knowledge differ in the learning processes through which they are created and the criteria used in their evaluation (Manniche 2012). One major implication of this typology is that different types of knowledge are characterized by a distinct mix of codified knowledge and tacit knowledge and are hence differently sensitive to distance in learning processes. The predominating knowledge types of the sector can be derived from Table 4.2 and Table 4.3.

First of all, Table 4.2 reveals that combinations of knowledge types occur rather rarely, only amounting to 20% of all knowledge interaction processes. Furthermore, the dominating knowledge bases of the sectors (according to Asheim 2007) are also reflected in the respective shares of knowledge types involved. Hence, cumulative knowledge dynamics still play a great role in innovation processes.

Table 4.2: Overview of knowledge interactions in innovation events

		Knowledge types						Combinations of knowledge types					
		Analytical (1)		Synthetic (2)		Symbolic (3)		Ana + Syn (1,2)		Syn + Sym (2,3)		A/S/S (1,2,3)	
Sector	Total No.	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Automotive	89	12	13	57	64	12	13	4	4	4	4	0	0
Biotechnology	145	35	24	26	18	26	18	21	14	37	26	0	0
Food & drink	78	10	13	32	41	29	37	3	4	4	5	0	0
ICT	87	9	10	47	54	4	5	27	31	0	0	0	0
KIBS	66	0	0	58	88	2	3	0	0	6	9	0	0
New media	57	8	14	8	14	30	53	0	0	9	16	2	4
Tourism	171	0	0	17	10	130	76	0	0	24	14	0	0
All sectors	693	74	11	245	35	233	34	55	8	84	12	2	0

Sources: Case studies conducted in the EURODITE project

4.3.2 Multi-scalarity and Proximity in Knowledge Dynamics

Table 4.3: Spatial organization of cumulative and combinatorial knowledge dynamics

	Knowledge types													
	All		Analytical (1)		Synthetic (2)		Symbolic (3)		An./Syn. (1,2)		Syn./Sym. (2,3)		A/S/S (1,2,3)	
Sectors	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
All sectors														
PKI	541	78	53	72	188	77	189	81	38	69	72	86	1	50
DKI	152	22	21	28	57	23	44	19	17	31	12	14	1	50
Automotive														
PKI	76	85	11	92	52	91	7	58	4	100	2	50	0	0
DKI	13	15	1	8	5	9	5	42	0	0	2	50	0	0
Biotechnology														
PKI	102	70	23	66	11	42	20	77	15	71	33	89	0	0
DKI	43	30	12	34	15	58	6	23	6	29	4	11	0	0
Food & drink														
PKI	64	82	7	70	28	88	25	86	2	67	2	50	0	0
DKI	14	18	3	30	4	13	4	14	1	33	2	50	0	0
ICT														
PKI	55	63	8	89	27	57	3	75	17	63	0		0	0
DKI	32	37	1	11	20	43	1	25	10	37	0		0	0
KIBS														
PKI	55	83	0	0	48	83	2	100	0	0	5	83	0	0
DKI	11	17	0	0	10	17	0	0	0	0	1	17	0	0
New media														
PKI	38	67	4	50	7	88	18	60	0	0	8	89	1	50
DKI	19	33	4	50	1	13	12	40	0	0	1	11	1	50
Tourism														
PKI	151	88	0	0	15	88	114	88	0	0	22	92	0	0
DKI	20	12	0	0	2	12	16	12	0	0	2	8	0	0

Sources: Case studies conducted in the EURODITE project

However, there are some exceptions in the biotechnology, ICT, and food & drink sectors. Here, knowledge interaction processes are more widely spread across different knowledge types than, for instance, in the KIBS sector. The biotechnology and ICT sectors are also rather strong regarding the combination of different knowledge types. Finally, it has to be acknowledged that there are hardly any knowledge interaction processes involving all three knowledge types together. Considering combinatorial knowledge dynamics as knowledge interaction processes combining knowledge types or integrating knowledge types outside the dominating knowledge base of a sector, these figures show that, especially in the biotechnology, food & drink and ICT sectors, the combination of knowledge types has become more important. Symbolic knowledge, in particular, appears to contribute a lot to the innovation processes, not only in those sectors dominated by a symbolic knowledge base (such as tourism or new media), but also in those sectors usually depicted as analytical or synthetic industries, such as biotechnology or food & drink (Asheim 2007).

Considering spatial organization, the quantitative empirical findings show that PKIs on the regional and national scales outnumber DKIs crossing national borders. As only a fifth of the knowledge interactions in all sectors are distant ones (second row in the first column,

Table 4.3), the mobilization of knowledge at the regional/national scale remains a major feature of firm knowledge dynamics. The empirical findings indicate that spatial proximity is apparently related to various other types of proximities, as suggested by Boschma (2005). Even though various innovations in communication technology facilitate the coordination of innovation processes at a distance, the focal organizations prefer to enter into proximal relationships with actors located in the same institutional setting of the region or nation. It might, therefore, be assumed that entering DKIs leads to a trade-off between higher coordination costs and the expected value of the distant knowledge, while institutional proximity facilitates the sharing and integration of knowledge.

Most interesting, however, is the finding that among all cases there was no single innovation biography which took place exclusively at the regional scale. Apparently, the geographical proximity of actors is an important but not sufficient mechanism supporting joint knowledge creation and sharing. Even though “DKIs” are smaller in numbers, their importance should not be underestimated. Instead, crossing the borders of the home region or nation for knowledge interaction is often motivated by the search for specific knowledge which is unavailable in the home region yet necessary for the innovation process to be conducted.

The SAS typology (see Asheim & Gertler 2005; Asheim 2007) suggests that the learning processes in sectors dominated by different knowledge types show different sensitivities towards geographical space. In fact, the findings across all sectors show that synthetic knowledge and symbolic knowledge are more sensitive to geographical distance than analytical knowledge. Similarly, those sectors associated with analytical knowledge, such as the biotechnology, ICT and the new media sectors (in this analysis rather software related), showed a relatively higher share of knowledge interaction processes over distance. Apparently, analytical knowledge and combinations of analytical knowledge and synthetic knowledge are able to “travel” more due to their codified nature. Synthetic knowledge and symbolic knowledge, however, are more rooted in cultural and institutional contexts, hence more difficult to be involved in distanciated learning (Asheim 2007).

Table 4.4: Sector-specific spatial organization of cumulative and combinatorial knowledge dynamics

Knowledge dynamics	Spatial organization	
	Proximal	Distant
Cumulative	Automotive, food & drink, KIBS and tourism	Biotechnology, ICT and new media
Combinatorial	Food & drink, KIBS, new media and tourism	Automotive, biotechnology and ICT

Sources: Case studies conducted in the EURODITE project

The empirical results at the sectoral level point to sector-specific modes of sourcing different knowledge types. Table 4.4 summarizes the findings and classifies sectors according to the spatial organization of their cumulative and combinatorial knowledge dynamics. Thus, cumulative knowledge dynamics comprise knowledge interactions involving the dominating knowledge type of the sectoral knowledge base. The categories "proximal" and "distant" should be understood as relative to the spatial organization across all sectors. For instance, in the automotive industry, synthetic knowledge is rather involved in PKI processes, whereas the integration of symbolic knowledge occurs relatively often in DKI processes. In the biotechnology industry, however, cumulative and combinatorial knowledge dynamics occur relatively often in DKI processes.

This leads to one of the main empirical findings of this contribution, presented in Table 4.4: while cumulative and combinatorial knowledge dynamics possess distinct characteristics, as set out in the previous section, mainly associated with cognitive distance between actors, it is rather difficult to clearly determine distinct differences in the spatial organization of both types of knowledge dynamics. Hence, combinatorial knowledge dynamics are not necessarily associated with spatially DKI processes, as one may intuitively think. In fact, there are sectoral specificities in the spatial organization of cumulative and combinatorial knowledge dynamics. For instance, in the food & drink, KIBS and tourism sectors, cumulative and combinatorial knowledge dynamics occur predominantly in PKI processes (compared with the shares of PKIs and DKIs across all sectors). In the biotechnology and ICT sectors, by contrast, cumulative and combinatorial knowledge dynamics tend to take place in distant interaction processes. Thus, different predominating knowledge bases may lead to different sensitivities of learning processes to geographical distance: the knowledge in the biotechnology and ICT sectors is suggested to be highly codifiable so that distanciated learning is facilitated.

Yet, there are also two sectors in which the spatial organization of both types of knowledge dynamics is contradictory: in the new media sector, which comprised many games software innovations in the sample, a relatively high share of cumulative knowledge dynamics take place in DKI processes, whereas combinatorial knowledge dynamics, by contrast, require proximity between actors. The automotive sector shows a different picture: here, cumulative knowledge dynamics occur through proximal interactions, whereas combinatorial knowledge dynamics take place through distanciated knowledge interaction processes. Another explanation may be provided by the context sensitivity of symbolic knowledge. In order to gain access to symbolic knowledge linked to distant contexts, for instance, to adapt cars or video games to preferences of foreign consumers, entering DKIs appears to be required.

Apparently, the sectoral domain still plays an important role in the integration of knowledge of various actors. Although it is thought that sectoral boundaries are becoming blurred, specific institutional settings still coordinate knowledge integration in learning processes. For instance, institutions and routines of the automotive sector (especially its original equipment manufacturers (OEMs)) have a worldwide reach, influencing the integration of actors in innovation processes on a global scale.

4.3.3 Insights from Qualitative Case-study Analysis: The Time Dimension

In addition to the quantitative meta-analysis of the case studies presented above, analyzing the case-study knowledge biographies allowed us to explore the time dimension in the analysis. The mere existence of PKIs and DKIs is not sufficient evidence to assume the multi-scalarity of innovation processes. The knowledge biographies showed not only that both proximal interactions and DKIs are apparently present in knowledge dynamics, but also that they are not separated in the course of the innovation event. One cannot identify particular phases of the innovation process that are only characterized by proximal or distant relationships. In many phases, knowledge interactions at more than one spatial scale are interwoven at the same time (Strambach & Stockhorst 2010). Furthermore, knowledge dynamics do not appear to develop in a linear way, for example, from proximal to distant relations. In cases such as the establishment of a research center in Lower Saxony, the knowledge creation process at no time included actors located in international territories (Blöcker & Jürgens 2009). Another case, however, describing a service product development in a software KIBS in

Bratislava, involved international actors right from the beginning (Rehák et al. 2009). In view of this, it seems that numerous factors influence and shape the actual course of the knowledge creation process. Knowledge dynamics, therefore, appear to be a rather idiosyncratic development. The reasons for this are that the territorial dimension very much depends on the types of actors and individuals who are involved, the quality of their relationships and the degree to which they are able to contribute with their cumulative knowledge base to a given innovation event.

A notable finding is that creating "temporary geographical proximity was a strategy to gain" short-term access to distant knowledge. In particular, one of the Turkish cases provides a demonstrative example. The knowledge interactions of two service innovation processes in the tourism sector of Antalya had a strikingly strong emphasis on distant relationships. In this example (Dulupçu et al. 2009), a tour operator developed a tourism concept focusing on professional training camps. Offers specially designed for football clubs from Eastern Europe were developed. In order to figure out the requirements of such a service product, the firm's head searched for very specific knowledge and therefore visited places where similar concepts already existed (e.g. Spain and Cyprus). What comes to light here is that temporary proximity was used in order to transfer very specific knowledge from sources distant to the focal actor's location. Temporary geographical proximity seems to be an enabling factor because in this case mainly codified knowledge was needed for a relatively clear purpose. To acquire it, the actor had to take the knowledge out of the context (decontextualization) he found abroad and, as a second step, needed to adapt this knowledge to the conditions in Antalya (recontextualization).

4.3.4 Place Specificities and the Organization of Knowledge Dynamics

Place specificities, as well as space, affect the micro-dynamics of knowledge. Even in the globalizing knowledge-based economy characterized by a higher mobility of knowledge (cf. Crevoisier & Jeannerat 2009), innovations are still spatially concentrated. Some places in Europe are much more dynamic than others. Additionally, the same industrial sectors show different economic performance in different places. Hence, in the following, we will elaborate on the ways processes of knowledge integration shape place specificities and vice versa.

4.3.4 Place Specificities and the Organization of Knowledge Dynamics

Knowledge integration processes shaping place specificities. A fundamental point is made from an evolutionary perspective by stressing the mechanism of path dependency and the complex co-evolution of different economic, technological, institutional and socio-cultural arenas leading to place-specific environments (Martin & Sunley 2006; Boschma & Martin 2010b). Cumulative knowledge bases are embedded in overlapping sets of interrelated industries and place-specific institution-building over time. The most frequently used aggregated secondary data in research on agglomeration economies cover both the place-specific economic and institutional environment and the innovation process only to a very limited extent, even though the findings could be statistically significant. By investigating the organization of knowledge dynamics with the qualitative in-depth biographical method, EURODITE provides empirical insights into the way knowledge dynamics shape territories as a part of the social learning processes.

Time turned out to be an essential dimension to understand business interactions leading to innovation at the micro-level, due to the fact that time defines the nature of interaction as a process in which sequential events are related to each other. The empirical findings indicate that previous interactions and future expectations of the firms and organizations involved in innovation events influence each other profoundly and, therefore, the output of the knowledge interaction processes.

Following the knowledge biographies in European regions in time and space, organizational and institutional changes are significant features of combinatorial knowledge dynamics. In many cases, new organizational forms which did not exist before the innovation event emerged and reshaped the territory and territorial configurations of actors as a part of the social process. Comparing the empirical cases across the different regional and sector contexts, three distinct kinds of new organizational forms could be identified: firm internal restructuring processes, the building of new networks and the foundation of new organizational bodies with their own strategic goals and with the ability to operate independently.

To combine specialized accumulated knowledge bases in order to exploit these for new purposes, internal resources and capacities of firms often had to be rearranged. Organizational change and the establishment of new organizational units, represented by "internal restructuring processes" (e.g. departments), within the boundaries of a firm itself could be observed in all sector contexts. In the case of the automotive industry in Lower Saxony, the development of a new steering system by an OEM required the foundation of a new technical development division to integrate several cumulative knowledge bases inside and outside the corporation, spread over heterogeneous actors (Blöcker & Jürgens 2009). Two case studies in Bratislava show that for globally operating KIBS, the establishment of new departments was an important basis to explore and exploit knowledge complementarities spatially and functionally distributed within the corporations (Rehák et al. 2009). In Slovakia, information security was not a major issue for a relatively long period of time. Due to change in the regulatory framework, the government adopted important laws such as the "Act on personal data protection" in 2002. Consequently, the demand for technical solutions rose significantly and multinational KIBS discovered the potential market openings. To create new generic solutions in the field of information and personal data security, de-contextualized, cumulative, experience-based knowledge, gained in former client projects in other countries and regions, had to be combined and integrated for new purposes. Knowledge sharing and the combination of different kinds of competences occurred in complex learning processes within diverse "knowledge communities" (Gertler 2008; Nooteboom 2008) in several places in Europe through organized temporary proximity. For the product innovations, in both cases, the co-evolving organizational change in the form of new department-building was an important means for the anchoring of available intra-organizational knowledge bases and their combination with external localized competences.

The findings also highlight "new networks" as an important type of organizational structures which emerged in the course of knowledge dynamics where each member to a large extent remained independent from the others. Firms and organizations were enabled to exploit parts of their respective knowledge resources for innovative problem solutions within networks of new actor constellations. For example, in the case of a development of a tourism route in Southern Sweden, different regional municipalities and museums built up a cooperative network in order to share complementary knowledge and to develop different attractions and places of interest (Dahlström et al. 2010). Furthermore, in the tourism case in Antalya, new cooperation networks which participate in the new service product development of a professional football camp were established among hotels (Dulupçu et al. 2009). Crucial for the building of new networks seems to be the fact that the actors have overlapping interests, sufficient cognitive proximity and a common understanding of the objective and economic value of the future cooperative outcome. These conditions appear to constitute a level of certainty which allows for a form of organization with loose coupling that is sufficient to integrate the knowledge bases. Ensuring that these conditions are fulfilled may thus be a mission for (regional) policy to be undertaken in fostering combinatorial knowledge dynamics.

Moreover, organizational change in the form of the establishment of "new organizational bodies" over time with their own strategic goals and with the ability to operate independently could be observed as an important mechanism for knowledge combination and integration. In cases where the expected outcome was nearer in time, it seemed much easier to sustain the organizational form of networks as a governance structure over the knowledge dynamics. However, diverse actors often started with decentralized networks. Later in time, these loose relations were integrated into a private limited company or a semi-public organization. In several cases, it could be observed that the establishment of organizational proximity was important for an intensified knowledge exchange in many firm-level knowledge dynamics. Taking the development of a new service product—a football route in the Ruhr Area—as an example (Butzin & Widmaier 2009), it can be concluded that the initial phases of the development have mainly been driven by one individual—the inventor of the concept. Involving many different partners from within the region (universities, KIBS, municipalities, etc.), this person was able to establish a network mostly using personal contacts to actors he knew from previous interactions. However, at a later stage, this situation had changed and a more cohesive organizational framework was needed in order to carry out further knowledge activities such as product development and marketing. Also in other sectors, such as automotive, new organizational bodies were established over time. In Lower Saxony (Blöcker & Jürgens 2009), diverse actors from universities and the automotive industry started with loose cooperation and in a later stage established a new research center for vehicle technology. A formal organization was decisive to create a platform for the integration of specialized cumulative knowledge of research organizations, universities and firms and to motivate them to use their expertise for a new purpose.

From the case studies, it can be concluded that the foundation of a formal organization, operating as a collective actor for the partners and equipped with resources, contributes to a closer coupling, reinforces the commitment and enhances trust-building, which is the basis for further knowledge sharing. However, this is the visible outcome of complex communication processes within the diverse "knowledge communities" over time. In these often time-consuming processes, knowledge exchange and sense-making take place. On a more abstract level, the partners define implicitly and explicitly their organizational routines regarding as to how to proceed and structure the uncertain innovative change process. A commonly agreed organizational framework can, therefore, be regarded as a prerequisite for trust-building and knowledge integration, especially in cases where actors fear the loss of knowledge or usually encounter each other as potential competitors in the field of new knowledge creation.

The knowledge biographies provide a great deal of empirical evidence that firm-level knowledge dynamics themselves reshape the territorial configuration of economies by creating new forms of organization as part of the innovation process. Yet place specificities may also shape the organization of cumulative and combinatorial knowledge dynamics. Hence, the following section provides a brief overview of the ways important place-specific actors (universities/research institutes and political actors) shape knowledge integration processes.

Place specificities shaping knowledge integration. Among the more important external actors at the local scale are "universities and research institutes". They function as producers of specific knowledge modules, often in combinatorial knowledge dynamics, or as providers of timely, accessible human resources. Distinct sector differences are obvious in the scope and role of universities in knowledge dynamics, as well as in the modes of knowledge interaction. In the tourism sector, the interaction mode between firms and universities can be typified as "mostly one-off", while the mode of knowledge interaction in an institutionalized mode on the "continuous basis of a formal organization" is more pronounced in the automotive industry. In the KIBS sector, however, the interaction mode can be labeled as "flexibly institutionalized" on the basis of informal personal relationships.

In the tourism sector, the participation of universities and research institutes is characterized by their temporary involvement: during the change process, universities produced a specified knowledge module. In the case of the establishment of a specialized tourism route in North Rhine-Westphalia (Butzin & Widmaier 2009), the business model was developed by a regional business school, while in the case concerning the creation of a high-quality tourist destination in Antalya, the university was helpful in providing specialized training of human resources (Dulupçu et al. 2009).

In the automotive industry, however, knowledge interactions with universities and research institutes are rather institutionalized. On the basis of formal organizations, such as established research centers or formal networks, firms and universities are continuously engaged in knowledge creation in a specific composite knowledge domain. The automotive industry is a multi-technology industry and the compositeness of knowledge, understood as the bringing together of different originally separated technological knowledge units (Antonelli & Calderini 2008), is an important feature for innovation in that industry operating in markets characterized by continuous technological change (see Antonelli & Calderini 2008; Jürgens et al. 2010). This fact became very obvious in the case studies, in which universities and research organizations were an important part of combinatorial knowledge dynamics. The same applies to the foundation of interdisciplinary centers for vehicle technology in Lower Saxony and Gothenburg (Blöcker & Jürgens 2009; Ernstsson & Larsson 2009). The objective was to integrate cumulative competences in automotive engineering research in several synthetic knowledge fields which were distributed across different locations and actors. The new centers were established to operate as platforms for the integration of specialized competencies and research activities in analytical and synthetic knowledge fields related to a specific problem, such as road and crash safety. The basis for these new cooperations was formed by existing long-term relationships between OEMs and local universities.

By contrast, in the KIBS sector, the interaction mode can be labeled as "flexibly institutionalized" on the basis of informal personal relationships. In the KIBS sector, the case studies show that universities mainly provided timely access to highly qualified human resources. Even though universities were not directly involved in the innovation events, as in the automotive examples, personal contacts with students, and the integration of graduates with competencies in highly specialized knowledge fields, had a decisive influence on the knowledge dynamics of KIBS firms. Universities play an important role in the firm's capability to build and mobilize network links to external knowledge-producing actors. For example, a teaching assignment of employees from an engineering KIBS in Stuttgart at a nearby university established a valuable access point to discover talented graduates in the field of visualization who were urgently needed to realize the innovation project (Strambach et al. 2009).

4.3.4 Place Specificities and the Organization of Knowledge Dynamics

In summary, universities and research institutes can be regarded as potential providers of cumulative knowledge, especially when it has been accumulated independently from the trajectories of the business environment. They may also play a great role in initiating or supporting combinatorial knowledge dynamics by providing complementary knowledge, which has been neglected by the private sector.

Regarding the role and scope of "political actors" in knowledge integration processes, their influence on both cumulative and combinatorial knowledge dynamics could be observed in all sectors. The diverse roles that political actors have played allows for a distinction between three different effects on knowledge dynamics, which can be described as "indirect", "incentive-based" and "direct".

Indirect effects unfold when political actors set combinatorial knowledge dynamics in motion without intending it. For instance, in 2007, the Danish government decided to reorganize the administrative structure at the municipal scale. In the course of this reform, four previously separated municipalities were merged into one administrative body. Even though it was not explicitly intended by the Danish government, this regulatory change had the consequence that the need for a mutual tourism organization (this particular case's innovation event) became very strong. The four municipalities had become one administrative entity so that suddenly there was the need for cooperation in tourism (Halkier et al. 2009).

Furthermore, in many cases, political actors tried to push developments into a certain direction and therefore mostly provided incentives such as financial funds or other benefits. Many automotive industry cases can be mentioned where "incentive-based initiatives" were observed. As demonstrated by the cases Gothenburg or Lower Saxony (Blöcker & Jürgens 2009; Ernstsson & Larsson 2009), political actors often tried to support regional cooperation and the integration of complementary but previously separated knowledge bases. Therefore, public funds were provided. In contrast to indirect political influences, the use of incentives cannot be separated from a particular purpose. Dynamics in very specific knowledge fields (notably very often in combinatorial knowledge dynamics) were supposed to be triggered. Thus, regional research centers and projects specializing in the combination of knowledge from formerly separated field were initiated by incentives provided by policy.

"Direct effects" that can be characterized by their aspiration to force specific knowledge dynamics to happen were identified, whereas innovative actors did not have many options to refuse this. Political actors (mostly on the national scale) may revise or create laws which require economic actors to actively pursue the integration of knowledge. For instance, one case located in the Slovakian KIBS sector was initiated by the change of the regulatory framework by the Slovakian government through the adoption of the "Act on personal data protection". Consequently, the demand for technical solutions rose significantly, so that domestic KIBS and Slovakian subsidiaries of foreign multinational KIBS started the creation of knowledge in this particular field to meet the demands of Slovakian clients. It is important to mention that the change of the regulatory framework influenced the knowledge dynamics of KIBS even though they had not been targeted in the first place (Rehák et al. 2009).

4.4 Conclusions: Implications for Public Policy

Micro-dynamics of knowledge at the firm level, as investigated in "EURODITE", offer a great deal of empirical evidence that the sourcing of external knowledge in distributed knowledge production is a significant feature of innovative change processes. The empirical results stress the qualitative shift towards a growing role of combinatorial knowledge in innovation processes. To summarize the central findings, it turns out that interaction processes in knowledge creation, use, and transformation are of a multi-scalar nature. The establishment of temporary geographical proximity in a dynamic way during the course of the innovation event is an essential mechanism for knowledge integration. Following the knowledge dynamics over time, organizational change and institutional dynamics co-evolve. Not only are knowledge integration processes territorially shaped by place specificities, but they also reshape these place-specificities over time.

Following innovation-oriented economic change processes in time and space, cumulative as well as combinatorial dynamics were found. The findings underline that knowledge combination is a challenging process. Typical for the generation of combinatorial knowledge is the unification of originally separated knowledge bases spread over a variety of actors, which are often located in different technological, sectoral and regional contexts. Besides forming a challenge for organizational management, fostering innovation by providing possibilities to bring together different sectors' knowledge domains and knowledge bases emerges as an increasingly important area for policy. While most regional policy initiatives tend to focus on certain pre-defined fields such as nanotechnology and biotechnology, the identification and exploitation of "related variety"

(Boschma & Iammarino 2009) between actors may yield promising results. Policy initiatives may build on what is already present in a region, even if it is often a mixed collection of agricultural activities, many different industries with various specializations and many different service industries. The intersection of several value chains at the regional level provides a rich repertoire for variation that can be used by firms to recombine and adapt pre-existing knowledge bases for new requirements. Place-specific institutional regimes are clearly important for the exploration and exploitation of such combinatorial knowledge. Asheim et al. (2011a) point in the same direction by developing an alternative innovation policy model for the construction of regional advantages. They argue for the foundation of a platform policy strategy based on related variety, which is defined on the basis of shared and complementary knowledge bases.

In combinatorial knowledge dynamics, manifold interfaces have to be overcome due to a high degree of cognitive diversity among the actors involved. In such actor constellations, a variety of contexts have to be integrated, and the minor degree of institutional overlap creates barriers to the easy development of mutual understanding. One major implication of the growing role of combinatorial knowledge processes for policy is to be aware of regional cumulative knowledge bases and the windows of opportunities that these open up for combinatorial knowledge dynamics. Furthermore, regional development policy may focus on ways to exploit place-specific knowledge bases, not only by promoting actors and interactive processes on the local scale but also by integrating local assets with complementary knowledge from beyond its jurisdiction. As the empirical findings show, a good proportion of interactions in innovation processes cross regional or even national borders.

The debate about the global-local dichotomy seems to fall short of the complexity of knowledge interactions over time in innovative change. During the innovation processes investigated here, actors at the local, regional, national and international scales were included. It was rarely the case that actors worked exclusively at one particular scale in innovative change processes. Rather, knowledge interaction processes are characterized by a mixed pattern of interactions at close and great distances and by a multi-scalar nature. Hence, from a policy perspective, the openness to non-local knowledge is an issue which has to be taken into account in the design of flexible institutions.

Knowledge dynamics at the micro-level also reflect the fact that geographical proximity is an important but not sufficient mechanism to support knowledge creation and knowledge sharing among actors. In combinatorial knowledge dynamics, particularly, the difficulties of implementing collaboration among firms are obvious. There are often barriers to innovative knowledge sharing. Overcoming such barriers requires forms of proximity other than geographical proximity, for example, cognitive, organizational and social proximities among the actors. The empirical findings have shown that innovating actors often use temporary spatial proximity to establish these other forms of proximity. To coordinate knowledge integration processes, actors collectively develop their own governance structures. These may result in internal restructuring, the establishment of new, loosely coupled networks and even the establishment of new organizational bodies, integrating resources from independent organizations. Policy may act as a "change agent" in supporting these institutional dynamics. Especially in cases in which the expected outcome of knowledge combinations lies in the more distant future, actors are reluctant to invest in mutual understanding as a prerequisite for integration of heterogeneous knowledge. For instance, possible tasks for regional policy actors as "change agents" may be the identification and communication of overlapping interests of actors from different sectors, the identification of accumulated, complementary knowledge assets in their jurisdiction and the promotion of the exploitation of these complementarities. Furthermore, policy may support strategic projects involving combinatorial knowledge dynamics by promoting cognitive proximity and a common understanding of the objective and economic value of the future cooperative outcome between participating actors.

In general, time is an important dimension in understanding knowledge dynamics. At the micro-level, different time horizons are present. In knowledge domains where symbolic knowledge is the main input, for instance, knowledge creation has much shorter cycles than analytical science-based knowledge production. Regarding the latter, the separation of knowledge exploitation and exploration in space and time is much more pronounced than in service industries dominated by symbolic knowledge. In addition, the sectoral shaping of firm-level knowledge dynamics was also obvious. Sector-specific institutions have a major impact on the organization of knowledge interaction processes, even though sector contexts are associated with more blurry boundaries. This has been reflected in the empirical findings (see section 4.3.4) in such a way that actors in science/education and policy foster combinatorial knowledge dynamics in various modes. For policy-makers, the challenge is to support these varied roles with appropriate and flexible institutional conditions. For instance, it is important that policy does not treat all universities under the same institutional regime, but is aware of the many kinds of knowledge production that exist. The science and technology model, based on research and development and the separation of knowledge exploration and exploitation, covers only one part of knowledge processes leading to innovative changes in the knowledge economy.

5 Exploring Plasticity in the Development Path of the Automotive Industry in Baden-Württemberg: the Role of Combinatorial Knowledge Dynamics

SIMONE STRAMBACH & BENJAMIN KLEMENT

(published in: Zeitschrift für Wirtschaftsgeographie, volume 57, issue 1-2, pages 67-82, DOI:10.1515/zfw.2013.0006)[8]

ABSTRACT. Profound insights into why some regional paths remain dynamic over several decades while others follow a bumpy road and become stuck in the past are still scarce. This paper addresses this gap by contributing to a deeper understanding of dynamics within territorial paths. It focuses on organizational and institutional changes connected with so-called combinatorial knowledge dynamics. We claim that especially innovations based on the transversal combination of separated knowledge bases are connected to the gradual transformation, recombination or creation of institutions at the micro-level. This contribution explores the dynamics within the automotive industry of Baden-Württemberg by providing a meso-level overview of the trajectory of its technological and institutional development as well as an analysis of a case study that illustrates the gradual institutional change on the micro-level in the course of knowledge combination

Keywords: innovation biography, institutional change, path plasticity, knowledge dynamics

[8] To improve readability, numbering of sections, tables, and figures has been harmonized with the rest of the thesis. The spelling has been adapted to the American spelling used in the rest of this thesis.

5.1 Introduction[9]

Why do some regions become victims of their former success, while others continue to thrive, even though they are characterized by agglomerations of the same industry? A particularly striking example for this contrasting development is provided by the automotive regions Detroit (USA) and Baden-Württemberg (Germany). Whereas the former provides textbook examples for industrial decline and all its devastating impacts on urban and socio-economic developments, the latter has been continuing to master several crises in the last decades. In this contribution, we argue that dynamics within the development path of Baden-Württemberg's automotive industry is achieved because actors in Baden-Württemberg's automotive industry are able to successfully explore path plasticity and drive combinatorial knowledge dynamics.

The concept of path plasticity is used to set the focus on the continuity of dynamic change within paths. At the territorial as well as at the organizational level there are barriers to – and opportunities for – innovation and knowledge dynamics within paths which are only partially understood and not acknowledged in detail within the different strands of innovation literature (Strambach & Halkier 2013). To explore both the plasticity and dynamics within paths the institutional and organizational dimensions are essential as they explain stability and change of development trajectories.

While substantial insights are developed in mechanisms producing stability of paths such as institutional complementarities, a process theory that may explain why some paths remain dynamic over a long time, while others become victims of their former success (Grabher 1993a; Hassink 2010a), has not been developed yet. Profound insights into how the dynamics enfold beyond stabilization are still scarce. Therefore, the paper aims at contributing to a deeper understanding of dynamics within territorial paths by focusing on organizational and institutional changes connected with combinatorial knowledge dynamics. We argue that especially these innovations based on the combination of knowledge from different originally separated knowledge bases are often interconnected with the transformation, recombination or creation of institutions at the micro-level, as they imply coping with many different cognitive, technological, organizational and institutional interfaces. Hence, in these knowledge exploration processes, many barriers have to be overcome caused by different forms of distance (Boschma 2005; Knoben &

[9] The research was supported by the European Commission (integrated project EURODITE 006187), which is gratefully acknowledged. The authors would like to thank two anonymous referees for useful comments on an earlier version of the text

Oerlemans 2006; Ibert 2010) and a low degree of institutional overlaps. In the bridging of these barriers, combinatorial knowledge dynamics have the potential to generate variety and diversity of organizational forms and organizational routines that may in a direct or indirect way foster dynamics within an established path.

The empirical investigation focuses on Baden-Württemberg's automotive industry and comprises two parts, located respectively on the meso- and on the micro-level. At first, there is an overview of the regional development path of the automotive industry. Despite undergoing several crises in global change, the path of the industrial sector can be characterized as long-term competitive, showing adaptive dynamics within the path. The second part is set on the micro-level and closely examines an innovation based on combinatorial knowledge dynamics.

In order to do so, the second part specifies combinatorial knowledge dynamics related to innovation and differentiates them from cumulative ones. In the following section, the relation of combinatorial knowledge dynamics to the creation and transformation of organizational routines is elaborated on. After stating three research-guiding questions, the development path of Baden-Württemberg's automotive industry is presented in part four. Following a short introduction of the applied methods, in part six the empirical analysis on the micro-level shows in one case study how combinatorial knowledge dynamics are carried out. In the last section of this paper, these conceptual and empirical results are reflected upon.

5.2 Combinatorial Knowledge Dynamics and Path Plasticity

The notion knowledge dynamics is being used recently in the field of research focusing on knowledge economics. In the following, we distinguish combinatorial knowledge dynamics from cumulative ones by their organizational and institutional characteristics and discuss their relationship to the plasticity of established technological and institutional development paths.

Knowledge dynamics on the micro-level emerge through the interactions of actors within organizations and between organizations contributing to innovation. Hence interaction processes among actors are central to the use and creation of knowledge and its transformation into innovations with economic value added. Drawing on the literature on knowledge economics, it becomes obvious that three factors affect knowledge dynamics in a generic way: the specific knowledge base of agents, their competencies or capabilities (Malerba & Orsenigo 2000; Amin & Cohendet 2004; Dosi et al. 2008) and the context in which these processes take place (Strambach 2008).

Knowledge is a contested concept. In our understanding knowledge constitutes a capacity for action (Stehr 1994). Knowledge does not easily flow like information due to its inherent tacit dimension, its process character and its context dependence as identified by the theory of knowledge economics (Polanyi 1985; Foray 2004; Nooteboom 2010). The commodification of knowledge is fundamentally grounded in complex social processes (Berger & Luckmann 1966; Stehr 1994) and involves multifaceted communication and learning between the involved actors.

In evolutionary economic theory, the cumulative nature of knowledge that leads to the formation of specific knowledge bases is widely acknowledged. The discourse on the need to differentiate further cumulative knowledge bases started only recently in economic geography. In the SAS typology, three types of knowledge bases are distinguished: the synthetic, analytical and the symbolic (Asheim 2007). The main characteristic of this typology is that knowledge types are not defined by their content or value, but by "the approaches to how, and principles of reasoning through which, knowledge is developed and by the criterion for evaluating the value and usefulness of this knowledge" (Manniche 2012: 1824). Hence, using this typology puts emphasis on organizational routines and institutions affecting the creation, transfer, transformation, and exploitation of knowledge and their different significance in various industries. Even though this relatively new conceptual approach is not yet a complete one, its emphasis on institutional differences between knowledge bases is useful for the distinction between cumulative and combinatorial knowledge dynamics.

According to Schumpeter (1934), it could be argued that innovations are always new combinations of existing knowledge and learning. Consequently, combination is considered in general as an essential source of novelty, innovation and technological change. However, using an institutional approach, knowledge dynamics that lead to innovation can be differentiated regarding their organizational and institutional characteristics. Not all types of knowledge exploration and exploitation processes generate the same need for institutional change. In innovation research the widely used differentiation between radical and incremental innovation points also in this direction assuming that radical innovation is often connected with the creation of new institutional settings.

The special feature of cumulative knowledge dynamics is that the production of new knowledge is directly dependent or builds mainly on previously generated knowledge bases structured over time by co-evolved functionally specialized institutional settings. Even in cumulative knowledge dynamics, actors may combine several specialized knowledge bases, too. However, for this kind of combinations the functional institutional settings in which the respective knowledge stocks are embedded are similar or have at least a very high degree of overlapping (for more detailed information to cumulative and combinatorial knowledge dynamics see Strambach & Klement 2012a). In cumulative knowledge dynamics, actors share a certain degree of overlapping institutional settings that facilitate knowledge exploration and exploitation processes.

Institutional settings are believed to emerge and co-evolve with innovation processes, contributing to knowledge accumulation and competence building due to both their constraining and their enabling functions (Campbell 2010) which in turn affect the continuity and stability of paths. Moreover, the innovation potential of prevailing institutions makes a certain variety of changes likely to be generated (Pelikan 2003: 255).

The specific characteristic which differentiates combinatorial knowledge dynamics from cumulative ones is their transversal nature. They come into existence by the unification of originally separated knowledge bases that provide distinct institutional settings. These knowledge bases may be placed in different technologies, sectors, organizations or territories (Crevoisier & Jeannerat 2009; Halkier 2012; Strambach & Klement 2012a). Hence, interaction in combinatorial knowledge dynamics implies coping with many different cognitive, technological, organizational and institutional interfaces to overcome barriers caused by different forms of distance. In knowledge exploration and knowledge sharing processes such knowledge interactions have to bridge various intra- and inter-organizational institutions. In turn, these boundaries and the lower degree of overlapping institutional settings affect and limit combinatorial knowledge production. Diversity, an important precondition and stimulator for creativity and innovation simultaneously causes misunderstandings and barriers to knowledge sharing and transforming processes at the micro-level (Carlile 2004; Boschma 2005; Nooteboom 2010).

Given the transversal nature of combinatorial knowledge interactions, they may often involve the transfer of institutions to different contexts, or rearrangements or recombinations of institutional principles and social practices in new and creative ways for new purposes. Developed institutional settings of paths by no way determine the behavior of actors. There is always a degree of plasticity even under constraint choices of a path which can be explored by creative and reflexive actors (Strambach & Halkier 2013). Path plasticity hereby should not be mistaken as the result of high adaptive dynamics within paths. The concept refers to a feature of development paths: the constrained changes and mechanisms leading to dynamics within paths. Path plasticity provides a certain scope for variation within a well-established institutional setting of a path. This characteristic of paths is rooted in the interpretative flexibility of institutions and incoherence of paths themselves due to the interconnectedness of institutional settings at different levels. The notion of path plasticity does not deny the development of path-dependent trajectories but draws attention to the fact that institutional settings also provide a scope for action that can be explored by creative agents, for instance by new recombination, reinterpretation or redeployment of institutions.

Thus, taking into account path plasticity allows for a novel perspective on the development of regional development paths. Whereas in the debate on path dependency, negative lock-ins and the delocking of paths by disruptive breakthroughs are emphasized, the notion of path plasticity focuses on the continuity of dynamic change, the relation between continuity and change and the gradual change of institutional settings (Strambach & Halkier 2013 in this issue).

We argue that actors participating in combinatorial knowledge dynamics – intentionally or unintentionally – explore path plasticity by overcoming small institutional overlaps, these knowledge dynamics have the potential to enhance the scope of variety within an established path not only through the creation of new knowledge but also by the creation of new organizational forms. The latter might challenge the innovation absorptivity of institutions (Pelikan 2003) and produce a need to change, even if only in a gradual way and in more peripheral institutional arenas of a path. However, following the reasoning of gradual institutional change, combinatorial knowledge dynamics may contribute to modes such as layering, conversion or drift and add over time to substantial transformative change of basic path specific institutions (Mahoney & Thelen 2010).

5.3 Organizational Routines and Combinatorial Knowledge Dynamics

Knowledge dynamics emerge and are founded in interactions processes of actors within firms and other organizations or between networks of firms and organizations. The micro-level of actors is an important analytical level to deepen the understanding of dynamics within paths and the territorial shaping of combinatorial knowledge production behind innovation. Since firms and organizations are highly responsive to shifts in the economic environment, they are central actors for initiating institutional change. To gain a more profound understanding of what limits and enables knowledge sharing in combinatorial knowledge dynamics, it is worth to take a more detailed look at organizational routines.

While routines are mainly treated as black-boxes in evolutionary economics and evolutionary economic geography and the term is applied in a passive way by explaining variety and selection processes (Dosi et al. 2008; Kinder & Radwan 2010; Strambach & Halkier 2013), organizational theory however focuses on the purposeful change and creation of routines by active agents. In the latter, there is no unified definition of organizational routines as the term is used for referring to both behavioral and co-cognitive regularities (Becker 2004). Yet they are essential institutions that coordinate and integrate knowledge using and exploring processes by establishing cognitive proximity among individual actors and communities at the firm level. Furthermore, they also link firms with their environment over time. At the micro-level of actors, knowledge interaction processes are strongly influenced by cognitive distance and proximity between them (Boschma 2005; Ibert 2010; Nooteboom 2010) since knowledge and sense-making are embedded in action contexts. Cognitions[10] determine perceptions and interpretation and judgments of situations. Actors located in similar institutional settings, for instance within an organization, can share views, interpretations, values, and norms of behavior which are not shared outside the organization. Based on organizational routines firms provide cognitive orientation and foster cumulative knowledge dynamics and cumulative competence building (Nooteboom 2010). As Grant (1996) points out, routines provide a mechanism for coordination which does not require the communication of knowledge in explicit form.

[10] Cognitions are broadly understood here as mental activities including perceptions, interpretations, sense making, knowledge and skills, norms and values which are developed by people in interaction with their social and physical environment (cf. Berger and Luckmann 1966)

Furthermore, organizational routines also link firms with their environment. They cannot easily be replicated and transferred to other contexts (Teece 2010) due to their collective and processual nature. As a collective outcome, they reflect social practices and localized learning processes at a certain point in time. The knowledge and competence-based theory of the firm (Kogut & Zander 1992; Nonaka & Takeuchi 1995; Teece et al. 1997) recognizes the weight of path dependencies of knowledge and organizational practice inherited from the past.

From an evolutionary perspective, the unreliability of routine imitation and the combinatorics of routines are considered as a major source of novelty (Becker et al. 2006; Boschma & Frenken 2011b). Compared to cumulative knowledge production, the development of organizational routines and governance structures which are capable to coordinate and govern combinatorial knowledge creation processes seems to be far more complex. Combinatorial knowledge dynamics are characterized as action contexts with the participation of a variety of different actors who belong to different organizations, industries or are located in different places. This transversal nature of combinatorial knowledge production is closely connected with more institutional diversity.

Substantial insights at the aggregated level of industries and technologies exist, showing that sector-specific institutions, established practices, and organizational routines differ considerably (Pavitt 1984; Malerba 2005). Marked sector differences of organizational routines related to knowledge creation, transfer and evaluation are made clear in research using the SAS typology of knowledge types, which identifies synthetic, analytic and symbolic knowledge bases (Asheim & Coenen 2006; Asheim 2007). Even though this typology does not yet represent a complete concept and still lacks a thorough distinction of its three types, it remains very valuable for the analysis of combinatorial knowledge dynamics. Other than alternative taxonomies of knowledge, the SAS typology acknowledges that different knowledge types make use of different organizational routines for their creation, transformation, evaluation and use based on their epistemological properties (Manniche 2012). Based on these insights and compared to cumulative knowledge production both a high degree of cognitive diversity and a low level of common knowledge among the actors can be considered as characteristic attributes of combinatorial knowledge production.

Given that institutional settings impact selection processes in the exploration of knowledge complementarities, and facilitate the exploitation, boundaries might be caused by cognitive distance, a low degree of institutional overlaps and the required overcoming of other forms of relational distance (Ibert 2010). Particularly as the efficiency of knowledge integration is influenced by the level of common knowledge, the frequency and variability of the activity and the structure, which economizes on communication (Kogut & Zander 1992; Grant 1996). Actors coming from a variety of backgrounds have to invest much more in cognitive coordination and establishing sufficient mutual understanding in order to explore complementarities of originally separated knowledge bases. The plasticity of institutions understood as their interpretative flexibility and the low degree of institutional coherence open up a wide room for divergent interpretations and perceptions (Strambach & Halkier 2013). In turn, that generates the need for complex communication processes to convert the variety of different actors' meanings into shared views. The latter enables the ability to collaborate and influence the willingness and commitment to do so (Nooteboom 2010: 77).

Building upon the knowledge-based view of the firm, it is obvious that actors in such action contexts have to invest in establishing mutual understanding, e. g. by rearranging, transferring, reinterpreting or creating organizational routines (Strambach & Klement 2012a). In turn, it can be assumed that combinatorial knowledge dynamics pose several challenges that innovating actors can only meet when they overcome these before-mentioned boundaries. Combinatorial knowledge dynamics have the potential to generate variety and diversity of organizational forms and organizational routines and contribute to institutional change.

Hence our research is guided by these questions: To what extent does the institutional setting of the region provide potential resources for actors to conduct combinatorial knowledge dynamics? How do actors overcome the boundaries implied by combinatorial knowledge dynamics? Finally, do combinatorial knowledge dynamics on the micro-level lead to gradual change in the regional institutional setting?

5.4 Institutional Changes in the Regional Trajectory of the Automotive Industry of Baden-Württemberg

Being home to the inventor of the automobile, Baden-Württemberg has evolved as one of Europe's most important cluster of the automotive industry. Besides the original equipment manufacturers (OEMs) *Daimler, Porsche* and *Audi* (belonging to the

Volkswagen Corporation) a variety of suppliers (e. g. *Robert Bosch*, *ZF Friedrichshafen*, *Mahle*, *Behr*) and engineering service providers (e. g. *Bertrandt*) are located there, especially in the Stuttgart region. A strong knowledge base in the synthetic knowledge domains of automotive, mechanical and electrical engineering has formed (Asheim & Gertler 2005).

The automotive industry's success can be counted as one of the major factors for the long-lasting economic success of Baden-Württemberg since the 1950s. In about 3,000 enterprises across the whole value chain, a turnover of 91.91 billion Euro was generated in 2009. Yet the successful history of the automotive industry in Baden-Württemberg was not as predictable and steady as one may assume. After an especially prosperous post-war era, it faced several challenges and adversities since the early 1990s (Hawlitschek 2011).

Baden-Württemberg's automotive industry managed to cope with manifold challenges over the last 20 years, recovered in relatively short time spans and is still going strong. The all-time high of the industry's turnover, 133.3 billion Euro, was reached in the last pre-crisis year of 2007 (Hawlitschek 2011). Even the current economic crisis has not had a big negative impact: The number of employees (198,958) in Baden-Württemberg's automotive industry has already been slightly higher (+4,195) in June 2012 than in December 2008 before the crisis (Statistik der Bundesagentur für Arbeit 2012; hereby the number of employees in NACE Rev.2 division 29 represent employees in the automotive industry).

A wide theoretical and empirical literature places emphasis on the advantageous effects of the long-established organization of the technology-based synthetic knowledge production and diffusion in the region for the innovativeness and competitiveness, particularly its established numerous interfaces, linkages, and overlaps between science, economy, and policy. Mainly four dimensions of the institutional setting have been identified that determined the industrial technology- and science-based innovation profile responsible for the long-term competitiveness of the regional automotive industry (Braczyk et al. 1996; Heidenreich & Krauss 1998):

- The regional research infrastructure and the specialization profile of the scientific system largely correspond to the industrial technology and the technological fields of the R&D-intensive core industries: automotive, mechanical engineering and electronics.
- Complementary institutional configurations in the scientific system provide a great potential of highly skilled human resources in the technological fields of synthetic and analytical knowledge bases.
- The occupational training and higher education system are closely linked to the skill and knowledge requirements of the core industries.
- Since the 1980s, a decentralized technology transfer structure for small and medium-sized enterprises facilitates knowledge exchange and knowledge generation in applied synthetic knowledge fields

These institutional settings with the intersection of the specific labor market institutions which characterize the German coordinated market economy (e.g. Casper et al. 2005) foster firms' investments in human capital and contribute to cumulative competence building of firms the important basis for innovative developments.

This co-evolved institutional setting that brought success in the previous 40 years faced several new challenges since the early 1990s: The new global flexibilization of production systems, the growing importance of non-European markets, changing consumer demands towards new market segments (e. g. minivans, small cars, SUVs), growing consumer awareness of environmental and sustainability issues and stricter environmental regulations. Furthermore, German automotive companies tended to overlook the value of non-technological types of innovations, such as organizational and service innovations (Braczyk et al. 1996). As the institutional setting was geared to support synthetic knowledge creation, symbolic knowledge bases were underdeveloped. Empirically reflected by the comparatively low share of service industries, particularly of media and knowledge-intensive business services in the regional economy, it became obvious that the stable, well-established institutional settings of Baden-Württemberg had caused rigidities and lock-in effects (Strambach 2002; cf. Cooke & Heidenreich 2004; Fuchs & Wassermann 2005).

Employment losses and economic downturn raised awareness by political and economic actors alike who took action in several ways. Hence, in the following years, various economic and institutional restructuring processes could be observed in the region as intended or unintended outcomes of multi-actor initiatives. By regarding these initiatives from the perspective of knowledge policies, we argue these are geared towards fostering combinatorial knowledge dynamics and contributed to gradual institutional change by opening up related variety (Boschma & Frenken 2011b) in the path of the automotive industry. In the following, we shed light on some examples for multi-actor initiatives that are geared towards fostering combinatorial knowledge dynamics mainly in two fields: the support of cross-sectoral networks and organizations and the extra-regional knowledge sourcing.

5.4.1 Cross-sectoral Networks and Organizations

Since the mid-1990s policy measures have been focusing on promoting bottom-up initiatives and self-organizing processes, and the increasingly multi-level nature of policy design and implementation is noticeable. Political actors in Baden-Württemberg recognized that the underdeveloped knowledge-intensive business services (KIBS) industry had potential value to the region's industrial core and supported it with the creation of new organizations to support complementary service industries in the information technology (IT) and media sector (Krauss 2009; Strambach 2012). Several publicly or privately funded sector organizations, e. g. *MFG Innovationsagentur für IT und Medien* and business networks (*bwcon*), foster the knowledge transfer and the use and application of IT know-how in Baden-Württemberg, aiming to intensify the exchange between research, educational organizations, software firms and customer sectors by maintaining a series of events, congresses, workshops and cluster initiatives (Fuchs & Wassermann 2005).

Regarding regional policy, governance structures have moved towards multi-actor and multi-level institutional setups (cf. Kaiser 2008) to suit open innovation forms and inter-organizational knowledge creation of the automotive industry. New organizations were directed to open up network relationships between different sectors to mobilize existing competencies from different knowledge bases to create innovation platforms. Cluster policy was introduced not only in sectoral but also in cross-sectoral competence areas to promote combinatorial knowledge dynamics (Baden-Württemberg Ministry of Economics 2009; Prognos AG 2009). With the financial support of the European structural funds, particularly the ERDF (*European Regional Development Fund*) program "innovation, knowledge-based economy and cluster", state-wide networks and regional cluster initiatives have been promoted in the period 2007 to 2013.

Initiatives were not only driven by regional policy but private businesses, as the following example of the *Automotive Simulation Center Stuttgart* (ASCS) shows (see *Figure 5.1*). The center allows for the novel combination of highly specialized cumulative knowledge bases and is located in the Stuttgart region. Analytical knowledge from the field of mathematics and computer sciences was brought together with carriers of different synthetic knowledge bases within the application field of the automotive industry. Two underlying reasons drove the bottom-up initiative: On the one hand, the material and knowledge resources of the high-performance computing center had to be put to new uses, as companies were able to upgrade their own computing capacities at lower costs. On the other hand, new regulations in the fields of CO2 emissions, security, and energy efficiency of automobiles called for a more extensive use of innovative simulation technologies.

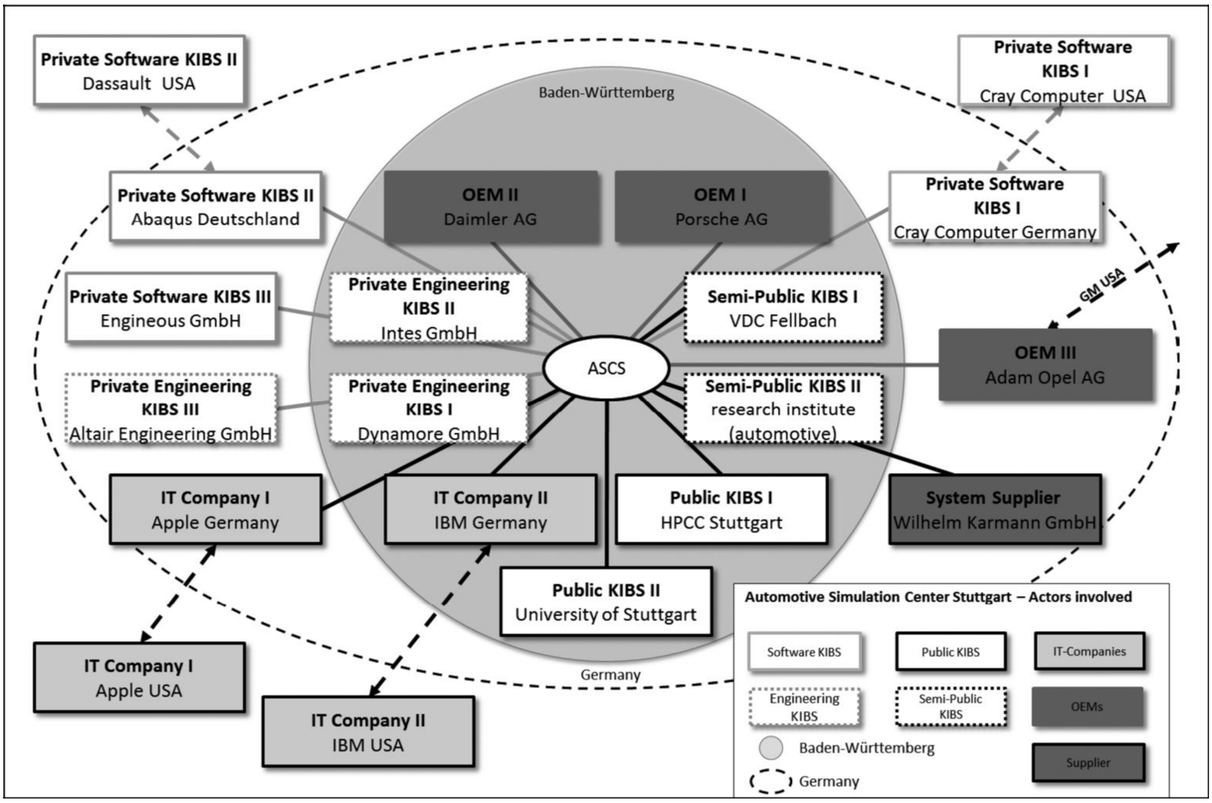


Figure 5.1: Actors involved in the Automotive Simulation Center Stuttgart (ASCS)
Sources: Own research

After a two years stimulation and networking process, the ASCS was founded in 2008 by two automotive OEM from Baden-Württemberg, one German OEM and one supplier, service engineering firms, foreign hardware manufacturers and software companies but also the *University of Stuttgart* and semi-public organizations in the region. The latter brought in the experienced-based knowledge of network and cooperation building to small and medium-sized suppliers. The center had been financed from the start by member fees and was only later supported by initial funding of the Baden-Württemberg *Ministry for Science, Research, and the Arts*.

Bringing all these actors together was difficult, as a lot of trust was required. Especially software developers were cautious at first to cooperate with their competitors. Yet in parts, participating companies were familiar with each other from previous collaborations on the national level in this field of technology. The initiator was a director of a national association focused on simulation technology in the automotive industry. His formerly built professional network relationships to experts with specialized synthetic knowledge bases allowed him access to a variety of potential partners on the national level, who were familiar with each other due to the work in the association. This familiarity was essential in building up trust amongst the partners.

5.4.2 Extra-regional Knowledge Sourcing

Furthermore, policy supported extra-regional knowledge interaction processes by taking part in transnational initiatives such as *Bench Learning in Cluster Management for the Automotive Sector in European Regions* (BeLCAR) or *Clusterinitiative Automotive Region Stuttgart* (CARS) (Strambach et al. 2009). The primary aim of CARS is the creation of linkages between existing regional, national and international networks and the network management. During the last years, more than 300 companies and organizations participated actively in this initiative. The creation of international networks and the anchoring of international knowledge occurs through cooperation with leading cluster initiatives of the European automotive regions. These international linkages enable knowledge transfer and flow of knowledge concerning sector related trends, technologies, and opportunities for scientific research as well as cooperation between companies. Among others, clean energies, sustainable mobility, software service for automotive industry or qualifications and skilling are subjects treated and discussed within communications platforms.

For the initiative BeLCAR, the regional development agency of the Stuttgart region collaborated with European regions (East England, Upper Austria, Lombardy, Catalonia and West Transdanubia) joined forces in order to improve the actions and innovative capacities of automotive clusters in Europe. The main objectives are the mobilization of existing automotive clusters in Europe to collaborate and exploit synergies as well as fostering the exchange of knowledge and good practice between automotive clusters. Besides initiating joint projects, the cluster management organizations themselves are involved in distant learning processes, which support the understanding of the success factors and weakness of clusters in the automotive sector through the exchange of experience-based knowledge (Grosz 2008).

Remarkably, these developments presented neither complete disruptions with the well-established structures of the cumulative knowledge bases which had proven to be successful, nor a rise of completely new actors, but a gradual reorganization of the institutional setting of the region. Nevertheless, they enhanced variety in the institutional setting which in turn diminished institutional inertia. Directly or indirectly these developments may have fostered dynamics within the path by opening up opportunities to explore complementary knowledge bases and contributed to the sustained success of the regional automotive industry.

5.5 Methodology

A qualitative research design was chosen in order to gain empirical insights into the nature of knowledge dynamics behind innovations in an inductive way. The empirical methods of data collection used a combination of secondary and primary research. Applied research heuristics were actor-focused, inspired by the actor-centered institutionalism (Mayntz & Scharpf 1995) and the SAS typology (Asheim 2007). The secondary research used literature review, document and media analysis with the objective to analyze the restructuring process at the meso-level of the region and the industry. The primary research contained explorative as well as semi-structured interviews with corporations in the automotive industry and (semi)public -organizations in Baden-Württemberg. Altogether, the empirical research is based on 23 qualitative interviews, of which four of these were conducted with regional (semi)public organizations.

In the empirical research, a biographical method originally used in social sciences (Wengraf et al. 2016) was applied and adapted to explore combinatorial knowledge dynamics behind innovation. A detailed description of the innovation biographies as an empirical instrument is beyond the scope of the paper, but more information can be found in Butzin et al. (2012), Butzin & Widmaier (2012) and Strambach (2012). Such an approach has a main advantage in the reconstruction of time-space paths of knowledge interactions: It enables grasping the dynamism without being limited to certain geographical or sectoral scales. Every innovation is unique and in the focus of the biography is the innovation event itself or, in other words, a change process. By examining the entire lifespan of an innovation, a biography captures the actors involved, their relationships, their knowledge contribution and their institutional and geographical settings. With a snowball sampling strategy, the sequences in time, the distributed knowledge activities and different actors of the innovation event were investigated.

In this article, one exemplary biographical case is presented to explore in depth the time-space path of the knowledge interaction processes. It comprises an innovation event of MEDIAKIBS, a firm providing services among others for clients in the automotive industry. This biography is based on four in-depth interviews lasting between one and a half and two hours. The empirical material was examined mainly by a deductive, theory-led coding strategy to built categories, supplemented by inductive ones formulated directly out of the material (Böhm 2000; Kuckartz 2010). For each phase of the innovation biography, the relevant types of knowledge brought in by different actors (using the SAS typology) and the different cumulative and combinatorial knowledge dynamics were identified alongside barriers to innovation, actors, actor constellations, their locations, and the type of collaboration.

5.6 Knowledge Combination on the Micro-level

Having outlined the structures and development path of the regional automotive industry, in the following we elaborate on combinatorial knowledge dynamics on the micro-level. On the basis of an in-depth case study, we explore what enables and limits combinatorial knowledge production and how these processes contribute to dynamism within the path.

MEDIAKIBS is a service provider established in 1994 near Stuttgart, operated in various fields such as graphic animation and digital post-production. After a period of serious crises, the firm specialized in 3D-visualization for the automotive industry. Its products and services are mostly related to clients' marketing activities. In 2005, the acquisition of new clients – as described in the following case study – required a fundamental organization change during which the number of employees increased fivefold. Within a year, MEDIAKIBS was able to increase its staff from 12 to 60 employees. Today, the company employs 130 professionals located in Stuttgart, Munich, Detroit, Los Angeles, Hamburg, and London. That is a remarkable change as MEDIAKIBS was a typical small-sized creative service provider like over 80 % of the firms in this sector until 2005. For a long time, the structure of the firm had remained the same and fluctuated around 12 employees, including two small subsidiaries in the automotive regions Munich and Detroit.

Closely interwoven with the organizational restructuring process was the development of a technological innovation – an automated content management tool that is the focus of this case study. However, the reconstruction of the technological innovation event by means of a biographical method shows that without the simultaneous organizational change and the development of new routines the technological innovation could not have been developed.

The technological innovation of the automated content management tool (ACM-box) allows for the standardization of visualization procedures and thus facilitates the management of large projects. Highly realistic digital computer models of automobiles can be integrated into any kind of photographic or cinematic environment. Furthermore, it accelerates the adaptation of marketing campaigns to different national or regional contexts by enabling quick editing of e. g. license plates and traffic signs.

This innovation can be characterized as the result of combinatorial knowledge dynamics since its creation requires bringing together highly specialized cumulative symbolic and synthetic knowledge bases located in different sectoral and spatial contexts. The exploited knowledge bases that are tapped comprise on the one hand the symbolic, marketing-related knowledge base on how to present cars in different cultural markets to various target groups with distinct lifestyles, norms, and values. In this knowledge domain, the core competence of the MEDIAKIBS is located. On the other hand, there is the rather specialized technology-related synthetic knowledge base on the application of visualization technology and on the application of information technology and software tools to organize, handle and store very high data volumes. Furthermore, the integration of specialized knowledge bases located in the domains of human resources management, firm and work organization was necessary to give birth to the innovation.

The biographical approach provides deeper insights into modes in which these combinatorial knowledge dynamics behind the innovation unfold in time and space. The central elements of the innovation biography as they appeared ex-post, reconstructed

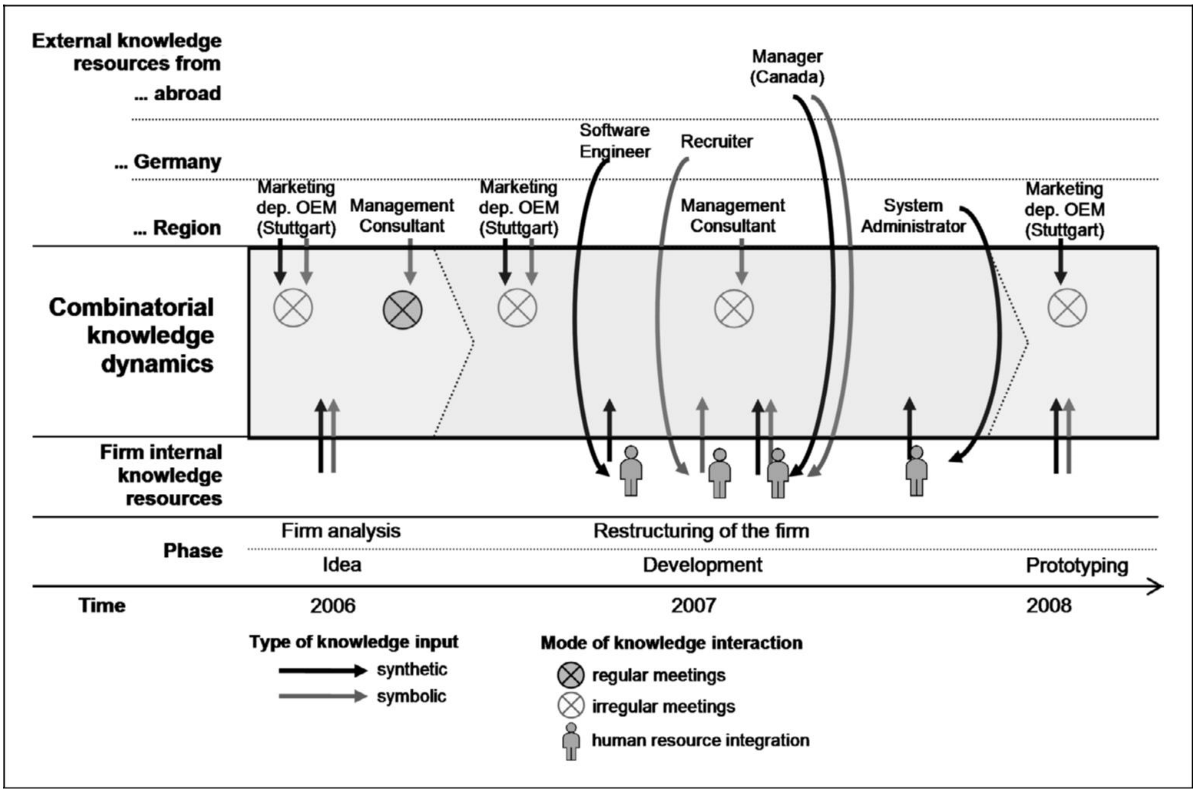


Figure 5.2: Innovation biography of MEDIAKIBS's automated content management tool
Sources: Own research

from the empirical material, are mapped in Figure 5.2. The chosen type of depiction should not mislead to think of innovation as a predefined linear sequence of events. Instead, in the course of the innovation situations emerged in which actors had to take decisions which were subject to uncertainties and challenges, leaving open the continuation and success of the project.

In 2006, the starting point for this innovative event was the search of an automotive OEM for a media partner to provide graphical material for a marketing campaign for the global launch of a new type of car (Figure 5.2). Because of personal contacts between the CEO of MEDIAKIBS and the marketing department of the OEM this large-scale contract could be acquired by MEDIAKIBS. Taking over this project was highly risky for MEDIAKIBS and the challenge was enormous. Previously, the firm produced pictures and films, individually crafted in a creative way by 3D artists on their own without any division of labor: This kind of organizational routine is a common practice in many small size creative media firms. However, in the first stage of the project, it became very obvious that the large-scale project could not be mastered by this mode of production at the scheduled time. The OEM requested the production of 350,000 high-quality photos, whereas previous projects usually comprised about five pictures.

In this critical situation, the *first phase* of the innovation process started and an internal search was set off to find problem solutions. Yet the CEO, while trained and highly-skilled in design, lacked the necessary knowledge about strategies to change the organizational structures or find technological solutions. Thus, an external management consultant from Baden-Württemberg was called in to support the analysis of the firm's routines and procedures.

During the following nine months a complex communication and learning processes took place. Several divergent interpretations and perceptions had to be overcome in order to create a common understanding of meanings of appropriate further actions. Knowledge exchange and trust building were facilitated by regular workshops and spontaneous meetings on site of the MEDIAKIBS. In these interaction processes, thoughts and goals for a new business model were discussed and the idea to develop an automated content management tool (ACM-box) came up.

In this phase, the moderation of the communication and learning processes by the consultant proved to be very important. He brought in his experience-based knowledge about organizational structures, processes, and routines accumulated in various projects with clients from the local automotive industry. By introducing the logic of specialization and modularization practiced for a long time in knowledge using and creation activities of automotive firms, the outline of a new business model gained clarity. The organizational routines in place in the automotive industry are often named product development process, which structures knowledge creation processes in time. The consultant's knowledge of these routines also affected the organization of the technological innovation development process of the ACM-box. A rough concept was created on how to integrate this innovation process into the general change process of the firm's new structure.

At the end of this phase, the decision was made to realize both the creation of the ACM-box and to change and introduce new organizational routines to approach the large-scale project from the client. However, some employees did not give up their skeptical attitude towards the planned restructuring. While used to work on several projects in an autonomous way with a high degree of freedom, the introduction of specialization and modularization were perceived as rather monotonous and hindering creativity. Especially the 3D artists who were integrated into the firm for the longest time most refused to realize the change. As divergent perceptions and cognitive distance could not be bridged, some of them left the firm.

At this point in time, the concrete process of routine change was in large parts open. In the *second phase,* the implementation of new routines and their further institutionalization into practices started. Several challenges had to be met in the organizational change process which meant upscaling of production and introduction of a higher degree of division of labor into the creative work processes. Many critical situations emerged, which could not be solved by internal knowledge resources. It required the integration of external human resources. Specialists in project management, business organization, system administration and personnel management were sourced. The CEO's personal social networks played an important role in getting access to highly specialized professionals with complementary knowledge in these domains who were able to connect smoothly to the complex application contexts. The sourcing was not limited to Baden-Württemberg though: the new project manager came from Canada for instance.

The implementation of the new software tools brought with the possibilities to modularize working processes and standardization in different production steps going along with allowed for higher efficiency and higher output. The employees, originally called 3D artists, now had to work on smaller parts in specialized production steps. These changes were enabled by the new project manager who had accumulated experience in the game industry, where the scaling of creative work is already more pronounced.

The change of organizational practices and the implementation of smaller specialized production steps connected with the dynamic growth of the firm in one year from 12 to 60 employees contained many frictions. While the newly employed staff adapted to the working processes smoothly, some parts of the staff refused to practice the newly installed system. This generated the need for many individual discussions. To overcome these problems new communication structures were initiated like regular meetings to generate mutual understanding and to convince the staff of the measures that had been taken.

Not only was the way of doing things altered by using a new technological solution, it implicated several adaptations in other organizational routines as well, affecting such diverse areas as business culture. The main difficulty in this innovation process was not its technological nature, but the organizational change that went with it. However, in the end, MEDIAKIBS was able to face the challenges and overcome these boundaries coming with combinatorial knowledge dynamics.

It enabled the company to evolve from a small-scale service provider to a technology provider working on a much larger scale. MEDIAKIBS's ability to combine its symbolic knowledge about marketing-related symbols and representations with synthetic knowledge on software technology in the visualization field appears to be responsible for the firm's present market success. In hindsight, the company might have stagnated or even lost business, had it continued its ways of doing business. Because of this innovation, clients from the automotive industry were provided with a new tool that can make the adaptation of global marketing campaigns to local consumer demands much more efficient.

5.7 Discussion

In the following, it is discussed first how the institutional settings provided potential scope for combinatorial knowledge dynamics, secondly how participating actors managed to overcome boundaries in combinatorial knowledge dynamics, and thirdly how gradual institutional change can be observed in the exemplary case study of MEDIAKIBS and the development path of the automotive industry.

5.7.1 The Potential of Institutional Settings

First of all, successful combinatorial knowledge dynamics require the existence of specialized cumulative knowledge bases that provide a potential scope for combination. It is essential in anticipating, understanding and exploiting opportunities for combination with other knowledge types. In line with Arthur's (2009) arguments on the evolution of technology, it can be stated that combinations of different knowledge types are not arbitrarily made, but require a sophisticated previous accumulation of specialized knowledge. For instance, for MEDIAKIBS the experience-based customer domain knowledge about the automotive OEM that the firm accumulated during several projects was essential to discover the need for the technological innovation and a new market that lead to initiate the combinatorial knowledge dynamics. The ASCS could build upon the expertise and experience of the computing center and its understanding of the special future demands for the application of simulation technology in the automotive industry.

Furthermore, the social and personal networks provide a decisive potential to get access to highly specialized and spatially distributed but complementary knowledge bases. Combining knowledge is not restricted to the local sphere. Some complementary knowledge sources had to be sourced over geographical distance. During the innovation event, MEDIAKIBS had to enhance its knowledge base mainly by acquiring and integrating external human resources. The search for additional professionals and staff crossed regional and even national borders, mostly by the far-reaching social personal network of the CEO. His relational proximity to this globally spread highly-skilled persons enabled MEDIAKIBS to acquire new complementary knowledge in a phase characterized by high uncertainty and risk.

Moreover, organizational routines which link firms with their environment are embedded in regional institutional settings. As outcomes of collective localized learning processes routines are shaped by place specificities and cannot easily be replicated and transferred to other contexts. However, precisely this property incorporates a significant innovation potential. MEDIAKIBS is an example of the transformation and recombination of routines, developed and practiced in sectors with different dominant knowledge bases. The introduction of recombined routines in new application contexts enabled the innovation development.

Regarding the development of the regional automotive industry, actors reverted to institutional forms that have already been dominant parts of the institutional setting, such as associations and business networks to support complementary service industries. Political actors strategically aimed at combining peripheral elements of the institutional setting with the dominant path of the automotive industry. In the process, they created cross-sectoral networks and organizations that bring together knowledge from various technological fields.

5.7.2 Overcoming Boundaries

Overcoming boundaries posed by combinatorial knowledge dynamics and using the creative potential of cognitive diversity in a fruitful way requires the development of a mutual understanding. The use of temporary spatial proximity in a dynamic and situative way appears to be a decisive mechanism in the exploration of knowledge complementarities and the bridging of cognitive distances. Combinatorial knowledge dynamics are especially characterized by high uncertainties in the pay-off and the time horizon of their outcome and require high investments to create mutual understandings between actors (Strambach & Klement 2012a). Divergent interpretations and perceptions have to be overcome in order to create a common understanding of meanings of appropriate further social actions. As the innovation events reflect, temporary spatial proximity facilitated the establishment of relational proximity (Ibert 2010).

Furthermore, combinatorial knowledge dynamics apparently are neither limited to the local sphere, nor completely global affairs. We could observe in these cases (also see Strambach & Klement 2012a) that there is an interplay of local knowledge grounded in place-specific developments with globally sourced complementary knowledge. Both MEDIAKIBS and ASCS are involved in in-depth interactions with local automotive OEMs. From their demands, the necessity and ideas for the described innovations were derived in the first place. Furthermore, local KIBS provided necessary knowledge inputs during the innovation process, especially in the case of MEDIAKIBS in which the external management consultant transferred knowledge on organizational routines gained in projects with clients from the local manufacturing industry to a new industry context.

On the meso-level, political actors in Baden-Württemberg already support the extra-regional sourcing of knowledge in various organizations aimed at supporting regional development, such as BeLCAR or CARS. In the case of the bottom-up initiative ASCS, remarkable efforts have been made towards bringing together the most suitable participants. Where the required knowledge (e. g. regarding hardware companies) was not locally available, the initiative showed openness towards actors from beyond the border of Baden-Württemberg and Germany. Even though the ASCS aimed to impact the competitiveness of regional automotive companies, the spatial scope of the knowledge sourced is international. Limiting the initiative exclusively on local actors would have diminished its technological scope and possibilities.

5.7.3 Gradual Institutional Change

On the meso-level, we can observe that the several challenges and adversities have been met by the creation of new institutional variety. These emerge in the form of new business networks or new organizations as collective actors with new competencies. These new organizations are geared towards the fostering of peripheral elements of the dominant path of the automotive industry and the combination of existing know- ledge bases within the region.

On the micro-level, in the case of MEDIAKIBS, the logic of organizational routines from the manufacturing industry was transferred to and recombined with routines used in the context of the media company, leading to a significant change in its business model formerly rooted only in the symbolic knowledge base. In the case of ASCS, an organization was transformed to enable actors from different sectors and stages of the value chain to work and conduct research in joint projects at the interface of the automotive and software industry.

5.8 Conclusions

Not all types of knowledge exploration and exploitation processes generate the same need for institutional change. Innovations based on the combination of separated knowledge bases are characterized by small institutional overlaps between actors. Hence, in the process of overcoming boundaries due to a lack of cognitive and other types of proximities between actors, combinatorial knowledge dynamics drive organizational change. Innovating actors exploit path plasticity by intentional, creative actions, in which existing institutions are reinterpreted, adapted, transferred and new organizational routines and forms are created in the process. Thereby combinatorial knowledge dynamics can play an important role in the creation of dynamics within paths that diminish the risk of negative lock-in effects. Even though our analysis is limited to processes at the micro-level, it can be assumed that these provide an important mechanism for dynamics at the regional or sectoral level.

This paper argues that even though the technological dimension of combinatorial knowledge dynamics is challenging already, they imply even more challenging organizational change processes. Actors have to be capable of managing these change processes in the first place. This study was able to show that for the anchoring of combinatorial knowledge new organizational forms were built which in turn contribute to institutional variety and diversity in the path. Here there is research potential to understand the fluid organization forms interconnected with knowledge combination. In the knowledge base literature distinct modes of creation, transformation, evaluation, and exploitation of knowledge are already acknowledged. Yet even though these should correspond to distinct organizational routines, this stream of literature does not explicitly refer to them. Hence, the development and characteristics of specific routines that enable innovations based on the combination of differentiated knowledge bases are not analyzed in detail yet. This study is limited in its empirical basis and rather explorative in nature. Nevertheless, the investigation of knowledge combination appears to be a fruitful area of research to enhance the understanding of regional development between path dependency and path plasticity.

Actors able to exploit path plasticity and drive combinatorial knowledge dynamics may contribute to regional and sectoral change processes by creating new organizational routines and forms. Indirect or indirect ways these support dynamics and adaptiveness of an established path. The continuous success of the automotive industry in Baden-Württemberg shows that "for things to remain the same, things must change" (Tomasi Di Lampedusa 1960).

6 Innovation in Creative Industries: Does (Related) Variety Matter for the Creativity of Urban Music Scenes?

BENJAMIN KLEMENT & SIMONE STRAMBACH

(submitted to Economic Geography on 26 July, 2017; currently under review)

ABSTRACT. This article investigates the role of related variety for innovation in creative industries by analyzing the relation between the composition and innovativeness of urban music scenes. While related variety has been found to be positively associated with several indicators of regional economic development and technological innovation, it remains unclear whether its merits also benefit innovation in creative industries. As innovation in creative industries is based on symbolic knowledge, the degree of variety in local contexts may affect the creativity of artists differently than the innovativeness of engineers and scientists. To test whether specialization, unrelated variety, or (semi-)related variety is linked to innovation in creative industries, this contribution applies the concept of related variety to the context of urban music scenes.

As innovation in creative industries is hidden from traditional innovation data, we utilize volunteered, geographic, and user-generated information from the social music platform last.fm. From relatedness measures between music genres, we generate an own classification system of music, which is used to calculate different related variety metrics of music scenes. Furthermore, our database allows for the identification of innovation in music as the emergence and combination of music genres. The results of this article suggest that semi-related variety promotes innovation in music, while related variety is only positively associated with combinatorial knowledge dynamics. Furthermore, specialization limits innovation in music scenes. Hence, policy concerned with creative industries needs to analyze not only aggregate data but also the composition of regional symbolic knowledge bases.

Keywords: symbolic knowledge, related variety, innovation, music, creative industry

6.1 Introduction

Understanding the sources of innovation in creative industries is a necessary and valuable endeavor. Creative industries have become a major source of employment, economic growth, and innovation, especially in urban economies (Brandellero & Kloosterman 2010; Florida 2012; Boix et al. 2016; DCMS 2016). They also act as sources of knowledge for other parts of the economy (Hatch 2013; Sedita et al. 2016).

Due to the importance of symbolic knowledge for innovation in creative industries (Asheim 2007), local knowledge sources are highly relevant (Martin & Moodysson 2011): Symbolic knowledge creation is highly context-specific and grounded in (inter)actions of localized communities (Brandellero & Kloosterman 2010; Martin & Moodysson 2011; Lena 2012; Martin & Moodysson 2013; Cohendet et al. 2014).

Recent studies in the field of Evolutionary Economic Geography (EEG) have demonstrated that the availability of local knowledge sources in regional knowledge bases affects the extent and direction of innovation (Boschma 2016). The introduction of the concept of technological relatedness to economic geography (Breschi et al. 2003; Frenken et al. 2007; Hidalgo et al. 2007) provided new opportunities to characterize the composition of knowledge bases by their specialization and (related) variety (Caragliu et al. 2015; Content & Frenken 2016). Evidently, knowledge bases that are characterized by related variety display higher levels of innovation than specialized or highly diversified ones (Tavassoli & Carbonara 2014; Castaldi et al. 2015; Content & Frenken 2016).

Only a few studies have applied these methods in the context of symbolic knowledge thus far (Berg & Hassink 2014). In EEG, studies have focused on the analysis of technological knowledge (Content & Frenken 2016). At the same time, the literature on differentiated knowledge bases (Asheim 2007) has stressed differences between knowledge bases and knowledge types, yet lacks systematic studies that analyze the structure of symbolic knowledge bases in itself (Manniche et al. 2017).

Thus, it remains an open question whether the merits of (related) variety identified for technological innovation are also valid for innovation in creative industries. Existing studies on creative industries point to a certain contradiction: While the importance of local scenes for creative industries indicate the merits of specialization (Florida et al. 2010), creative industries apparently also benefit from a high variety of knowledge sources (Gong & Hassink 2017). Against this backdrop, this contribution aims at resolving this contradiction by providing deeper insights into whether it is specialization, variety or related variety that are conducive to innovation in creative industries. It does so by the example of the music industry, in which urban music scenes represent knowledge bases.

Operationalizing urban music scenes as symbolic knowledge bases poses some challenges. First of all, analyzing the composition of knowledge bases requires knowledge to be disaggregated into bits that are classified in some way, for example by technological classes assigned to patents (Colombelli et al. 2013). Only then can network-based methods be employed to reveal the relatedness between knowledge bits from existing combinations between them (Quatraro 2010). Furthermore, the related variety of knowledge bases is determined by calculating entropy on different levels of hierarchical classification systems (Castaldi et al. 2015; Content & Frenken 2016). While for technological knowledge, these classification systems are readily available, symbolic knowledge, eludes standardized, „accounting methods“ typically used in innovation studies to capture innovative activity and performance (Granger 2013). Instead, the classification of arts is a product of social, collective processes, not of central authorities (DiMaggio 1987).

For present purposes, this article introduces a novel way to identify and classify bits of symbolic knowledge. To compensate for the lack of such a system in music, this contribution is the first to create a 'folksonomy, a collective vocabulary (…) of tags assigned by many users' (Trant 2008) in order to compute related variety metrics. It does so by using volunteered, user-generated information from the social media platform Last.fm. From this data source, a music database was constructed that covers 8769 artists active between 1970-2015 in 33 urban regions in North America and Europe. User-generated data are especially suitable to analyze symbolic knowledge, as innovation in creative industries is less based on functionality and more on how changes of aesthetic content resonate with consumers (Miles & Green 2008; Martin & Moodysson 2011; Stoneman 2015). With the advent of social media, expressions of user reactions, evaluations, and experiences abound. This contribution leverages this abundance of such user-generated content to identify aesthetic content and novelty.

The results of this study reveal the composition of urban music scenes by their unrelated variety (UV), semi-related variety (SRV), and related variety (RV) (Castaldi et al. 2015) along with their average relatedness and specialization coefficient. Furthermore, we operationalize innovation as the creation, combination, and exploitation of symbolic knowledge in order to illustrate the creativity of urban music scenes. Our findings suggest that neither specialization nor variety promotes innovation in creative industries. At the same time, we find evidence that not all forms of related variety are equally important in explaining the level of innovation in symbolic knowledge bases. By disentangling innovation, this contribution can also point to the mechanisms through which related variety promotes innovation in creative industries.

The remainder of this article is structured as follows. While section 6.2 introduces the understanding of innovation in music as symbolic knowledge creation, section 6.3 formulates three hypotheses on the relation between the variety and creativity of urban music scenes. Section 6.4 presents how methods from EEG were transferred to the creative industry context. The results of the statistical analysis of the relationship between composition and creativity of music scenes are displayed and discussed in section 6.5, followed by concluding remarks in section 6.6.

6.2 Innovation in Creative Industries as Symbolic Knowledge Creation

Even though creative industries are supposed to be inherently innovative (Lee & Rodríguez-Pose 2014b), innovation in these industries has been hidden from traditional measures of innovations and was rarely studied (Miles & Green 2008). It is often linked to changes in aesthetic content, which are difficult to capture systematically (Stoneman 2015). The creation of aesthetic content requires knowledge of socially constructed symbols, ideas, habits, and norms that trigger 'reactions in the mind of consumers' (Martin & Moodysson 2011: 1188).

This knowledge has been coined 'symbolic knowledge' in the typology of the differentiated knowledge bases approach (Asheim 2007). In this typology, types of knowledge are not distinguished by their intensity, codifiability or content, but by their epistemological characteristics (Manniche 2012). The different knowledge types are associated with distinct rationales of knowledge creation, evaluation, validation, and diffusion (Asheim et al. 2011a). The different rationales originate from the different subject matters of these knowledge types. While analytical knowledge is concerned with the understanding and explanation of features of the natural world by discovering and applying scientific laws (Moodysson et al. 2008), synthetic knowledge is used to harness features of the natural world to solve human problems (Asheim 2007). Symbolic knowledge, however, refers to understanding the social world and is necessary to interpret and create symbols that are constructed by and within social contexts. It is used to create meaning, desire, aesthetic qualities, symbols, sounds, or images (Asheim & Hansen 2009).

Consequently, the three knowledge types also differ strongly in their context-dependency. Whereas and the natural world is independent of social or geographic context, the social world varies strongly between contexts. Thus, the value of symbolic knowledge varies between contexts and creators of symbolic knowledge have to tap into the localized habits, norms, and the 'everyday culture' of social groups to gain it (Asheim & Hansen 2009; Martin & Moodysson 2011). In contrast to technological knowledge, the value of new symbolic knowledge is strongly tied to consumers' interpretations and understanding, meaning that new symbols that are not understood or even disregarded, hold little value for their producers. Consequently, a transfer of symbolic knowledge between contexts is difficult (Martin & Moodysson 2011; Rekers 2016). The high context-dependency of symbolic knowledge also affects the institutional dimension of its combination. Symbolic knowledge that stems from different social contexts is especially difficult to integrate. These combinatorial knowledge dynamics demand considerably higher efforts from knowledge creators (Strambach & Klement 2012a).

The importance of symbolic knowledge for music is obvious. The success of musicians is ultimately depending on their ability to cater to an audience's taste (Pinheiro & Dowd 2009; Zwaan et al. 2009), which requires symbolic knowledge. Like symbolic knowledge, taste is deeply rooted in social, geographically bound contexts (Krims 2014) and forms in social interactions that assign value to certain types of music while denying it to others (Atkinson 2011). A common way to distinguish types of music is by music genres. We follow Lena & Peterson (2008: 698) in understanding music genres as 'systems of orientations, expectations, and conventions that bind together an industry, performers, critics, and fans in making what they identify as a distinctive sort of music'. Accordingly, it is not only the musicological characteristics that differentiate music, but also the symbolical meaning of language, dress codes, images, ideals, social practices, or conventions of musical performance that artists must be knowledgeable of in order to appeal to consumers (Peterson & Bennett 2004; Lena 2012). Hence, the music genres that local artists belong to can serve as bits of symbolic knowledge that constitute symbolic knowledge bases of urban music scenes, as illustrated in section 6.4. The next section will explore how the composition of these symbolic knowledge bases can be related to innovation in music.

6.3 Relatedness and Variety in Music Scenes

The concept of relatedness was made popular by a study of Hidalgo et al. (2007), in which the similarity between exported products of countries was used to characterize 'product spaces' on the national level. At the same time, interest in relatedness between economic activities on a regional level grew among economic geographers (Frenken et al. 2007), as its merits were obvious for the analysis of the relations between the composition of regional economies and aspects of economic growth. While formerly regional economies were mostly described by the shares of different industries, occupations, technologies, etc., the concept of relatedness allows taking into account the different similarities between economic activities. It provided the impetus for many studies anchored in EEG to analyze the composition of regional economies in depth ; Content & Frenken 2016). Relatedness between economic activities has since been identified by labor mobility flows (Neffke & Henning 2013; Otto et al. 2014; Fitjar & Timmermans 2016), joint use of technologies (Quatraro 2014), co-production in plants (Neffke et al. 2011) or semantic co-occurrences in titles of scientific articles (Boschma et al. 2014).

With the help of these measures, the variety of activities found in a regional economy can be differentiated by the relatedness between its constituents. The concept of related variety (Frenken et al. 2007) opened up new avenues for the debate on the merits of MAR (Marshallian) vs. JAC (Jacobs) externalities. Whereas unrelated variety provides a rich diversity of economic activities to be combined, the cognitive distance between them may be too high to allow combinations. At the same time, in specialized regional economies, opportunities for spillovers and re-combinations are rare (Antonelli et al. 2010). Regional economies characterized by related variety, however, can provide the optimal degree of cognitive distance to foster knowledge spillovers and (re-)combination, thereby facilitating innovation and driving employment growth (Frenken et al. 2007), which several studies have demonstrated (Content & Frenken 2016).

6.3.1 Variety and Innovation in Music

To analyze the relationship between the degree of variety in urban music scenes and their musical innovativeness, we test three hypotheses that are elaborated on as follows.

Hypothesis 1: The specialization of urban music scenes is positively associated with their musical innovativeness

The merits of localization economies have been discussed in economic geography for several decades and for a number of economic sectors (Caragliu et al. 2015). The music industry also tends to agglomerate in certain places (Scott 1999; Watson 2008; Florida et al. 2010), as an abundance of case studies that explore geographically denoted music genres show (Bell 1998; Bader & Scharenberg 2010; Lloyd 2014)

They illustrate how innovation in music may be linked to the specialization of music scenes: The traditional understanding of local scenes implies that specialization forges a common understanding among music professionals, fans and critics on which kinds of music and accompanying symbols are desirable. Signals about which pieces of music are reputable can reduce the typically ever-present uncertainty along several stages of the value chain (Lange & Bürkner 2013). In some specialized scenes, a strong narrative evolves that intertwines qualities of place with music-related characteristics (Spracklen et al. 2012; Cohen 2013; Weinstein 2014).

Furthermore, the coherent knowledge base found in specialized scenes may facilitate collective learning processes by reducing misunderstanding and providing complementarities that can be exploited by innovators. Concerning technological knowledge bases, their coherence has been identified as being positively associated with the amount (Kogler et al. 2013) and direction (Neffke et al. 2011) of technological innovation. It remains to be tested whether this holds true for symbolic knowledge creation as well.

Hypothesis 2: The unrelated variety of urban music scenes is positively associated with their musical innovativeness

Creative industries agglomerate mainly in cities (Florida 2012; Boix et al. 2016; DCMS 2016) not only because of localization economies but because of the heterogeneity of talent and activities found there, which provides manifold opportunities for recombination and inspiration (Jacobs 1969; Gong & Hassink 2017). In fact, large metropolitan areas with a great diversity of talent and economic activities are home to clusters of professional musicians (Florida et al. 2010) and the emergence of innovative, "new rock" genres (Johansson & Bell 2009).

From the perspective of EEG, however, in a knowledge base with high unrelated variety, the optimal level of cognitive proximity may be exceeded (Neffke et al. 2011). Consequently, studies do not find positive effects of unrelated variety on various growth variables (Frenken et al. 2007; Antonelli et al. 2010; Tavassoli & Carbonara 2014). However, Castaldi et al. (2015) also show that unrelated variety of knowledge bases is positively associated with the rate of radical innovations, in which unrelated knowledge domains are brought together.

The radical nature of symbolic knowledge creation could be one of the reasons why unrelated variety may have a different role for symbolic knowledge creation. Innovators in the arts often seek to deviate from the mainstream (Cohendet et al. 2014). Breaking the rules of mainstream music is a highly localized process, as Lena (2012) shows by the example of the emergence of rap music in New York: A wide range of genre-related aspects and practices are purposefully chosen to establish boundaries against established music styles (Lena 2012; Cohendet et al. 2014). According to Cohendet et al. (2014), a heterogeneous environment is conducive to innovation by providing sources of inspiration, recombination, collaboration, but also conflicts for new art movements. Thereby the codes, norms, and practices that should be associated with the new art form are enforced.

Hypothesis 3: The related variety of urban music scenes is positively associated with their musical innovativeness

The concept of related variety (Frenken et al. 2007) suggests that the composition of economic activities can also exhibit a beneficial mix of specialization and diversification. Related variety characterizes regions that possess a variety of economic activities that are also related (Otto et al. 2014). The original argument posed by Frenken et al. (2007) was that knowledge spillovers and combinations are more likely to occur between related economic activities than between unrelated ones. According to a review of 16 studies on related variety by Content & Frenken (2016), most studies have identified related variety to be associated positively with a range of variables associated with economic development.

Related variety is apparently also associated positively with regional innovation intensity measured by patent indicators (Tavassoli & Carbonara 2014; Castaldi et al. 2015). Especially the level of incremental innovation seems to benefit from related variety (Castaldi et al. 2015). Studies on diversification show that knowledge cores of related activities provide not only hotbeds but also vantages points, from which new analytical and synthetic knowledge emerges (Boschma et al. 2014; Rigby 2015). It has also been shown that related variety within the whole sector of creative industries is associated with its positive employment growth (Lazzeretti et al. 2017), pointing to cross-pollination between different creative industries.

But there are no studies that examine the effects of related variety on the creation of non-technological knowledge. It can be noted, however, that qualitative case studies often narrate the emergence of new art forms, such as music genres, as tales of the clash and intermingling of local scenes. Three recurring factors emerge in the literature: The role of inspiration and knowledge spillovers from within and outside local scenes (Lena & Peterson 2008; Watson et al. 2009; French 2017), the importance of agglomeration economies for the facilitation of interaction between music professionals (Lange & Bürkner 2013; Lloyd 2014; Brandellero & Pfeffer 2015), and the place-specific characteristics that shape identities, conventions, narratives and musical qualities of music genres (Leyshon et al. 1995; Bottà 2009; Weinstein 2014).

Urban music scenes featuring related variety may bring together these three factors by providing specialized contexts that offer agglomeration economies and place-specificities, from which artists can also draw a wide variety of complementary knowledge sources for inspiration.

6.4 Methodology

To analyze the relationship between variety and innovation in music scenes, data on artists originating from 33 cities active between 1970 and 2015 were collected. The data were collected from the social music platform last.fm, which was established in London (UK) in 2002 and possesses ~50 million users (Mauch et al. 2015). Users allow Last.fm to automatically track what they listen to on digital devices. In return, last.fm offers a comprehensive database of artists, songs, albums and genres as well as personalized radio stations and recommendations based on these data. One of the merits of this data source is that as soon as a single user listens to an artist, their profile is generated automatically on the website. Thus, selection bias is significantly reduced compared to other sources (Sordo et al. 2008).

Most important to this analysis, users can describe artists by as many tags as they please. The five tags most frequently used by last.fm users are displayed publicly on the artist profiles.[11], while the top 100 artists most frequently tagged with a tag are visible on a tag profile site. Tags mostly refer to genres, but also to general descriptions regarding instruments, gender or geographic origin (Sordo et al. 2008). The latter ones were employed to select the cities to be included in this database. Cities, whose city-related tags (e.g., miami bass, portland, compton) were used by more than 1,000 users were included in our sample. Only cities from North America and Europe were considered, as analyzing user-generated content written in alphabets other than the Latin one would not have been feasible. Furthermore, as last.fm is based in the Global North, data may be biased for music from the Global South.

Artists were included in the database when they fulfilled the following conditions:

1) Active at some point between January 1st,1970 and December 31st, 2014 and
2) Originating from the sample cities and
3) Amongst the 100 artists most frequently tagged with city-related tags or
4) Amongst the 100 artists most frequently tagged with genre-related tags[12].

For each artist, we collected data on their origin, years of activity, five most-used tags, and their number of last.fm listeners. Data on origin and activity were acquired from user-generated biographical information on last.fm when available but also researched and cross-referenced via other music-related websites, such as discogs.com, allmusic.com, artists' web presences and Wikipedia. Artists were attributed to a music scene when their location of residence at the time of the release of their first record belonged to a city's metropolitan statistical area.

[11] Since a site relaunch in 2015 that occurred after data collection, six tags are displayed.
[12] First, the top 100 artists for all relevant city-related tags were collected. Then the top 100 artists for any genre-related tags these artists were tagged with were included in the database. Any genre-related tag these artists introduced to the database was sourced for, and so on for all genres used to tag more than 20 artists in the database.

To reduce noise in the data, artists with less than 1000 listeners on last.fm were excluded from the database. Furthermore, tags that do not refer to music genres (e.g., 90s, sad, female vocalists) or were used to tag <30 artists on last.fm were omitted. After consolidating spelling variations for artists and tags, the database contained 8769 artists from 33 North-American and European cities.

6.4.1 Relatedness between Music Genres

As mentioned above, artist profiles on last.fm display the five tags that were most frequently used by users to describe them. Similar to other studies on relatedness ; Quatraro 2014); (Hidalgo et al. 2007; Neffke et al. 2011), this is regarded as the portfolio of the economic entity 'artist', in which genres co-occur.

We argue that the co-occurrences of genres point to complementarities, as artists evidently can combine aspects of these genres in such a way that listeners reflect these combinations in their own classification. Of course, the boundaries between music genres are blurred and co-occurrences can also arise from users' disagreement over the classification of an artist. However, this would still point to a similarity between these two genres. Hence, as most studies using the concept of relatedness, we cannot disentangle, whether relatedness stems from complementarity or from similarity (Boschma 2016).

The co-occurrences of genres are used to calculate the relatedness between all genre pairs, following the framework of Hidalgo et al. (2007). From the co-occurrence data based on the portfolios of all artists, a matrix of n*n (n=918) genres is constructed that displays how often each genre combination is jointly used to tag artists. The co-occurrence matrix of genres *g* shows the frequency *F* of artists tagged with any genre and of artists tagged with each pair of genres *i* and *j.* The relatedness $\phi_{i,j}$ is calculated as the minimum of the pairwise conditional probability of an artist being tagged with a genre given that it is tagged with another:

(1)

$$\phi_{i,j} = \min\{P(Fg_i \mid Fg_j), P(Fg_j \mid Fg_i)\}$$

For instance, in the database, there are 363 artists tagged with jazz, and 396 artists tagged with funk, while 95 artists are tagged with both genres. The share of funk artists that are also tagged as jazz represents the minimum conditional probability, resulting in $\phi_{jazz,funk}$

= 95/396= 0.24.We determine all pairs of genres that which satisfy $\phi_{i,j}$ > 0.04034192 as related, as this is the mean relatedness of all genre pairs with non-zero *F.*

6.4.2 A Classification System of Music Genres

Related variety is usually calculated by measuring the entropy on different levels of aggregation of a classification system of technologies or industries (Content & Frenken 2016). To calculate corresponding forms of variety for music scenes, a classification system of music genres is required that satisfies two conditions: First, it has to provide a system of hierarchy with different levels of aggregation. Second, it should group genres together that are related. Often, the measurement of related variety is criticized for presuming that elements belonging to a common category are related (Neffke & Henning 2013). To respond to this critique, this study employs relatedness data to generate an own classification system of music.

We also have to create an own classification system, as there is no central authority classifying music into genres. Retailers and record companies use systems that are directed to generate sales (Sordo et al. 2008). There are also online sources such as Myspace that rely on self-classification by artists, which also can provide insights on the geographic distribution of genres (Brydges et al. 2013). Yet these are similarly influenced by commercial considerations and biased self-assessments. In contrast, the last.fm data employed here accrued from the tagging activities of last.fm users and resembles volunteered, user-generated information with geographic footprints (Elwood et al. 2012; Crampton et al. 2013; Stefanidis et al. 2013). These tags form a folksonomy, a ‘collective vocabulary (…) of tags assigned by many users’ (Trant 2008). With relatedness metrics, a non-hierarchical, bottom-up folksonomy can be created, which is especially capable to provide a fine-grained taxonomy of music (Sordo et al. 2008).

The classification system (see Table 6.1) is constructed as follows: For each genre *i* we find amongst all other genres the potential superordinate genres that meet the criteria (1) ϕ_{ij} > 0.04034192 and (2) $F_j > F_i$. We argue that as *F* denotes the number of artists tagged with this genre, it represents the popularity of a genre and that the popularity of a superordinate genre has to be higher than its subordinate. Amongst these genres, the genre with maximum *F* is chosen as the superordinate genre g_S. If there is no genre that meets condition (1), the genre which maximizes ϕ_{ij} is chosen as the superordinate genre.

6.4.2 A Classification System of Music Genres

All genres with the same superordinate genres are grouped together with g_s in a category named after g_s, which is grouped with other genres in their respective superordinate category, and so forth. The last step in which the most popular genre would become g_s of all other categories was omitted. In the end, the 918 genres of the database were classified in a system that contains seven streams and seven levels of aggregation, which are numbered by digits similar to the NACE classification. We follow Ennis (1992) in calling the highest level of aggregation on the 2-digit-levels ‘streams’. These are families of genres that probably share aesthetics, audiences, and institutions. To improve comprehensibility, categories on the 4-digit-level are called ‘music styles’ in the following.

Table 6.1: A classification system of music genres generated from relatedness metrics

01	**Electronic**	**03**	**Hip-Hop**	**05**	**Pop**	**07**	**Singer-Songwriter**
01.00	electronic	03.00	hip-hop	05.00	pop	07.00	singer-songwriter
01.01	ambient	03.01	dirty south	05.01	disco	07.01	acoustic rock
01.02	chillout	03.02	east coast rap	05.02	dreamgaze	07.02	americana
01.03	dance	03.03	gangsta rap	05.03	funk	07.03	country
01.04	deep house	03.04	rap	05.04	party punk	07.04	electrofolk
01.05	downtempo	03.05	rnb	05.05	teen pop	07.05	mellow rock
01.06	dubstep	03.06	soul	05.06	ye-ye	07.06	progg
01.07	electro	03.07	southern rap				
01.08	electronica	03.08	underground hip-hop	**06**	**Rock**		
01.09	house	03.09	underground rap	06.00	rock		
01.10	idm	03.10	west coast rap	06.01	blues		
01.11	industrial			06.02	blues rock		
01.12	minimal	**04**	**Indie**	06.03	classic rock		
01.13	rocktronica	04.00	indie	06.04	emo		
01.14	synthpop	04.01	alternative	06.05	garage rock		
01.15	techno	04.02	alternative rock	06.06	hard rock		
01.16	trip-hop	04.03	britpop	06.07	loungecore		
		04.04	electro-acoustic	06.08	metal		
02	**Experimental**	04.05	folk	06.09	ostrock		
02.00	experimental	04.06	hamburger schule	06.10	power rock		
02.01	avant-garde	04.07	indie pop	06.11	progressive rock		
02.02	drone	04.08	indie rock	06.12	punk		
02.03	jazz	04.09	lo-fi	06.13	punk rock		
02.04	math rock	04.10	new weird caledonia	06.14	wizard rock		
02.05	no wave	04.11	post-punk				
02.06	noise	04.12	shoegaze				
02.07	noise rock						
02.08	psychedelic						

Sources: Own analysis of last.fm data

6.4.3 Music Scenes as Symbolic Knowledge Spaces

From the population of artists in the sample cities, the genres they are tagged with, the relatedness between genres, and the classification of genres by a folksonomy, network-based visualizations of music scenes can be created. These depict the composition of music scenes by the music genres existing in it at a certain time.

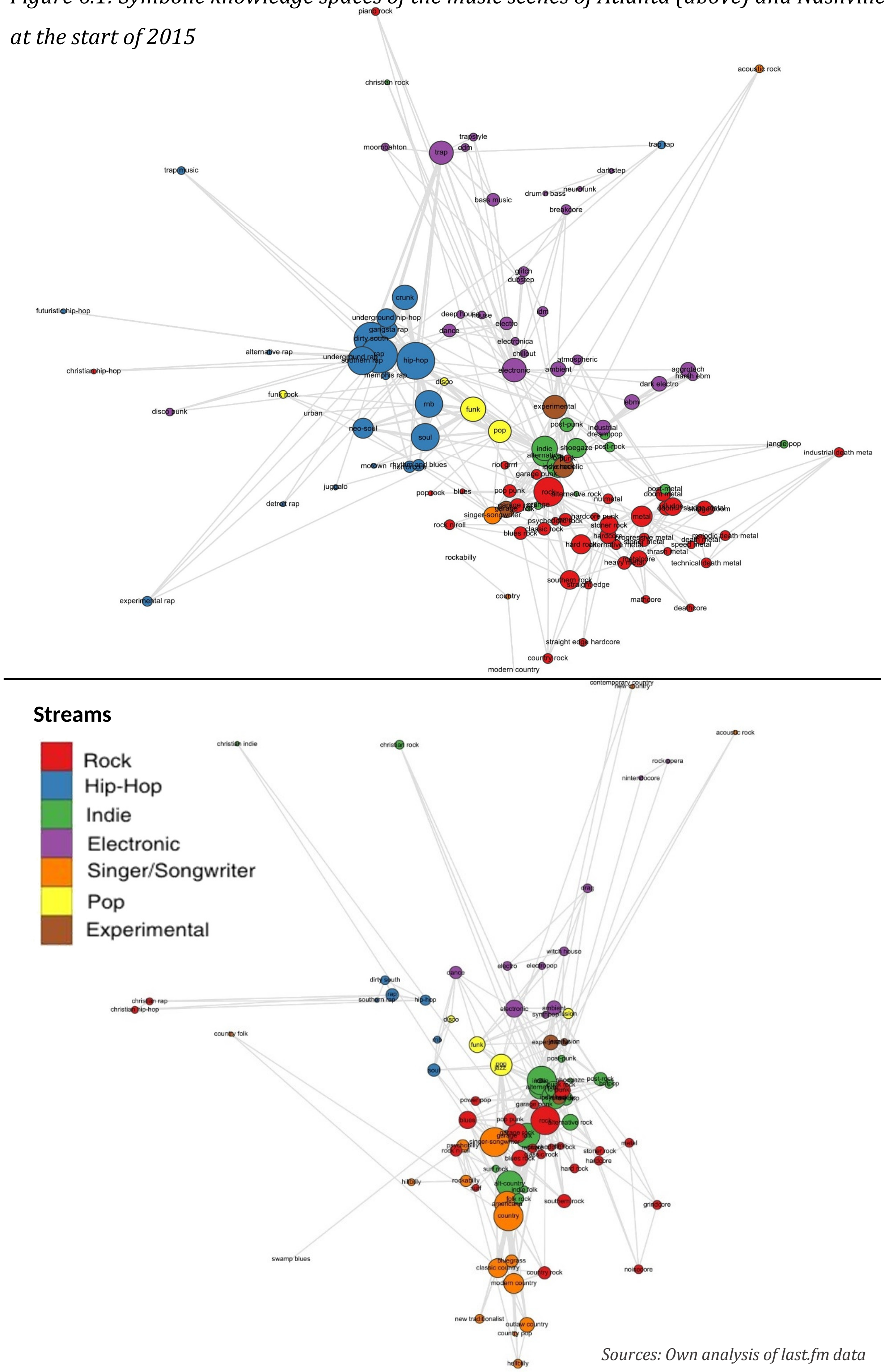
In the existing literature, these network-based visualizations are called spaces. For instance, these spaces have been constructed to map the products (Hidalgo et al. 2007), industries (Neffke et al. 2011), and technological knowledge ; Rigby 2015; Balland & Rigby 2016) present in regional or national economies. Despite using the word "space", the coordinates of and the ties between the nodes of these networks do not show spatial information but inform about the relatedness between constituent elements. For present purposes, we characterize music scenes by their symbolic knowledge spaces.

These symbolic knowledge spaces provide ways to characterize music scenes, compare them, and display their evolution over time. While the nodes of these spaces depict music genres, the ties between two nodes show if and how often local artists were tagged with both genres. The size of nodes reflects the relative popularity of genres in the respective music scene, calculated by the log degree of nodes in the network. The coordinates of nodes in the networks are not random but computed from the relatedness between genres in the entire database by a Fruchterman-Reingold algorithm. The algorithm sorts less popular, relatively unconnected genres at the periphery of the network, while popular genres are found in the center. For present purposes, coordinates were fixed in all knowledge spaces to allow easier comparability. The color of nodes depicts to which stream of the generated classification system of music genres (Table 6.1) a music genre belongs.

Figure 6.1 shows the symbolic knowledge spaces of two important music scenes (Florida & Jackson 2010), Atlanta and Nashville, at the end of 2014. In fact, both have been described in existing studies as centers of distinctive music scenes. While Atlanta has become a major center of rap and hip-hop (French 2017), Nashville's has a long history as the center of country music (Lloyd 2014).

6.4.3 Music Scenes as Symbolic Knowledge Spaces

Figure 6.1: Symbolic knowledge spaces of the music scenes of Atlanta (above) and Nashville at the start of 2015



Sources: Own analysis of last.fm data

6.4.3 Music Scenes as Symbolic Knowledge Spaces

This is also visible in their symbolic knowledge spaces. While rap and hip-hop are depicted by blue nodes, especially prominent in Atlanta's knowledge space, the country and singer-songwriter music typical for Nashville is depicted by orange nodes. Both take a prominent role in their respective knowledge space, as expected. What the symbolic knowledge spaces also show is how these central genres are connected to other genres present in the local music scene. Thus, they inform about the coherence of music scenes, structural holes, cross-pollination between genres, or possible diversification routes. In the case of Atlanta, one could argue that there is a certain dualism between the cluster of hip-hop genres and rock/indie music on the bottom right. Both clusters, however, appear open and linked to electronic and pop music, especially the rap cluster which is linked to the recently emerged trap (Haithcoat 2012) in the upper center. In the bottom half of the Figure, Nashville's music scene appears very coherent and dense and shows little diversification beyond guitar-oriented music.

Symbolic knowledge spaces can also show the evolution of music scenes and display in which directions music scenes diversified. Figure 6.2 provides the example of the evolution of Berlin's music scene by capturing the music scene at the beginning of 1985,1995, 2005, and 2015. It can be seen that the seeds for Berlin's thriving techno scene (Bader & Scharenberg 2010; Lange & Bürkner 2013) were laid in the 1980s when electronic music was mostly linked to experimental krautrock (brown in the picture). After reunification, a cluster of electronic genres emerges, while other genres remain relatively stagnant. What is characteristic of the Berlin music scene, though, is that many artists from other genres implement electronic elements, so that electronic becomes a central element of the music scene. At the turn of the millennium, a new cluster of genres in the rap/hip-hop stream emerges very quickly, relatively separate from the other genres in the scene. At the same time, a high variety of electronic subgenres emerges. Between 2005 and 2015, there is little change in the overall picture. Most noticeable, the electronic stream becomes very dominant in comparison to the slightly increased indie stream of music.

While these visualizations provide an intriguing way to explore and narrate the structure music scenes, their analytical value is limited. To use the structure of music scenes in quantitative analysis, several variety metrics have to be calculated, as shown in the next section.

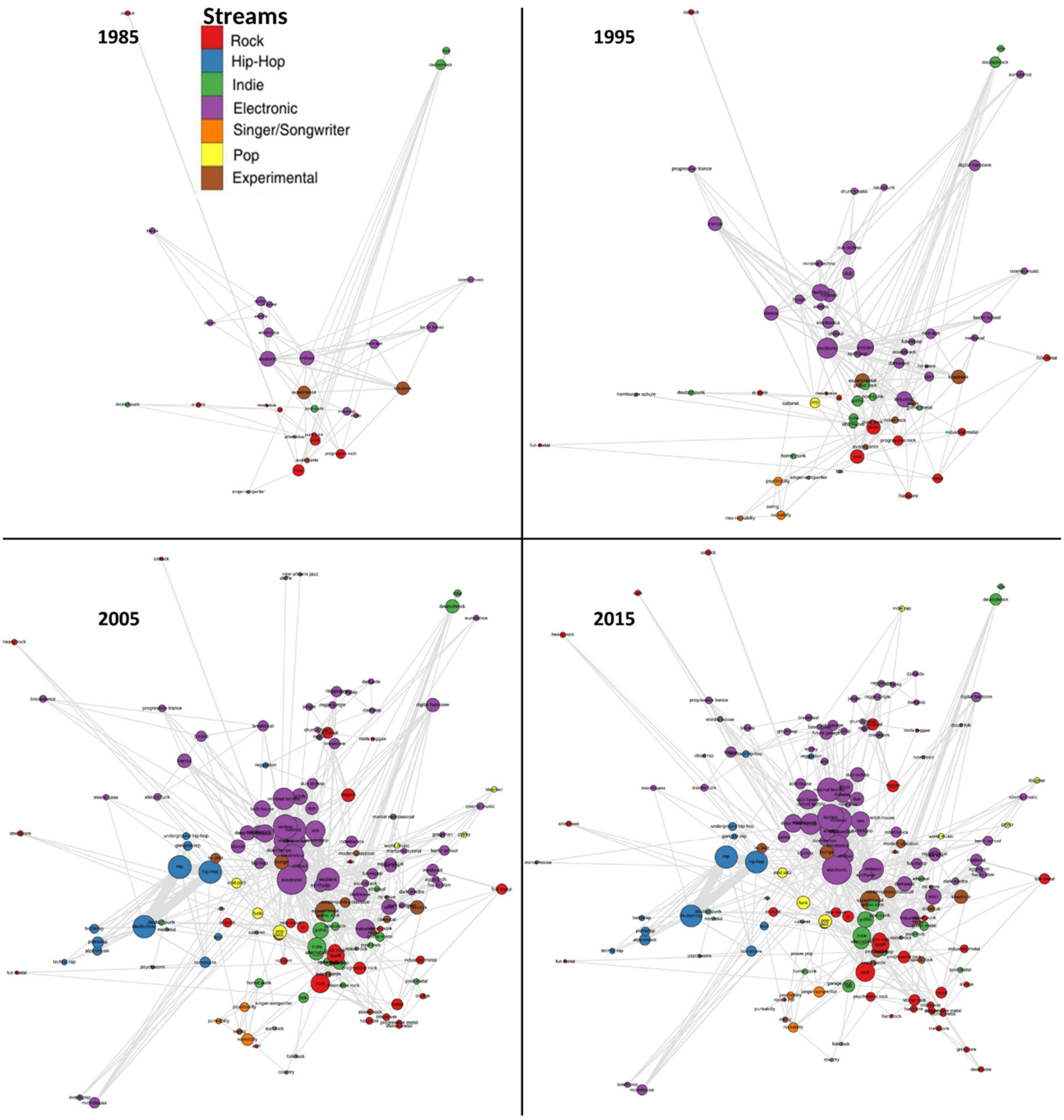


Figure 6.2: Evolution of the symbolic knowledge space of the Berlin music scene, 1985-2015
Sources: Own analysis of last.fm data

6.4.4 The Independent Variables: Specialization, Relatedness, and (Related) Variety

The independent variables of this study characterize the composition of the symbolic knowledge bases at distinct points in time. They were calculated for all measuring points *t*, which are 5 years apart, starting from January 1, 1970 and ending in 2010.

To test H_1, the specialization of music scenes is measured by the specialization coefficient and the average relatedness of ties in the music scene. The specialization coefficient is calculated by measuring the deviation of shares of genres on music scenes to the ones for the whole sample at a given time. (2) denotes how the specialization coefficient SC_{mt} (Bathelt & Glückler 2012: 92)) for a music scene m at a time t is calculated by using the frequencies f of local artists and F of all artists tagged with a genre i. SC reaches its minimum 0 when the composition of a music scene equals the total sample and its maximum 1 when it is home only to artists tagged with one genre.

(2)

$$SC_{mt} = \frac{1}{2}\sum_{i=1}^{I}\left|\frac{f_{imt}}{f_{mt}} - \frac{F_{it}}{F_t}\right|$$

Furthermore, the average relatedness AR_{mt} of ties found in a music scene is calculated, similarly to the cognitive proximity measure found in Feldman et al. (2015). Whereas SC treats all distances between genres as the same, this measure takes the relatedness between genres into account and characterizes the coherence of music scenes. (3) displays how AR is obtained by dividing the sum of the relatedness matrix R weighted by the frequencies of the co-occurrence matrix of a music scene CM_{mt} with the sum of CM. Like $\phi_{i,j}$, AR ranges between 0 and 1.

(3)

$$AR_{mt} = \frac{\sum CM_{mt}R}{\sum CM_{mt}}$$

To test H_2 and H_3, we follow Castaldi et al. (2015) in calculating three different measures of variety in such a way that the variety of streams, the highest level of aggregation of our classification system, refers to unrelated variety. The variety of music styles on the 4-digit-level within streams refers to semi-related variety, while the variety of genres within the 4-digit level refers to related variety.

For the calculation of unrelated, semi-related and related variety, the Shannon entropy (Shannon 1948) at different levels of aggregation is calculated (Castaldi et al. 2015) as follows. Let all events of a local artist A being tagged with a given genre i be noted as A_i, with their corresponding probabilities p_i, with $i = 1,\ldots, I$. Every level of aggregation can be understood as a set of groups S_g, with $g = 1, \ldots, G$, to which all events A_i are exclusively assigned to. Then (4) obtains the probability that an artist from a music scene is tagged with a genre from a group g.

(4)

$$P_g = \sum_{i \in S_g} p_i$$

Following Frenken et al. (2007) and Castaldi et al. (2015), the measurement of unrelated variety (UV_{mt}) for a music scene *m* at a given point in time *t* is then achieved as shown in (5), in which *k* represents the categories of music genres at the level of streams, where *k*=1,…,*K*.

(5)

$$UV_{mt} = \sum_{k=1}^{7} P_{kmt} ln\left(\frac{1}{P_{kmt}}\right)$$

As the decomposition theorem (Theil 1972) states, the entropy at the level of events is equal to the entropy at any level of aggregation plus the weighted sum of the corresponding within-group entropy (Frenken et al. 2007). Thus, semi-related variety (SRV_{mt}) and related variety (RV_{mt}) are obtained according to (6) and (7) (Castaldi et al. 2015).

(6)

$$SRV_{mt} = \sum_{l=1}^{79} P_{lmt} ln\left(\frac{1}{P_{lmt}}\right) - \sum_{k=1}^{7} P_{kmt} ln\left(\frac{1}{P_{kmt}}\right)$$

(7)

$$RV_{mt} = \sum_{i=1}^{919} P_{imt} ln\left(\frac{1}{P_{imt}}\right) - \sum_{l=1}^{79} P_{lmt} ln\left(\frac{1}{P_{lmt}}\right)$$

Here, *l* indexes the music styles at the 4-digit level and *i* indexes the genres. High semi-related variety would be attained in a music scene with a high variety of music styles within streams (e.g., the sub-genres of rock music), while related variety depends on the variety of genres found within music styles at the 4-digit level (e.g., the sub-genres of the metal genre). As entropy refers to the uncertainty of probability distributions, a music scene in which all p_i are equal would have the maximum entropy of *ln(I)*, while a music scene, whose artists are all located within one genre would reach the minimum value of 0. Theoretically, different variety measures are independent of each other but may correlate empirically (Castaldi et al. 2015).

6.4.5 The Dependent Variables: Innovation in Music

From the database, we compute the dependent variables NEW GENRES, PIONEERS, COMBINATORS and SUPERSTARS to capture the creation, combination, and exploitation of symbolic knowledge in music scenes for distinct 5-year-long time periods between all measuring points *t.*

First of all, innovation in music can be understood as the creation of symbolic knowledge by the emergence of a new genre. All genres are regarded as NEW GENRES that were not used to tag artists established before 1970 and assigned to at least 30 artists in our database. Following these criteria, of the 919 genres in the database 118 count as new genres.

The birth of a genre is determined by the earliest establishment year of any artist tagged with it. Among all artists tagged with a new genre, the ones founded within four years of the birth of a genre are called PIONEERS. These criteria correspond to 661 artists in the database. The locations of these pioneers are understood as birthplaces of a new genre. It is necessary to measure both pioneers and new genres, as some artists are instrumental in the emergence of several genres and most genres are brought into existence by several pioneers.

Furthermore, with the variable COMBINATORS, we acknowledge the importance of recombination for innovation in creative industries (Miles & Green 2008) and the concept of combinatorial knowledge dynamics (Strambach & Klement 2012a). To identify novel combinations between music genres, we compared the values of co-occurrence matrices at subsequent *t*, whereas novel combinations of music genres are indicated by a number of co-occurrences of two genres changing from 0 to positive values. All artists that combined music genres that came into existence before t-1, but were not connected before t, are called COMBINATORS. To avoid conflation with the NEW GENRES variable, all combinations involving new genres during the pioneering phase were omitted from this variable. 2384 artists are identified as combinators.

Innovation in music may also manifest in the success of artists. Popular artists may have been unique or innovative in other ways than previously mentioned and may point to the exploitation of symbolic knowledge. These artists often arise in the industrial phase (Lena 2012) of a genre, bringing genres which used to be limited to underground scenes to a wider mainstream audience. For the purpose of this study, the variable SUPERSTARS records how many artists that have more than one million listeners on last.fm were established in a music scene. On the whole, 385 artists in the database are regarded as superstars.

6.5 Empirical Findings

As these variables on creativity and composition of music scenes have not been constructed before, some descriptive insights are necessary before we turn to the analysis of the relation between the composition and creativity of music scenes. The 5 most and least innovative music scenes are presented in Table 6.2. Innovation in music appears to be unevenly distributed and linked closely to city size. New York City alone was home to pioneers of 48% of the 118 new genres in this database. In the bottom 5 lists, the prevalence of cities from the Southern USA is noticeable. Apparently, innovation in music mirrors the general process of the music industry moving away from traditional centers towards large metropolitan areas, as indicated by Florida et al. (2010).

Table 6.2: Innovation in music scenes from 1970 to 2015

	Combinators		Superstars		Pioneers		New Genres	
Rank	City	Value	City	Value	City	Value	City	Value
1	New York City	377	London	66	New York City	140	New York City	57
2	London	317	New York City	65	London	110	London	40
3	Los Angeles	302	Los Angeles	64	Los Angeles	73	Los Angeles	33
4	Chicago	119	Chicago	14	San Francisco	37	San Francisco	29
5	San Francisco	113	Atlanta	14	Chicago	36	Chicago	22
29	Sheffield	23	Minneapolis	1	Liverpool	5	Gothenburg	3
30	Leeds	22	Liverpool	1	Montreal	4	Memphis	3
31	Houston	21	Memphis	1	New Orleans	3	Barcelona	3
32	Nashville	21	Hamburg	0	Barcelona	2	New Orleans	2
33	Memphis	20	Barcelona	0	Nashville	1	Nashville	1

Sources: Own analysis of last.fm data

Looking at innovativeness of music scenes over time (Figure 6.3) reveals that user-generated data are time-dependent. Yet this figure should not be taken as evidence for a decreasing creativity in music. In this study, only genres with more than 30 tagged artists are considered new genres. This may result in right-truncation of this variable. Conventions on the names of new genres emerged within the last 10 years may not have been agreed upon yet and consequently were used less.

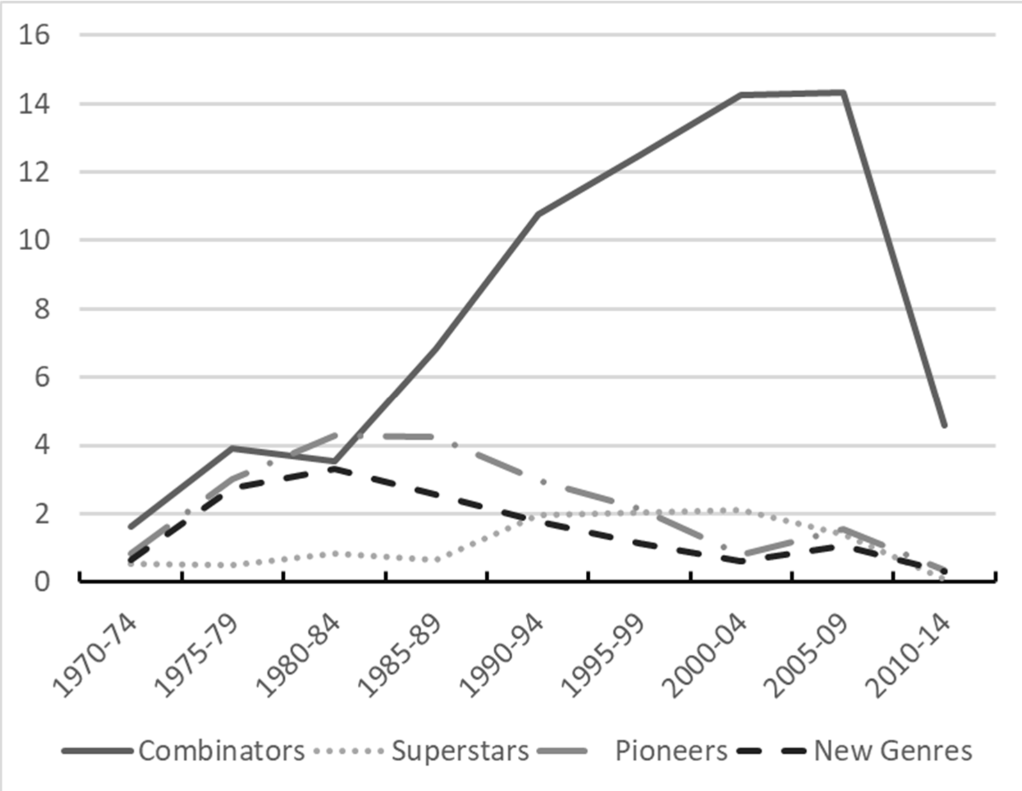


Figure 6.3: Average innovativeness per music scene over time
Sources: Own analysis of last.fm data

Table 6.3: Characteristics of urban music scenes (averages over 1970-2015)

No. of artists			Specialization Coeff.		Avg. Relatedness	
Rank	City	Value	City	Value	City	Value
1	New York City	405.67	Barcelona	0.65	Barcelona	0.15
2	London	299.67	Bristol	0.63	Minneapolis	0.15
3	Los Angeles	286.67	Nashville	0.62	Memphis	0.14
4	Chicago	147.67	Seattle	0.61	Houston	0.14
5	Detroit	107.89	Gothenburg	0.61	Seattle	0.14
29	Liverpool	25.00	Chicago	0.41	Glasgow	0.10
30	Leeds	24.56	London	0.37	Manchester	0.10
31	Barcelona	24.00	San Francisco	0.32	Baltimore	0.09
32	Baltimore	22.11	New York City	0.28	Gothenburg	0.09
33	Sheffield	21.33	Los Angeles	0.24	Berlin	0.08

Sources: Own analysis of last.fm data

Considering control and independent variables, Table 6.3 displays the characteristics of music scenes according to their average number of artists, their specialization, or average relatedness. Music scenes differ strongly by size, as indicated by the number of local artists. Unsurprisingly, the most populous cities in the sample (New York City, London, Los Angeles) are also leading in music scene size. Yet more relevant to this study are the variables capturing the composition of music scenes. Leading in regards to average SC are cities, which also have been associated with pop culture and case studies with certain music genres. As the average relatedness (AR) takes into account the distance between genres that artists bridge when they combine genres, music scenes in which many artists belong to clusters of related genres have the highest scores.

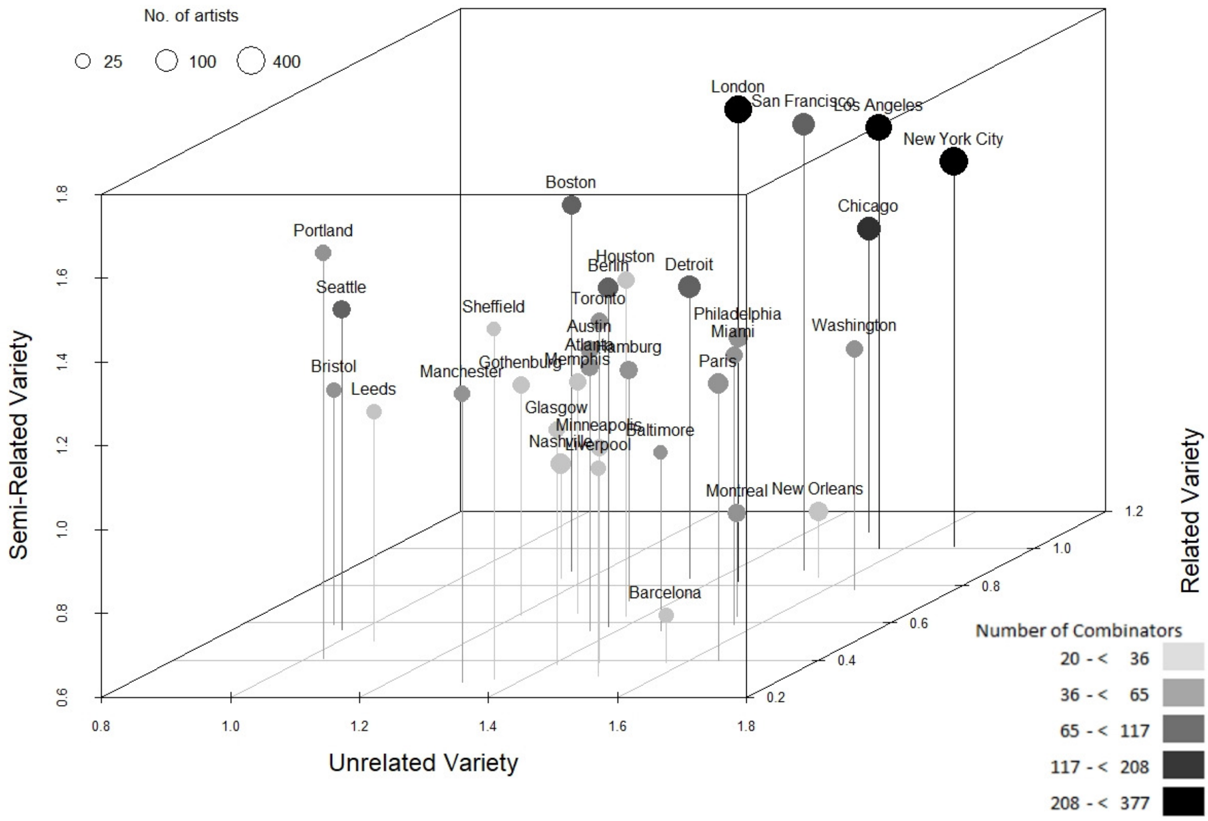


Figure 6.4: Variety and innovation music scenes

Sources: Own analysis of last.fm data

As we calculated three variety metrics, a 3D scatterplot (Figure 6.4) is especially suited to display how music scenes can be characterized by different combinations of variety forms. In general, the possible maximum of entropy measures depends on the number of artists present in a music scene, as a higher number of artists can be active in a higher number of genres. Thus, the average, log-transformed number of artists per music scene is visualized by the size of points. In fact, UV is highest in large cities or cities where local artists are assigned to multiple streams. An especially low unrelated variety is found in Portland, Seattle, Bristol, and Leeds, where most local artists belong to only one or two streams. Considering RV, Chicago takes the top spot, while UK music scenes score low on related variety. The height of points represents the semi-related variety, which is highest in London, New York City, Boston, and cities on the US west coast. It is particularly low for the music scenes of Barcelona, New Orleans, or Montreal.

Figure 6.4 also provides a first look at the relationship between the composition of music scenes and their creativity. The shade of points refers to innovation in the form of combination of symbolic knowledge. For clearer visibility, the number of combinators is visualized according to a logarithmic scale. A visual inspection shows that the shade of points increases with their height which depends on their semi-related variety. Apparently, music scenes with high SRV tend to have a higher number of combinators, At the same time, the relation between UV or RV to the number of combinators does not seem to be very distinctive. As larger points also appear to be darker shaded, the size of music scenes is also linked to innovation in music scenes.

In addition to that, Figure 6.5 displays how the independent variables have changed over time. Even though last.fm listeners are free to listen to and tag artists from all time periods, of course, artists from the last 20 years are more present in the users' listening habits and thus also for our sample. This is indicated by the number of artists per music scene sharply increasing over the years. With larger music scene size, variety and relatedness indicators increase, while the specialization coefficient drops sharply after 1990. This points to a strong time variance of the data.

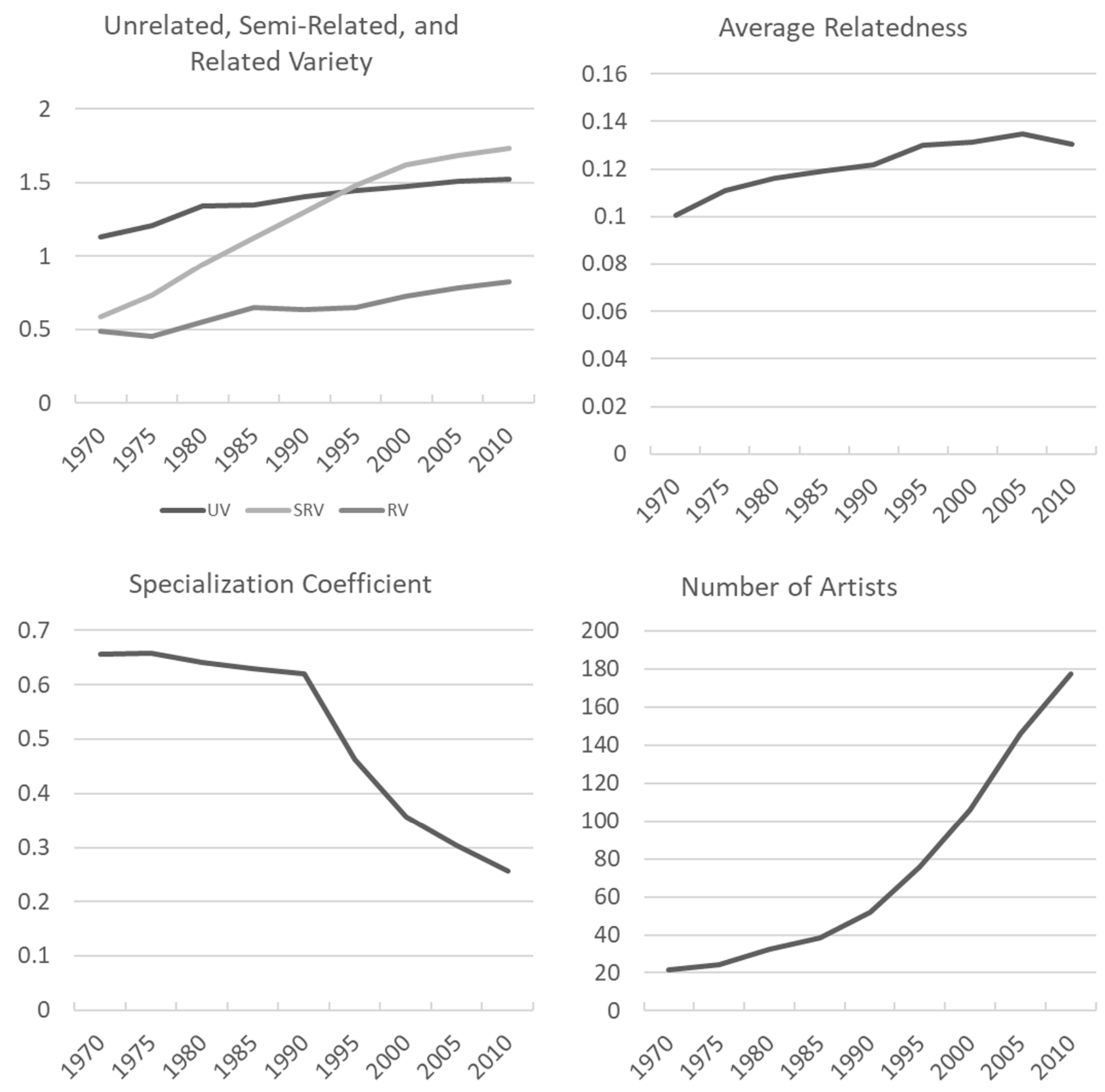


Figure 6.5: Average composition of music scenes over time
Sources: Own analysis of last.fm data

6.5.1 Composition and Innovativeness of music scenes

The previous illustrations show that an analysis of the relation between innovativeness and composition of music scenes has to account for effects of time and scene size on both independent and dependent variables. Furthermore, there is a risk of endogeneity, as innovation may not only be promoted by (related) variety but also create variety. Hence, this study applies panel data analysis with lagged independent variables. The high time-dependence of the data (which is supported by the results of Hausman tests) and the intent of this study to investigate how the composition of music scenes is related to their innovativeness call for a model with time-fixed effects. The number of artists in a music scene is used to control for effects of scene size on both independent and dependent variables.

Consequently, the data of this analysis are structured as balanced panel data. The independent variables and control variables are measured at nine points in time (*t-1*) between 1970 and 2010 that are 5 years apart. The starting population of 1970 and corresponding variety data result from artists founded before 1970 and active in 1970. The dependent variables are aggregated for the time period (*t*) over the following five years (e.g., 1970-1974, 2010-2014). As there are 33 cities in the sample, this results in 297 observations. As the descriptive statistics in Table 6.4 show, innovation in music is not observed in every city/time span-combination and its distribution is right-skewed. Thus, it is necessary to log-transform the dependent variables correlating and the control variable.

Table 6.4: Descriptive statistics

Dependent variables	Observed	Mean	Standard deviation	Median	Min	Max
Combinators	297	8.03	12.15	4.00	0.00	76.00
Superstars	297	1.13	2.54	0.00	0.00	16.00
Pioneers	297	2.24	5.01	1.00	0.00	45.00
New Genres	297	1.57	2.68	1.00	0.00	19.00
Independent variables						
Specialization Coeff.	297	0.51	0.20	0.50	0.00	0.97
Avg. Relatedness	297	0.12	0.03	0.12	0.00	0.23
Unrelated Variety	297	1.38	0.30	1.43	0.00	1.78
Semi-related Variety	297	1.24	0.50	1.37	0.00	1.95
Related Variety	297	0.64	0.31	0.69	0.00	1.41
No. of artists	297	74.86	116.44	41.00	0.00	930.00

Sources: Own analysis of last.fm data

The estimates for the time-fixed effects models on the relation between innovativeness and composition of music scenes are displayed in Table 6.5. As specification tests revealed evidence of heteroskedasticity of unknown form, the displayed estimates were calculated with heteroskedasticity-consistent standard errors (Zeileis 2004). Multicollinearity was not a concern, as VIF values ranged between 1.146 (AR) and 5.343 (No. of artists).

Table 6.5: Estimates of time-fixed effects models

Independent variables	*Dependent variables (log-transformed)*			
	$COMBINATORS_t$	$SUPERSTARS_t$	$PIONEERS_t$	$NEW\ GENRES_t$
Specialization $Coefficient_{t-1}$	-0.531	-0.746	-1.263	-1.247
	(0.426)	(0.422) .	(0.458) **	(0.403) **
Average $Relatedness_{t-1}$	-1.650	0.676	-0.700	0.064
	(1.956)	(1.286)	(1.736)	(1.409)
Unrelated $Variety_{t-1}$	-0.085	-0.265	0.161	0.104
	(0.249)	(0.154) .	(0.214)	(0.201)
Semi-related $Variety_{t-1}$	0.535	0.237	0.722	0.559
	(0.214) *	(0.139) .	(0.186) ***	(0.168) ***
Related $Variety_{t-1}$	0.306	-0.225	0.160	0.101
	(0.175) .	(0.157)	(0.181)	(0.146)
No. of $artists_{t-1}$ (log)	0.440	0.346	0.130	0.066
	(0.119) ***	(0.100) ***	(0.109)	(0.085)
Adjusted R^2	0.479	0.335	0.296	0.253
F Statistic (df = 6; 282)	47.683 ***	27.214 ***	23.102 ***	19.034 ***

Note: Estimates for time-fixed effects regressions (oneway)
Heteroskedasticity-consistent standard errors in parentheses
(***) p <0.001, (**) p<0.01, (*) p<0.05, (.) p<0.1
log-transformed variables were transformed by the function ln(x+1)
Balanced Panel: n=33, T=9, N=297

Sources: Own analysis of last.fm

Several of the explanatory variables are related to different aspects of innovativeness. First of all, there is a clearly negative relation between the specialization coefficient of music scenes and the creation of symbolic knowledge operationalized by PIONEERS and NEW GENRES. Average relatedness, however, which also points to the specialization of music scenes in terms of knowledge base coherence, does not show any significant relation to innovation in music. But neither is unrelated variety, which can be interpreted as the opposite of specialization. It is even negatively related to the number of superstars in a scene. The most noticeable results concern the semi-related variety of music scenes, as it is significantly and positively associated with all innovation indicators. Finally, related variety, that is the variety of sub-genres within music styles at the 4-digit level, is only weakly significant at the .1 level and positively related only to COMBINATORS.

6.5.2 Discussion of results

Our initially proposed hypothesis H_1 that implied a positive relation of specialization with symbolic knowledge creation and combination cannot be confirmed. Neither the specialization coefficient nor the average relatedness of music scenes is positively related to any dependent variable. In fact, SC is even negatively related to the emergence of new genres and pioneers and the exploitation of symbolic knowledge by superstars. Apparently, localization economies do not promote innovation in music, but rather limit it. This indicates that strong negative effects of path-dependency (Martin 2010; Henning et al. 2013) have an impact on symbolic knowledge creation.

Yet H_2 that refers to the merits of unrelated variety cannot be confirmed either. Artists especially are limited in exploiting available elements of symbolic knowledge when these are distributed too broadly across the symbolic knowledge space. Apparently, it is less the quantity of sources of inspiration that promotes innovation in music, but more their complementarity. This supports the previously mentioned context-dependency of symbolic knowledge (Asheim 2007): A certain degree of relatedness between knowledge sources appears necessary to reduce the variety of contexts that have to be integrated in order to combine or create symbolic knowledge.

In fact, the results confirm our hypothesis H_3 that a form of related variety of music scenes is positively related to their innovativeness. This is especially true for the combination of symbolic knowledge in music scenes, as both semi-related and related variety are related to the number of combinators. However, there are limits to the degree of relatedness, as indicated by the weak or non-existent relation of RV with the majority of innovation variables, while semi-related variety is positively related to all dependent variables. Evidently, the related variety of sub-genres within music styles on the 4-digital level (e.g., the sub-genres of metal music) already refers to a variety that is too narrow to provide inspirational sources. The semi-related variety of music styles within streams (e.g., the sub-genres of rock music), however, is significantly and positively related to all innovation indicators. Music scenes with this kind of variety have apparently reached an optimal level of variety that is conducive to innovation in music.

As both variables are associated with the number of combinators, the original assumption proposed in the related variety literature (Frenken et al. 2007) that (re-)combination is the main mechanism by which relatedness between activities in a knowledge base promotes innovation, is supported. One may argue that a knowledge base with high related variety simply provides a quantitatively larger pool of combinable elements. Yet, as related variety turns out to only affect only one out of four types of innovation, the distance between knowledge sources also plays an important role in promoting symbolic knowledge combination. However, it has to be noted that in this study the elements that are combined do not have to be present in the music scene before their combination. Thus, related variety may also promote the combination of external knowledge with the existing knowledge base in some way.

Judging from the fit of the models, the combination of symbolic knowledge is best explained by the composition of music scenes. This appears logical, as the related variety variables best reflect the local availability of combinable elements in knowledge bases. In contrast, the creation of symbolic knowledge, as indicated by the number of pioneers and new genres, is considerably less well explained by the composition of music scenes. It can be assumed that for the creation of symbolic knowledge not only the composition of the local music scene is relevant, but also its ability to attract and anchor external knowledge (Jeannerat & Crevoisier 2011). Interestingly, the independent variables have relatively low significance levels for the explanation of the number of superstars. The exploitation of symbolic knowledge may be more dependent on other factors not included in these models, such as the agglomeration economies and networks found in a music cluster able to produce and market a high number of mainstream acts, like the one found in Nashville (Lloyd 2014).

6.6 Conclusions

This article investigated the relationship between the composition of symbolic knowledge bases and their innovativeness. Its major methodological contribution lies in transferring methods and metrics from EEG typically used to analyze technological knowledge to the analysis of innovation in a creative industry. We were able to characterize 33 music scenes from Northern America and Europa by their specialization, average relatedness, and (semi-)related variety (Castaldi et al. 2015) over the time period from 1970 to 2015. In addition, novel ways to operationalize the creation, combination, and exploitation of symbolic knowledge were introduced to capture innovation in music. Thereby this contribution demonstrated that the composition of symbolic knowledge bases is related to their innovativeness.

Even though pop cultural discourses and narratives emphasize the specialization of urban music scenes in distinct music genres, this study indicates that specialization of music scenes limits their innovativeness. These findings indicate that excessive accumulation of symbolic knowledge in a specialized field may limit opportunities for creation and combination of symbolic knowledge and thereby support central claims of the path dependency literature (Martin 2010; Henning et al. 2013).

At the same time, the findings of this article do not imply that the opposite of specialization, unrelated variety, promotes innovation. In the words of a sound engineer, there is a 'sweet spot' between variety and specialization of music scenes that is characterized by high semi-related variety, the variety within broader streams of music (e.g., rock music, electronic music, hip-hop music). This analysis illustrates that this type of variety is positively associated with the number of combinators, superstars, pioneers and new genres in music scenes. Related variety of music scenes, which refers to the variety within narrower music styles (e.g., metal, punk, techno, gangsta rap), however, turned out to be only positively related to the creation of new genre combinations in music scenes. These findings highlight that the effects of related variety highly depend on the hierarchical levels of classification systems used in its calculation.

One major contribution of this study is the identification and analysis of combinatorial knowledge dynamics (Strambach & Klement 2012a) in symbolic knowledge bases that allows gaining insights on the actual mechanism that links (semi-)related variety to innovation. That both related variety measures are positively related to the combination of symbolic knowledge supports the original hypothesis of Frenken et al. (2007) that the relatedness of elements in a knowledge base facilitates their (re-)combination, thereby leading to higher levels of innovation.

The findings of this study provide several avenues for future research. First of all, how a music scene characterized by high related variety affects actors on the micro-level in practice may provide a fruitful area for future qualitative research. Does it indeed promote (re-)combination of knowledge or do such music scenes also have a higher absorptive capacity (Cohen & Levinthal 1990) that facilitates the integration of external symbolic knowledge? It also may point to rich systems of actors, infrastructures, and resources (fans, press, music industry, venues, etc.) that enable artists to experiment in a commercially viable environment. In turn, qualitative studies may also explore in detail how the specialization of symbolic knowledge bases affects innovators in creative industries in negative ways.

Furthermore, extending quantitative studies of symbolic knowledge creation to other creative industries and to other regions of the world is required to provide context for the findings of this study and evaluate its validity for innovation in creative industries in general. Quantitative analysis in the Global South or in areas such as literature, architecture or design have their unique challenges and require entirely different data sources. Yet we are optimistic that similar sources of volunteered user-generated information with geographic footprints can be found in these domains as well.

This study also has implications for policy in the areas of creative/music city promotion. It calls attention to the role of the structure of music scenes for their further development. Not only the quantity of actors should be monitored, but also to what genres/styles of music these belong. Policy actors concerned with the promotion of creative industries, especially the music industry, are well-advised to pay attention to the evolution of the composition of symbolic knowledge bases. Especially an over-specialization has to be prevented as this limits innovativeness and adaption to new trends, which are essential for the long-run success of creative cities (Brandellero & Kloosterman 2010). Thus, policy measures should counteract specialization tendencies by identifying scene-specific streams of music and coordinate efforts to enhance variety within these streams.

7 How do new Music Genres emerge? Diversification Processes in Symbolic Knowledge Bases

BENJAMIN KLEMENT & SIMONE STRAMBACH

(submitted to Regional Studies on September 7, 2017, currently under review)

ABSTRACT. Using data on the emergence of music genres from 1970-2015, this paper examines the relative importance of related and unrelated diversification processes for symbolic knowledge creation. Modelling 33 urban music scenes from Northern America and Europe as network-based symbolic knowledge bases allows for testing whether new genres are related or unrelated to pre-existing knowledge bases. The results show that new music genres spawn mainly from local knowledge sources in the center of music scenes. But symbolic knowledge creation rarely happens without contributions of extralocal knowledge. These unrelated diversification processes are grounded in the anchoring of trends and fashions originating elsewhere.

Keywords: symbolic knowledge, diversification, knowledge base, music, relatedness

JEL Codes: O31, R11, Z1, Z11

7.1 Introduction

The ability of regions to transform their economic landscape has recently drawn attention from economic geographers. Whether or not the introduction of new activities required for this transformation are related or unrelated to existing regional knowledge bases, is widely discussed in evolutionary economic geography (EEG) (Boschma 2016; Grillitsch & Trippl 2016; Boschma et al. 2017). Related and unrelated diversification processes have been investigated in a variety of contexts, such as regional industrial dynamics (Neffke et al. 2011; Essletzbichler 2015), the emergence of new industries (Binz & Anadon 2016; Tanner 2016), and technological (Rigby 2015) or scientific knowledge creation (Heimeriks & Boschma 2014; Feldman et al. 2015).

Yet these processes have not been studied in the context of symbolic knowledge creation, which plays a great role for innovation in creative and cultural industries (Asheim et al. 2011a). Regional economies with a high share of these industries face a constantly shifting landscape of fads, fashions, trends, technological and social changes (Brandellero & Kloosterman 2010). Nevertheless, only a few scholars have applied concepts of EEG to the analysis of creative industries (Berg & Hassink 2014) because of the distinct nature of symbolic knowledge creation (Asheim 2007; Martin & Moodysson 2013).

Consequently, there are still open questions regarding the relative importance of related and unrelated diversification processes for symbolic knowledge creation: Is new symbolic knowledge related or unrelated to existing knowledge bases? In which cases does symbolic knowledge come from local, respectively extralocal sources? This article addresses these questions by providing a detailed analysis of local *and* extralocal knowledge sources in regional diversification processes, whereas the primary focus of EEG research on regional diversification has been laid on the analysis of local, pre-existing knowledge bases (Boschma 2016).

We argue that similar to technological knowledge bases (Martin 2012; Essletzbichler 2015), network-based symbolic knowledge bases can be constructed. In this study, local music scenes (Florida et al. 2010) provide examples of symbolic knowledge bases. They are constituted by the symbolic knowledge produced by local artists and operationalized as network-based symbolic knowledge 'spaces' ; Rigby 2015), from which new music genres emerge as examples of symbolic knowledge creation.

To construct these symbolic knowledge bases, this study employs the co-occurrences of user-generated tags. We acknowledge the need to systematically analyze the relative importance of related and unrelated diversification (Boschma 2016) and analyze the nature of so-called parent genres from which new music genres spawned. Our results suggest that symbolic knowledge creation rarely happens without contributions of extralocal knowledge, amongst other things because the contextualization of extralocal knowledge plays a greater role for symbolic than for technological knowledge creation.

The remainder of this article is structured as follows. Section 7.2 and 7.3 form the theoretical framework for this study by applying concepts of (un)related diversification to symbolic knowledge creation. In section 7.4, the method of constructing music scenes as network-based symbolic knowledge spaces is presented. The following section 7.5 displays the empirical results, while section 7.6 provides concluding remarks.

7.2 Symbolic Knowledge Creation

In the differentiated knowledge bases approach (Asheim 2007) the notion of symbolic knowledge refers to the knowledge required to create and interpret socially constructed symbols, ideas, habits, and norms that trigger 'reactions in the mind of consumers' (Martin & Moodysson 2011: 1188). It is especially significant for creative/cultural industries that create, for instance, films, books, media, music, art, advertising, design, fashion, or video games (Asheim 2007). It is used to attribute products and services with meaning, aesthetic content, and affect and is essential for the creation of sign-value and product differentiation. We argue that this is of particular importance in the field of music, as the success of artists is strongly tied to their ability to cater to an audience's taste (Pinheiro & Dowd 2009; Zwaan et al. 2009). Audiences do not evaluate music merely by its musicological qualities, but by the symbolical meaning of language, dress codes, images, social practices, or conventions of musical performance that differ between types of music (Lena 2012).

This stands in stark contrast to technological knowledge, the science-based analytical knowledge and engineering-based synthetic knowledge that is required to discover and apply natural phenomena to human needs (Asheim et al. 2011a). Whereas natural phenomena are universal and independent of social or geographic context, symbols are socially constructed by and within social contexts. Consequently, symbolic knowledge is highly context-specific and very sensitive to distance-decay effects (Strambach 2008; Asheim et al. 2011a; Martin & Moodysson 2011). The spatial organization of innovation processes based on symbolic knowledge tends to be localized and linked to local specificities (Martin & Moodysson 2011; Martin & Moodysson 2013; Rekers 2016). The following section explores how these differences in technological knowledge creation may influence diversification processes.

7.3 The Emergence of New Genres: Related or Unrelated to Existing Scenes?

Related diversification has been identified as the most common way of how regions develop new activities. Several studies have replicated the results of Neffke et al. (2011) showing that new activities have a higher probability to enter a region when the density of related activities in the knowledge base is high. Preexisting regional knowledge bases obviously shape the direction of the diversification paths of industrial structures (Boschma et al. 2013; Essletzbichler 2015), as well as technological (Rigby 2015) and scientific advancement (Heimeriks & Boschma 2014; Feldman et al. 2015). As 'related activities demand similar capabilities' (Boschma 2016), new activities are easier to acquire or develop when they are close to the existing knowledge base in a region.

Recent contributions to the path development literature (Binz et al. 2015; Grillitsch & Trippl 2016; Miörner & Trippl 2016), however, emphasize that processes of unrelated diversification may be rarer than related diversification, but not necessarily of lesser importance. Especially peripheral regions are confronted with several challenges when attempting to diversify from their own limited knowledge base. Therefore, they require the ability to access and anchor external knowledge (Binz et al. 2015; Jeannerat & Crevoisier 2015; Isaksen & Trippl 2016). Furthermore, some factors that explain the inclination of some regions to diversify into unrelated activities are not captured by the study of regional knowledge bases, such as brain circulation (Binz & Anadon 2016) or institutional configurations (Boschma & Capone 2015),

7.3.1 The Emergence of New Genres as Related Diversification

Against this backdrop, there are a number of reasons why the emergence of new music genres could be a product of related or unrelated diversification. First of all, processes of related diversification may be most important for music, as the spatial nature of innovation processes of symbolic industries has been characterized as being very dependent on local forms of knowledge sourcing (Martin & Moodysson 2011). Indeed, the music industry itself tends to locate in clusters (Florida et al. 2010), even in the digital age, as cities provide a thicket of local, flexible and volatile interactions of diverse actors (Watson 2008; Tironi 2012; Hracs 2013). Historical accounts of the avant-garde phase of genres point to highly localized scenes, which sometimes are even limited to individual neighborhoods, outside of which new music styles are initially not well understood or even disregarded (Lena 2012).

Furthermore, places become associated with certain music styles that can shape the direction of further development. Existing narratives or scenes may incentivize artists to develop new styles on top of existing specializations of music scenes. In fact, Johansson & Bell (2009) show for a selection of newly emerged rock genres that these mostly originated from cities with already thriving rock scenes. Another example of this process is provided by the case of Manchester, where in the late 1970s a post-punk scene emerged that used the imagery of the post-industrial city to construct a unique image and narrative for their music. Later, actors from this scene were involved in the emergence of the style madchester in which post-punk is mixed with dance music, from which a thriving acid house/rave scene spawned in the late 1980s (Bottà 2009). Once a city has established meaning in the world of music, it may also become difficult for artists to overcome the expectations of listeners and find it more promising to associate themselves with the existing heritage of places (Spracklen et al. 2012).

In addition to that, new music genres are not necessarily radically new. There is a dizzying array of sub-genres and sub-subgenres that may be new by name and character, but almost indistinguishable to outsiders. Fans, critics, and artists apparently demand a high degree of differentiation of existing styles (McLeod 2001). In an analysis of acoustic features of music from 1960-2010, Mauch et al. (2015) find that popular music has evolved rather gradually except for three stylistic revolutions in 1964, 1983 and 1991. For the above reasons, the emergence of new genres may also be characterized by the gradual recombination of similar genres that were specializations of their respective birthplaces.

7.3.2 The Emergence of New Genres as Unrelated Diversification

Yet there are also good reasons for unrelated diversification being the dominant process in the emergence of new symbolic knowledge. First of all, probably more than scientists or engineers, artists seek to express themselves through their work. Thus, in order to find individual fulfillment or give a voice to the problems and identities of distinct social groups, pioneering artists may be eager to break with mainstream rules (Cohendet et al. 2014) or to combine previously unconnected genres (Lena & Peterson 2008). In some cases, the desire to deviate from the mainstream by forming counter-movements to existing trends is associated with geographical separation from the mainstream. Especially in smaller, peripheral cities in the blind spots of the established music industry, specialized scenes that celebrate otherness could flourish freely, like early Heavy Metal in Birmingham (Weinstein 2014), Death Metal in Tampa and Gothenburg (Dunn 2004) or Grunge in Seattle (Bell 1998).

Moreover, the intangible nature of music allows its practically limitless geographical diffusion, especially in the age of digital distribution of music files (Leyshon 2001; Hracs 2013). The more mobile music becomes, the more relevant anchoring processes may become for the evolution of music scenes. Anchoring refers to the decontextualization of mobile knowledge from its origin and its interaction with new contexts (Crevoisier & Jeannerat 2009). In fact, foreign music is increasingly present in most national music charts (Verboord & Brandellero 2016). By the diffusion of genres through distribution, media, and performances, translocal scenes are formed (Bennett 2004). For instance, the previously mentioned post-punk scene in Manchester was apparently spawned by two concerts of the Sex Pistols in 1976. The imported punk music and lifestyle inspired several artists that turned out to become essential figures of the local music scene in the following years (Bottà 2009). Especially in rap music, processes of local appropriation and adaptation of rap to local contexts can be witnessed. In places devoid of an existing rap scene, new local variants of rap emerge that are closely related to specificities of places (Androutsopoulos & Scholz 2003; French 2017). For these reasons, unrelated diversification may play a great role in the emergence of new symbolic knowledge.

7.4 Data and Methods

The measurement of symbolic knowledge poses several challenges. Due to its context-dependency and subjective nature (Asheim et al. 2011a; Martin & Moodysson 2011), there is no central organization concerned with classifying symbolic knowledge and determining its novelty (Sordo et al. 2008). Technically, every product of creative industries is new. But ultimately, consumers decide whether or not its aesthetic content is novel or valuable to them (Brandellero & Kloosterman 2010; Stoneman 2015).

As the main goal of creating symbolic knowledge is to 'trig reactions in the minds of consumers', it is only consequential to utilize consumers' reactions in determining the nature and novelty of symbolic knowledge. Social media allows capturing how products resonate with consumers not just by their monetary success in the marketplace (Stoneman 2015), but by consumers' expressions of evaluation, classification, and description, which can be searched for via keywords and (hash)tags (Trant 2008; Reithmeier et al. 2016). In addition to that, on many social media platforms, geographic information is voluntarily produced, either proactively in the form of geographically related tags but also passively as geographic footprints of users' actions (Crampton et al. 2013).

7.4.1 Constructing Symbolic Knowledge Bases from User-generated Data

Thus, this contribution employs user-generated data from the social music platform last.fm that provides geographic content as well as information on consumers' classifications of pieces of music. Last.fm was established in 2002 in London (UK) and possesses a user base of 50 million profiles. Users of last.fm allow the site to automatically track what they listen to on digital devices, music players or streaming platforms via a small application that records MP3 metadata. In return, users get personalized profiles, radio stations, and recommendations based on their musical preferences (Mauch et al. 2015).

Most important to this analysis, users are encouraged to describe artists with tags. The five tags most frequently used by last.fm users are displayed publicly on the website.[13] Tags mostly refer to genres, but also to general descriptions regarding instruments, gender or geographical origin. (Sordo et al. 2008; Trant 2008). The latter ones were utilized to create a sample of cities for this study. Cities, whose city-related tags (e.g., memphis rap, seattle, south london) were used by more than 1000 users were included in our sample. Only cities from North America and Western Europe were included, as analyzing user-generated content written in alphabets other than the Latin one would have been beyond the authors' capabilities.

For every tag, last.fm lists the artists most frequently described with this tag (for instance, see https://www.last.fm/tag/rock/artists). We collected data for artists who originated

[13] After a site relaunch in 2015, six tags are displayed. The data acquisition started before the site relaunch.

from the sampled cities, were active between 1970 and 2015, and belonged to the top 100 artists of relevant city-related tags or the top 100 of genre-related tags.[14] We collected additional data on the five tags most used to describe them, their number of last.fm listeners, and user-contributed biographical data on their origin and years of activity. Spatial and temporal data were acquired from last.fm when available, but also researched and cross-referenced on other music-related websites, such as discogs.com, allmusic.com, artists' web presences and Wikipedia. Artists were attributed to a city's music scene when their location at the time of their first record release belonged to a sample city's metropolitan area. Artists with less than 1000 listeners, genres that were used to tag less than 30 artists and tags not referring to music genres were omitted from the database. Spelling variations for artists and tags were consolidated so that eventually, the database contained 8769 artists from 33 North-American and European cities.

These data were used to construct symbolic knowledge bases of urban music scenes at 5-year intervals, starting from January 1, 1970. In general, symbolic knowledge bases (music scenes) are made up of bits of symbolic knowledge (music genres) produced by local symbolic knowledge creators (artists). When two tags are used to describe the same artist, tags co-occur. Co-occurrences of genres can be interpreted similarly to the co-occurrences of technologies (Antonelli et al. 2010 or products (Hidalgo et al. 2007; Neffke et al. 2011) in portfolios of economic entities. These have been used to create network-based knowledge spaces that characterize knowledge bases of territories (Hidalgo et al. 2007; Rigby 2015). In similar fashion, from the co-tagging data, we construct a matrix of n*n genres for each music scene at each measured point in time. From these adjacency matrices, music scenes are constructed as network-based knowledge spaces.

7.4.2 Measuring New Genres and Their Parent Genres

In the focus of this article stands the emergence of new music genres as examples for symbolic knowledge creation. For present purposes, a new genre is a genre that was not used to tag any artist from the database who was established before 1970. Furthermore, it has to be used to tag at least 30 artists in the database. In music, there is an overwhelming abundance of sub-genres and sub-subgenres. Some of these new genre

[14] As artists sourced by city-related tags filled the database, the database also filled with genre-related tags which were used in this step. The top 100 artists of genre-related tags used for more than 20 artists in the database were included in the database.

names result from an imagination of novelty that benefits artists, press and fans alike (McLeod 2001). Thus, it is appropriate in this study to only examine the emergence of genres which have reached a certain relevance.

The year of birth of a new genre is given by the earliest establishment date of all artists tagged with it. In this study, artists who were founded during the 4 years following the year of birth are called pioneers. This time-span is practically oriented at the 5-year time interval used to measure symbolic knowledge bases. Even though the speed of diffusion of every genre is different, this time span appeared to be reasonably short to distinguish pioneers from adopters, and reasonably long enough for genres to develop.

The locations of pioneers are understood as birthplaces of genres. To analyze the relationship between characteristics of these birthplaces and new music genres it is necessary to establish a link between both. Similar to Tanner (2016), we identify for each new genre those genres that pioneers are co-tagged with and have emerged earlier than the new genre itself. These genres chronologically precede the new genres and are related to it at the time of its emergence. Hence, they are called parent genres. Parent genres are linked to the respective time and place of activity of the pioneers who are tagged with them. To measure the presence of parent genres in the respective knowledge bases of birthplaces prior to the emergence of music genres, we use two indicators that are inspired by the closeness indicator of Neffke et al. (2011), who determined the number of industries related to a new industry that were part of the knowledge base prior to the industry's emergence.

Our indicators, however, are based on the ratio of parent genres meeting a certain criterion. The range of both measures is between 0 and 1, whereas low values point to unrelated diversification and high values are signs of related diversification processes. First, the Local Index (LI) of a new genre measures the share of its parent genres that were part of their respective symbolic knowledge bases prior to its emergence on all its parent genres. Second, the Specialization Index (SI) of a new genre is the share of its parent genres that have a location quotient >1 on all its parent genres.

Furthermore, the characteristics of parent genres are displayed by their network centrality (Newman 2013). These illustrate to what extent a parent genre has accumulated in the symbolic knowledge bases of birthplaces and how central it is in them. The following centrality measures were calculated: node strength (sum of weights of a node's ties), degree (number of separate nodes tied to the genre), betweenness (number of shortest paths that pass through the node, tie weights ignored), eigenvector centrality (connectivity to other well-connected nodes, ties weighted), and closeness (inverse total length of paths from the node to all other nodes in disconnected networks with ignored weights following Opsahl et al. (2010)). To allow comparability across music scenes with different sizes, centrality measures are normalized when possible. While node strength and degree are directly based on the accumulation of symbolic knowledge, structural properties of the music scene affect the closeness, eigenvector and betweenness centrality.

7.5 Empirical Results

Table 7.1 lists all genres identified as new genres for this study. Most of them emerged between 1975 and 1990, but not necessarily because of a diminishing creativity in music. Genre names may not be popular enough to be taken up by last.fm users or originate from other areas than the sample cities. Furthermore, there may be issues with right truncation of the data as the process of establishing naming conventions around genres takes a certain time (Lena 2012).

These new genres were pioneered by 661 artists, who were co-tagged with 2768 tags. Among these co-tags are many duplicates because multiple pioneers from the same city were tagged with the new genre and the same co-tags. After removing these duplicates, 1920 parent genres remained, of which 316 genres were excluded from the analysis because they emerged at the same time as the new genre or after the latest measuring point prior to the emergence of the new genre.

Of the remaining 1604 parent genres, 1079 were present before in the respective knowledge base and are called local parent genres in the following. The remaining 525 parent genres that were not present in the birthplace before are understood as extralocal. While local parent genres point to the process of related diversification, extralocal parent genres point to the importance of unrelated diversification. If one had to put numbers to the relative importance of related versus unrelated diversification, our data suggest that symbolic knowledge creation is based on a mix of two parts related and one part unrelated diversification.

7.5 Empirical Results

Table 7.1: New music genres by the first year of appearance in the database

Time period	New Genres	Count
1970-74	Alternative Rock, Breakbeat, Doom Metal, Industrial, New Wave, Noise, Noise Rock, No Wave, Oi, Pop Punk, Pop Rock, Rap, Street Punk, Synthpop, World Music	15
1975-79	Britpop, Chicago House, Dark Ambient, Deathrock, Deep House, Dream Pop, Dub, EBM, Electro, Garage Punk, Glam Metal, Gothic, Gothic Rock, Grunge, Hair Metal, Hardcore, Hardcore Punk, Horror Punk, House, Indie Pop, Indie Rock, Industrial Rock, Minimal, Power Metal, Progressive Metal, Riot Grrrl, Shoegaze, Speed Metal, Stoner Metal, Straight Edge, Thrash Metal, Twee	32
1980-84	Acid, Acid House, Chillout, Crossover, Death Metal, Downtempo, Emo, Gangsta Rap, Grindcore, IDM, Industrial Metal, Metalcore, Neo-Soul, NYHC, Post-Hardcore, Post-Rock, Ska Punk, Sludge, Techno, Thrash, Trance, West Coast Rap	23
1985-89	Beatdown, Brutal Death Metal, Darkwave, Dirty South, Drum n Bass, East Coast Rap, Electroclash, G-Funk, Horrorcore, Indie Folk, Jazz Hop, Jungle, Math Rock, Mathcore, Melodic Death Metal, Memphis Rap, Noise Pop, Nu Metal, Rapcore, Southern Rap, Stoner, Tech House, Technical Death Metal, Trip-Hop, Underground Hip-Hop, Underground Rap	26
1990-94	Black Metal, Breakcore, Breaks, Deutschrap, Freak Folk, Melodic Hardcore, Minimal Techno, New Weird America, Screamo, UK Garage	10
1995-99	Deathcore, Dubstep, Electropop, Glitch, Grime, Indietronica	6
2000-04	Bass Music, Future Garage, New Rave	3
2005-09	Chillwave, Trap, Witch House	3
	Total	118

Table 7.2 provides descriptive statistics of the new genres identified in this analysis. As indicated above, most of the new genres emerged before 1981. On average, a new genre originates from 3.32 birthplaces with the maximum of 15 birthplaces reached by the genre witch house, which is also the newest genre in the database. Furthermore, a new genre is pioneered by 7.14 artists on average, while the maximum of 32 pioneers was reached by the genre hardcore.

Table 7.2: Descriptive statistics of new genres

Characteristics of new genres	Observed	Mean	Standard deviation	Median	Min	Max
Year of birth	118	1983.08	8.24	1981.50	1970.00	2006.00
No. of pioneers	118	7.14	5.96	5.00	1.00	32.00
No. of birthplaces	118	3.32	2.44	3.00	1.00	15.00
No. of parent genres	118	13.59	10.79	11.00	1.00	56.00
Local Index	118	0.67	0.23	0.69	0.00	1.00
Specialization Index	118	0.52	0.23	0.50	0.00	1.00

On average, a new genre has 13.59 parent genres. From the characteristics of these parent genres, LI and SI are calculated. According to them, an average new genre emerges with 67% of its parent genres present in its birthplaces, while 52% of parent genres are also specializations of birthplaces. This also points to the importance of related diversification for the emergence of new music genres. A closer look at the relative frequencies of new genres by LI and SI displayed in Figure 7.1 shows that it is most probable that a new genre emerges with at least 50% of their parent genres being present in their respective birthplaces. However, there are hardly any genres in which no unrelated diversification processes play a role. Of 118 genres, this applies only for the genres rap, jungle, melodic hardcore, breakbeat, alternative rock, beatdown, ebm, emo, g-funk, indie folk, minimal, pop rock, post-rock, stoner metal, and world music.

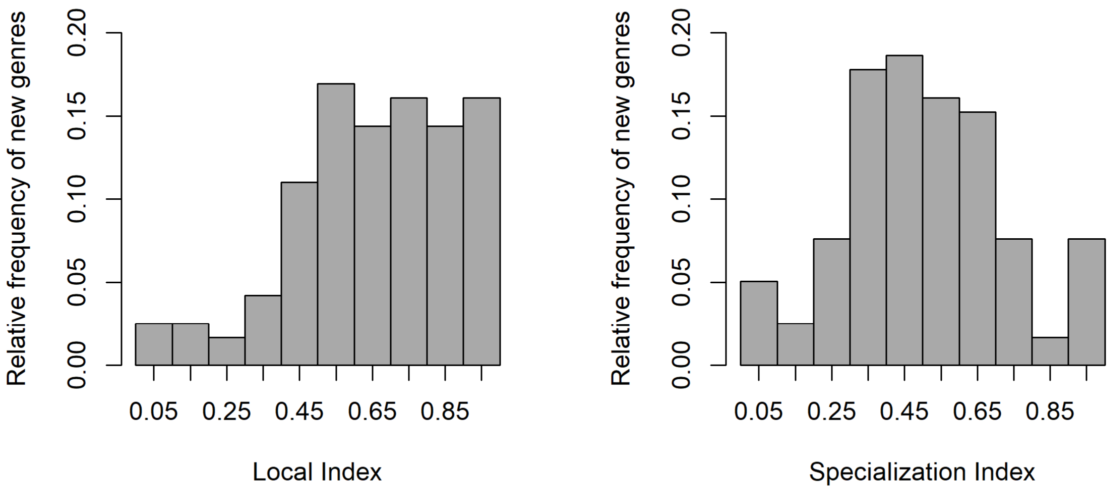


Figure 7.1: Local Index and Specialization Index of New Genres
Sources: Own analysis of last.fm data

Considering unrelated diversification, only for 26 new genres, less than 50% of all parent genres were local ones. At the same time, it is also extremely rare that new genres only have extralocal knowledge sources. Only detroit techno, doom metal, and west coast rap emerged purely from unrelated diversification.

Yet not only is the presence of parent genres of interest, but also whether or not symbolic knowledge bases had accumulated the symbolic knowledge from which new knowledge emerged. The distribution of the SI of new genres in Figure 7.1 shows that most new genres emerged when half of their parents also had been specializations of their birthplaces. Rarely, genres originate from the combination of specializations of its birthplace. Only for nine new genres, all parent genres had a location quotient of >1, e.g., jungle, emo, or beatdown.

These descriptive insights show that the creation of new symbolic knowledge tends to be based primarily on pre-existing symbolic knowledge bases. But at the same time, only for 15 genres, extralocal symbolic knowledge did not play any role. Obviously, it is a mix of related and unrelated diversification that leads to the emergence of most new music genres. The following two sub-sections provide a closer look into related and unrelated diversification processes.

7.5.1 Characteristics of Local Parent Genres

Examining the characteristics of local parent genres shows whether new knowledge tends to emerge in the center or at the periphery of symbolic knowledge bases. To analyze the characteristics of local parent genres, logit models are used to estimate whether or not the probability of a genre becoming a parent genre depends on its network centrality. All genres in all symbolic knowledge bases from 1970 to 2010 were coded with a dichotomous variable that indicates whether or not they became a parent genre in the subsequent five year-interval. After testing for multicollinearity, the following set of network centrality measures (see Table 7.3) with $1.608 \leq VIF \leq 4.572$ was chosen as independent variables. Additionally, the number of nodes of knowledge bases and year-specific dummies act as control variables accounting for size and time effects. Model (1) includes only control variables, (2) comprises network centrality measures indicating the accumulation of symbolic knowledge and (3) includes network centrality measures that depend on the position of a genre in the network. (4) displays the full model including all network centrality measures.

Table 7.3: Logit models for the relationship between the network centrality of genres and their probability to become parent genres

	Dependent variable: Parent genre (1/0)			
	Logit models			
	(1)	(2)	(3)	(4)
Network size	0.006***	0.006***	0.008***	0.007***
	(0.001)	(0.001)	(0.001)	(0.001)
Node strength		0.008***		0.008***
		(0.001)		(0.001)
Degree (norm.)		2.747***		1.556**
		(0.353)		(0.608)
Betweenness (norm.)			4.305***	3.186***
			(0.533)	(0.598)
Eigenvector Centrality			1.403***	0.022
			(0.312)	(0.382)
Closeness (norm.)			0.269	-0.427
			(0.400)	(0.414)
Constant	-3.327***	-3.937***	-3.792***	-3.589***
	(0.188)	(0.216)	(0.250)	(0.249)
Year dummies	Yes	Yes	Yes	Yes
Observations	18,875	18,873	18,873	18,873
Log Likelihood	-2,676.96	-2,562.37	-2,586.00	-2,548.68
Akaike Inf. Crit.	5,355.93	5,148.75	5,198.00	5,127.36
McFadden's R^2	0.110	0.148	0.141	0.153
Note:				*p<0.1; **p<0.05; ***p<0.01

The control variables had the expected influence on the probability of a genre becoming a parent in all models. As most of the new genres in this analysis emerged before 1985 (see Table 7.1), earlier time dummies are positively associated with the dependent variable, while time dummies after 1990 are negatively related. The low fit of the model points to the fact that claiming to be able to predict musical creativity only by the centrality of genres would be overconfident. Still the results suggest that the creation of new symbolic knowledge does not appear to happen by chance but is based on pre-existing symbolic knowledge bases.

Among the analyzed network centrality measures, the node strength of a genre is significantly and positively related to parent genres. This simple measure reflects the accumulation of symbolic knowledge and is closely linked to the number of artists tagged with a genre. The normalized degree, which refers to the number of genres linked to a genre, is also positively associated with parent genres. This shows that complementary genres that can be more easily combined with other genres are more likely to become a parent genre.

Interestingly, among those network centrality measures that depend on structural properties of symbolic knowledge bases, only the normalized betweenness turns out to be significantly and positively related to parent genres in both models (3) and (4). Consequently, new symbolic knowledge is apparently not created at the fringes of music scenes, but in their center. Within these centers, it is the more complementary, popular genres that tend to spawn new genres. Examples for parent genres with high normalized betweenness are electronic in Paris (2005), from which chillwave, trap and witch house emerged, or rock in London (1975), which spawned industrial rock and speed metal.

But not all network centrality measures are associated with the emergence of music genres. Eigenvector centrality, which is high for sub-genres in clusters of central genres, was only significant in (3), but not in (4). This speaks against symbolic knowledge creation being a result of continued specialization along the same path. Furthermore, the normalized closeness, which points to the average distance of a genre to all other genres in the network, was not related to the emergence of new music genres.

7.5.2 Characteristics of Extralocal Parent Genres

The characteristics of extralocal knowledge sources provide insights into the process of unrelated diversification. Figure 7.2 compares the age (difference in years to the first appearance in the database), diffusion (number of music scenes in which genre was present), and popularity (number of artists tagged with the genre) of extralocal and local parent genres at the time when they became parent genres. Apparently, extralocal parent genres are younger, less diffused and less popular than their local counterparts. Additional Mann-Whitney-U tests confirmed that there are significant ($p < 0.001$) differences between medians for all comparisons. This indicates that unrelated diversification entails the localization of current trends emerged elsewhere. Together with the insights from section 7.5.1, this suggests that the emergence of new symbolic knowledge can be described as a process of linking local specializations with global trends. It may be a good example for the process of 'anchoring' (Crevoisier & Jeannerat 2009) of mobile knowledge with the more immobile knowledge accumulated as specialized knowledge bases that had co-evolved and were embedded in specific institutional contexts (Strambach & Klement 2012a).

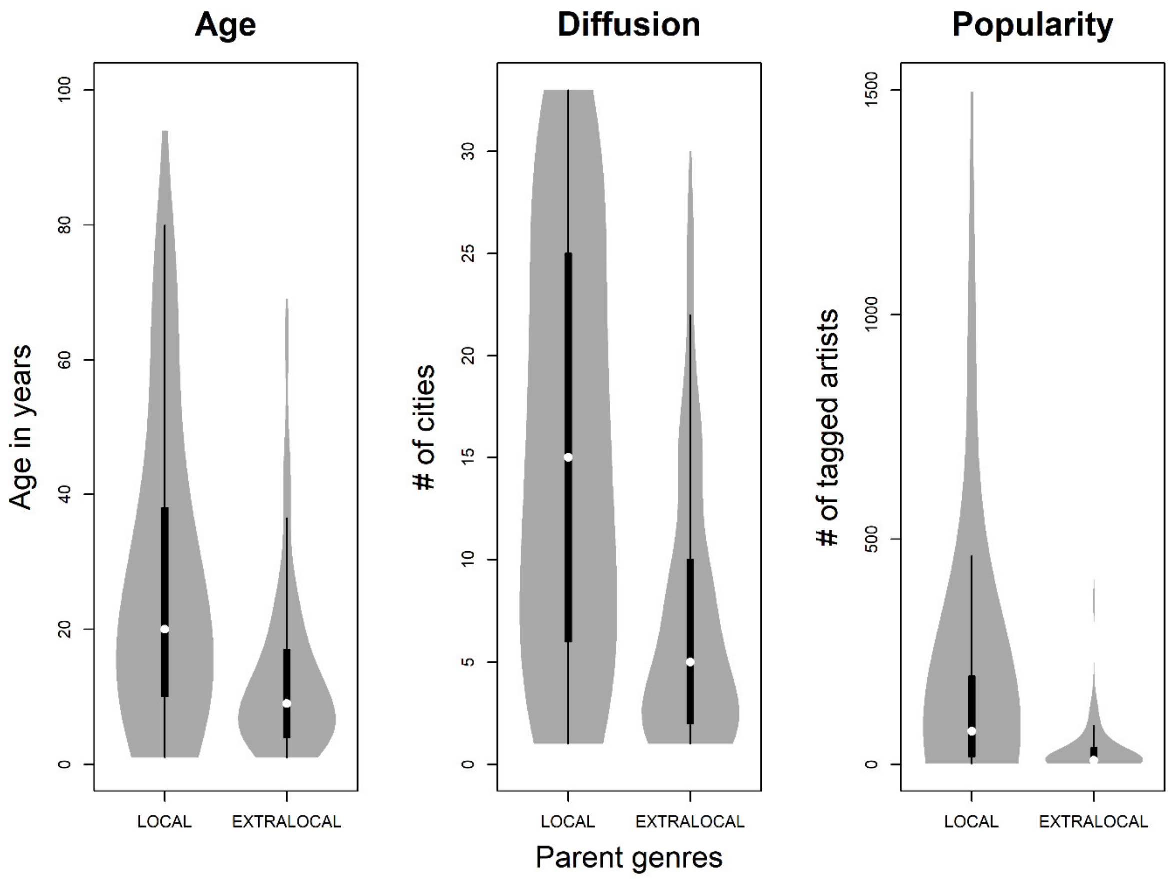


Figure 7.2: Violin Plots Comparing the Age, Diffusion, and Popularity of Local and Extralocal Parent Genres
Sources: Own analysis of last.fm data

Good examples of the localization process are music genres whose names contain geographical references. In our data, there were 13 such genres, e.g., Detroit Techno, New York Hardcore, or West Coast Rap. These genres tend to be the result of unrelated diversification: Mann-Whitney-U tests showed that these geographical music genres have a significantly (p= 0.064) lower LI than other genres. On average, 44% of their 92 parent genres are extralocal, while for non-geographical genres, 32% of genres are extralocal.

In the formation of geographical genres, a lot of boundary work (Lena 2012) is done against different interpretations of music styles in other places, as indicated by the rivalries in hip-hop between east and west coast (French 2017) and the emergence of hardcore 'tribes' that developed distinct conventions on the music, performance, and lifestyle in several US cities (Blush & Petros 2010). From a theoretical perspective, it is one distinctive feature of symbolic knowledge that it can have very different meanings in different contexts (Asheim & Hansen 2009). Thus, emerging trends can have different local interpretations linked to local idiosyncrasies. While the natural world, whose understanding constitutes analytic or synthetic knowledge, remains relatively unchanged across social or geographic contexts, the social world (and the symbolic knowledge required to succeed in it) varies strongly.

7.6 Conclusions

This article analyzed the relative importance of related and unrelated diversification. In contrast to other studies in this field, this study focused on symbolic knowledge creation. It introduced a novel method to model music scenes as network-based symbolic knowledge bases ; Rigby 2015) by employing volunteered, user-generated data. The creation of symbolic knowledge, operationalized as the emergence of new music genres, was studied by examining the characteristics of their parent genres.

A major contribution of this study is the in-depth analysis of local and extralocal knowledge sources. The results suggest that a mix of two parts related and one part unrelated diversification processes lead to symbolic knowledge creation. Locally accumulated knowledge sources affect the direction of symbolic knowledge creation, while the complementarity of knowledge bits promote their likelihood to become parent genres.

Yet apparently the emergence of new symbolic knowledge rarely happens without any contributions of extralocal knowledge. Unrelated diversification plays a considerable role in symbolic knowledge creation. Extralocal parent genres are younger, less diffused and less popular than their related counterparts, pointing to the importance of the regional ability to anchor (Crevoisier & Jeannerat 2009) symbolic knowledge in the form of trends and fashions from elsewhere.

7.6 Conclusions

From a theoretical point of view, these empirical findings support the general arguments made in the relatedness literature (Neffke et al. 2011; Boschma 2016). The direction of the diversification of symbolic knowledge bases is influenced by previously accumulated knowledge. But the results also point to the high relevance of anchoring (Crevoisier & Jeannerat 2009) for symbolic knowledge creation. The emergence of new symbolic knowledge is apparently a result of the interplay of cumulative and combinatorial knowledge dynamics (Strambach & Klement 2012a), in which mobile trends are combined with place specificities.

For regional policy concerned with the promotion of creative industries this study implies that region-specific strengths should be promoted while openness to external trends and fashions has to be established and maintained as well. This sounds easy, but symbolic knowledge varies highly across contexts and is closely linked to attitudes, values, and norms (Asheim & Hansen 2009). Thus, external trends can completely oppose the conventions of an established, specialized scene, which limits local opportunities for anchoring. Future research opportunities lie in the qualitative analysis of processes, institutions, and actors that promote the anchoring of symbolic knowledge. Triangulating quantitative analysis with qualitative insights may provide a more complete perspective on regional diversification processes.

V CONCLUSIONS

"This is the end, beautiful friend
This is the end, my only friend, the end
Of our elaborate plans, the end
Of everything that stands, the end
No safety or surprise, the end"
(THE DOORS, 1967)

8 Conclusions

This central aim of this thesis is to explore the relationship of knowledge dynamics to different forms of path development. In order to do so, four research questions were posed. The four previous chapters looked at these research question from different perspectives and by the analysis of different empirical settings. In the next section, the findings of the papers presented in chapters 4-7 are brought together, synthesized, and arranged according to the research questions of this thesis. This way, the relationship between knowledge dynamics and the elements and institutions of economic landscapes is illustrated.

8.1 Main Findings

1 In what ways do cumulative and combinatorial knowledge dynamics differ on the micro-level?

The central contribution of this thesis is the differentiation and application of knowledge dynamics on the micro-level. Especially chapter 4 focuses on this first research question and provides an overview of the differentiation between both types of knowledge dynamics, as repeated in Table 8.1.

Table 8.1: Differentiation of knowledge dynamics

Dimension	Cumulative Knowledge Dynamics	Combinatorial Knowlege Dynamics
Actors		
Heterogeneity in constellation	Low	High
Cognitive distance	Low	High
Institutional overlaps	High	Low
Interactions		
Existing knowledge base	Broaden/deepen	Unification
Variety of contexts	Low	High
Investment in mutual understanding	Low	High
Bridging of organizational/ technological/sectoral interfaces	Low	High
Time		
Expected outcome	Nearer in time	Distant in time

Sources: Own table, modified from Strambach & Klement (2012a)

The concept of knowledge dynamics puts emphasis on **the institutional and organizational dimension of combining knowledge**. This differentiation is based on the assumption that even though many innovations are based on the combination of knowledge (Schumpeter 1934), some innovations are characterized by high degrees of institutional and cognitive distance (Boschma 2005). The underlying combinatorial knowledge dynamics involve the unification of knowledge bases developed in and linked to distinct institutional settings. Consequently, they generate a particular need for institutional and organizational change, as innovating actors have to cope with many different cognitive, technological, organizational, and institutional barriers. In order to overcome these barriers, several interfaces have to be created and different relational distances (Boschma 2005; Ibert 2010) have to be bridged. Overall, this is a challenging process, as existing institutions or organizational routines cannot be used or exploited in their existing forms. Instead, new routines or institutions have to be created that facilitate the decontextualization of involved knowledge bases and their adaptation to new contexts, a process that is usually typical for KIBS (Strambach 2008).

In contrast, cumulative knowledge dynamics are characterized by a certain stability given by the fact that existing knowledge bases are deepened. In these cases, existing institutional environments guide and stabilize the innovation process. Consequently, cumulative knowledge production is easier to accomplish than its combinatorial counterpart. In practice, this may have been demonstrated recently by the Diesel scandal of German automakers, in which test conditions were creatively, but illegally, circumvented. Apparently, it was much easier to innovate illegally along established organizational networks and routines than to initiate combinatorial knowledge dynamics necessary to reach the environmental requirements in legal ways.

In different contexts of this thesis, it was shown that **cumulative knowledge dynamics are quantitatively much more prevalent than combinatorial ones**. Chapter 4 showed in a study of different sectors that overall, only 20% of all observed knowledge interaction processes could be characterized as combinatorial knowledge dynamics, with biotechnology being the most combinatorial sector with a share of 40% (Table 4.2). At the same time, innovations based on completely cumulative or combinatorial knowledge dynamics were almost non-existent. These findings suggest that a mix of cumulative and combinatorial knowledge dynamics is necessary to create novelty**.** This is supported by other studies on scientific knowledge creation that have also shown that new impactful research tends to be characterized by a mix of conventional knowledge accumulated in established research domains with infusions of atypical knowledge (Uzzi et al. 2013; Mukherjee et al. 2016).

The **geography of knowledge dynamics is characterized by multi-scalarity** (Crevoisier & Jeannerat 2009). This means that knowledge dynamics were very rarely limited to one scale. They are neither completely global nor completely local. Local knowledge sources are, however, more important than extralocal ones. While 80% of knowledge interactions analyzed in chapter 4 did not cross national borders, two-thirds of the symbolic knowledge sources analyzed in chapter 6 originated from the same region. It is interesting to see that in very different research contexts, the quantitative relations between local and extralocal knowledge sources are similar. At the same time, among the 62 case studies in chapter 4, no case was limited to the regional scale. The results for symbolic knowledge creation were similar: Of the 118 music genres analyzed in chapter 7, only 15 emerged exclusively from locally accumulated knowledge, while only 3 had only extralocal parent genres. Hence, in the vast majority of cases (e.g. 85% for music genres), there was an **interplay of local knowledge with extralocal knowledge sources**.

Regarding the spatio-temporal characteristics of knowledge dynamics, it is difficult to detect any regularities. As this thesis shows, combinatorial knowledge dynamics are not necessarily characterized by geographical proximity or distance. Other forms of relational proximity (Ibert 2010) or temporary geographical proximity (Torre 2008) are rather used to compensate for the lack of cognitive/institutional proximity in combinatorial knowledge dynamics. Regarding the time dimension of knowledge dynamics, the studies of chapter 4 and 5 could also not identify a distinct phase of the innovation process in which combinatorial knowledge dynamics are more present.

Finally, what this thesis has demonstrated is that **the concept of knowledge dynamics can be flexibly adapted to different research contexts** and be linked to other research strands. While originally, the different routines and institutions associated with knowledge bases informed the differentiation of knowledge dynamics, new quantitative methods to determine the relatedness between knowledge bits or industries can also be used to differentiate knowledge dynamics. This is possible, because, at their core, both knowledge base and relatedness literature strands focus on the commonalities and differences between knowledge (Boschma 2017).

2 How do cumulative and combinatorial knowledge dynamics affect elements of economic landscapes and vice versa?

When studying the relationship between knowledge dynamics, it is reasonable to first look at the interaction of knowledge dynamics with the elements of economic landscapes.

First of all, knowledge dynamics, especially combinatorial ones, result in the **creation of new elements of the economic landscape**, especially of non-firm actors. Chapters 4 and 5 show that in order to compensate for institutional and cognitive distance, actors actively seek to constitute organizational proximity, for instance by establishing new independent organizational bodies with own governance structures. Joint organizations facilitate combinatorial knowledge dynamics by providing mechanisms to generate trust and common understanding of the objective and economic value of the outcome.

Furthermore, **existing resources are rearranged in new organizational forms** in order to foster combinatorial knowledge dynamics. New networks and cooperatives are formed, or existing organizations (such as the ASCS in chapter 5) are equipped with new goals, routines (see below) and participants. Within existing firms, new organizational units were created from rearrangements of existing resources and capacities. This points to the important role of the interaction of cumulative and combinatorial knowledge dynamics for path modernization and path branching processes.

In the analysis of the **emergence of new symbolic knowledge** elements in chapter 7, the interaction of cumulative and combinatorial knowledge dynamics is demonstrated. Evidently, accumulated symbolic knowledge is more likely to spawn new symbolic knowledge, especially when it has a certain degree of complementarity. Yet, about a third of knowledge inputs are characterized as unrelated, external symbolic knowledge that is novel, rare, and upcoming. This points to new symbolic knowledge emerging as local interpretations of global trends, in which mobile symbolic knowledge that emerged in another institutional context was contextualized in another region. Thus, the evolution of symbolic knowledge bases is characterized by anchoring (Crevoisier & Jeannerat 2009) of mobile knowledge with accumulated symbolic knowledge bases.

Yet the existing elements of the economic landscape also affect knowledge dynamics. Chapter 6, in particular, deals with the composition of symbolic knowledge bases. It shows that too much accumulation of symbolic knowledge limits the creation of new symbolic knowledge, thereby illustrating the disadvantages of path extension (Isaksen 2015). Instead, **(semi-)related variety promotes the combination of previously unconnected symbolic knowledge**. For combination to occur, there has to be a certain variety of elements within a specific field/domain/stream.

Thereby, this thesis shows empirically that the many merits of related variety suggested by the respective literature (Content & Frenken 2016) apparently result from its promotion of the combinatorial mechanisms of innovation, as chapter 6 illustrates. This shows how the **concept of knowledge dynamics provides microfoundations for the analysis of relatedness** and is able to explore processes and underlying mechanism that have eluded the existing relatedness literature

3 **How do cumulative and combinatorial knowledge dynamics affect institutions of economic landscapes and vice versa?**

Chapters 4 and 5 have illustrated that **combinatorial knowledge dynamics contribute to institutional change**. Not only are new organizations created (see above), but new institutions have to be created as well. In combinatorial knowledge dynamics, there are only small institutional overlaps, as actors are rooted in different knowledge bases and institutional contexts. Thus, institutional overlaps have to be enlarged or created to enable actors to work and invent together. It could be observed that innovating actors exploit path plasticity (see below) by intentional, creative actions, in which existing institutions are created, reinterpreted, adapted, or transferred. In the bridging of the many barriers posed by knowledge integration, combinatorial knowledge dynamics have the potential to generate variety and diversity of institutions and organizational routines that may in a direct or indirect way foster dynamics within an established path, as processes of gradual institutional change (Mahoney & Thelen 2010) could be observed.

As especially the MEDIAKIBS case study of chapter 5 shows, conducting combinatorial knowledge dynamics is a difficult process. As the knowledge base literature states, the rationales guiding knowledge dynamics can differ considerably (Asheim 2007), resulting in conflicts between actors. Thus, when two or more actors rooted in different institutional contexts come together, they cannot simply bring together the rules guiding their knowledge creation processes. New institutions cannot simply be composed by put institutions together like pieces of a puzzle. Instead, bringing institutions together in combinatorial knowledge dynamics rather resembles a process of agglutination, in which the resulting new institution may not resemble the original components. **Thereby, existing institutions are layered with new institutional components or converted to new goals, functions, or purposes** (Mahoney & Thelen 2010). Examples of these processes can be found in the reformation, restructuring or redeployment of organizational arrangements (Chapters 4 and 5). This can be considered an important contribution to path modernization by organizational, respectively institutional innovation (Grillitsch & Trippl 2016). Hence, actors involved in combinatorial knowledge dynamics are not only innovators in a technological sense, but also in an institutional sense as “institutional navigators and entrepreneurs” (Sotarauta 2016).

Of course, knowledge dynamics are also influenced by the institutional settings in which they unfold. As chapter 4 shows, sector-specific institutions, as predicted by the knowledge base literature (Asheim 2007; Manniche 2012) affect the geography of cumulative and combinatorial knowledge dynamics. Chapter 5 shows that while institutions and organizational routines tend to be linked with the continuity and stability of cumulative knowledge dynamics, **exploring path plasticity** (Strambach & Storz 2008; Strambach 2010c) **is associated with to combinatorial knowledge dynamics**.

Peripheral elements of institutional settings were creatively combined and integrated with existing institutional forms in order to promote and conduct combinatorial knowledge dynamics. Thus, approaches to alternative forms of path development linked to adaptation and resilience have to acknowledge the creative agency of individual and collective actors who explore and exploit the scope for action given by existing institutional settings (Bristow & Healy 2014; Sotarauta 2016).

While chapters 6 and 7 did not explicitly study institutions, the symbolic knowledge bases of different music scenes are strongly linked to different institutional settings, as music genres are separated from each other by many conventions and rules who may conflict with each other (Lena 2012). Hence, even something as intangible as music cannot be combined arbitrarily, as illustrated by the extent and direction of symbolic knowledge creation. As both chapters demonstrated, **symbolic knowledge creation and combination did not thrive in specialized knowledge bases**. Along the lines of path extension (Isaksen 2015), non-technological innovation was rather rare. Instead, it was found that the related variety of symbolic knowledge bases promoted innovation.

4 How can knowledge dynamics in symbolic knowledge bases be differentiated by measures of relatedness?

To an increasing extent, combinations of knowledge within knowledge bases are explored in recent studies (Boschma 2017). Chapters 6 and 7 of this thesis demonstrate how knowledge dynamics within **symbolic knowledge bases can be differentiated by utilizing network-based relatedness metrics.** As long as economic entities are characterized by multiple features, relatedness between these features can be calculated by using co-occurrence metrics (Neffke & Henning 2013). The problem in the field of non-technological innovation is that classifications of economic entities are hidden from official statistics (Miles & Green 2008). Fortunately for researchers, more and more social practices leave a digital trail on different online platforms, thereby producing digital social data, which often have a geographical dimension (Poorthuis et al. 2016).

On the internet, a wealth of digital social data accrues from the description, reaction or commentary of goods of the creative economy. Hence, it has become visible how these goods resonate with a large audience of consumers. Their reactions to and interactions with innovations can be used as indicators, especially for innovations in the creative economy. These so-called **resonance indicators** can be considered a new, separate type of innovation indicators beside the typical input, throughput and output indicators (see Grupp & Mogee 2004). Resonance indicators measure not the output itself, but the output's appeal to and effect on consumers. As this thesis shows, resonance indicators can inform researchers on characteristics, popularity, or novelty of these products. Compared with traditional innovation indicators, not the actions of a few experts construct the data, but the actions of an anonymous crowd of people. While experts intend the construction of data, the actions of the crowd typically are not directed at producing data. Instead, their actions produce a data stream that can be tapped and handled by researchers.

Chapters 6 and 7 demonstrated by the field of music how digital social data can be utilized to transfer EEG methods to the analysis of non-technological innovation. Thereby symbolic knowledge was disaggregated as classified knowledge bits so that relatedness, related variety, and innovativeness metrics could be computed. Most importantly, the **cognitive distance between symbolic knowledge bits was identified and used to distinguish combinatorial from cumulative knowledge dynamics**. The evolution of urban music scenes could be described by the deepening and unification of symbolic knowledge bases, providing valuable insights into the processes underlying non-technological creativity.

There are good reasons to **use these resonance indicators in other areas** in which traditional innovation indicators fail to capture innovation. This may not only be the case in non-technological innovation but also in rapidly emerging or changing industries or technological fields (Jurowetzki & Hain 2014; Mateos-Garcia et al. 2014). Especially social innovations, which refer to the change and creation of social practices (Hochgerner 2011) should be measurable by digital trails of social practices. Also in the field of sustainability transition, where the diffusion of sustainable social practices is a decisive factor for the success of new solutions (van den Heiligenberg et al. 2017, 2017), these indicators may be promising instruments.

A synthesis of these results provides answers to the main research question of this thesis:

M **Which role do cumulative and combinatorial dynamics play for continuity and change in regional path development?**

Combinatorial knowledge dynamics, in particular, contribute to changes in regional path development. Not only do combinatorial knowledge dynamics affect the creation of new elements in the economic landscape, but also the creation and change of its institutional dimension. While many innovations can be considered "new combinations" (Schumpeter 1934), combinatorial knowledge dynamics that involve the unification of separate knowledge bases rooted in different institutional contexts, are accompanied by important institutional and organizational change processes. These are most valuable to the creation of dynamics within existing paths, as the papers of this thesis demonstrate.

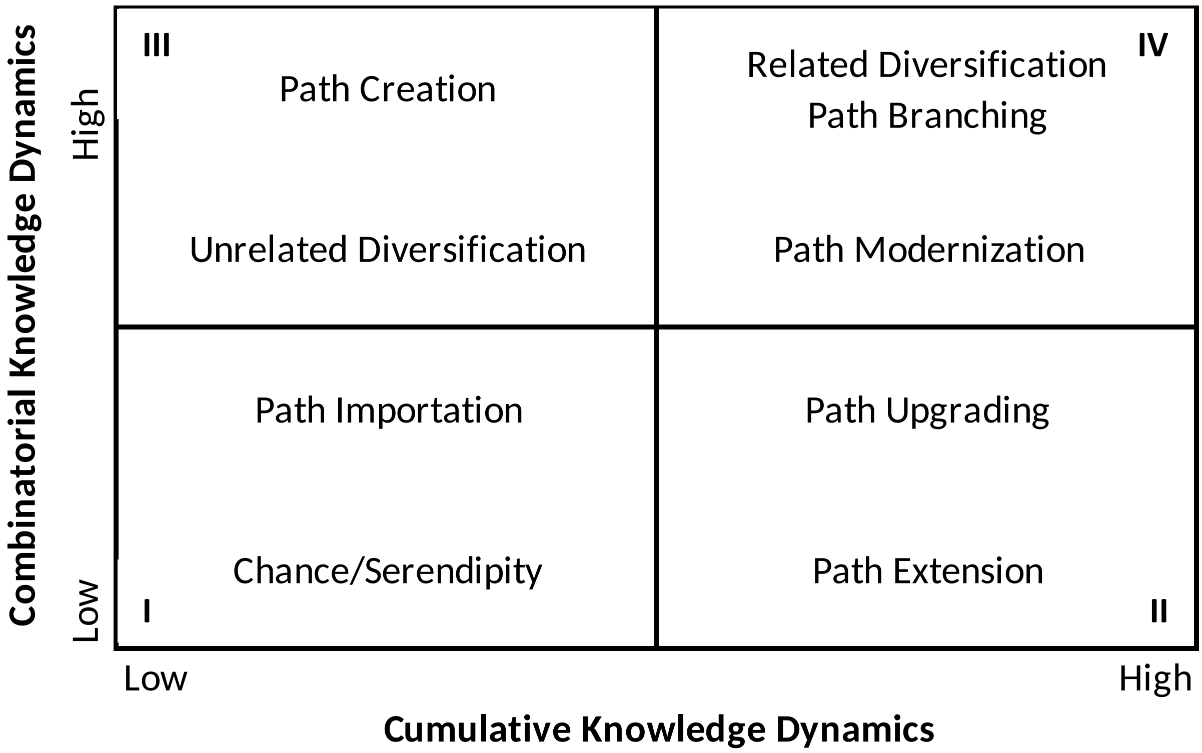


Figure 8.1: Relationship between types of knowledge dynamics and forms of path development

However, combinatorial knowledge dynamics are most effective and feasible when coupled with cumulative knowledge dynamics. They shape and affect the extent and direction of renewal processes. By the interplay of cumulative and combinatorial knowledge dynamics, the continuity and change of paths can be achieved simultaneously.

Figure 8.1 illustrates how different types of knowledge dynamics can be associated with forms of path development. This can be understood as the theoretical contribution of this thesis, which is supported by the empirical examples found in its papers.

In quadrant I on the bottom left, both cumulative and combinatorial knowledge dynamics are relatively unpronounced. This is the case with chance events, as they are not linked to existing activities and do not necessarily require combination or external linkages. In path importation, the occurrence of actual combinatorial knowledge dynamics, e.g. between local and external actors are also rare. Especially the analysis of symbolic knowledge bases in chapters 6 and 7 showed that these types of path development are relevant, but only to a limited degree. The innovations of the case studies of chapters 4 and 5 also cannot be considered as detached from the locally accumulated knowledge base.

In quadrant II on the bottom right, path extension and path upgrading are found, as in both forms the continuous improvement of existing activities, and consequently a high degree of cumulative knowledge dynamics prevails. As the analysis of symbolic knowledge bases in chapter 6 demonstrates, path extension can – as suggested by existing literature (Isaksen 2015) – lead to diminished degrees of innovativeness. Furthermore, regarding the case study of chapter 5, a lack of combinatorial knowledge dynamics in MEDIAKIBDS certainly would not have resulted in such a dynamical firm development as was observed.

Quadrant III comprises forms of path development, in which a high degree of combinatorial knowledge dynamics, but a low degree of cumulative knowledge dynamics exists. New activities are dissimilar to existing ones and there is a lot of (re-)combination involved: Especially the combination of unrelated knowledge bits is supposed to be associated with the emergence of completely new paths (Castaldi et al. 2015). Especially chapter 7 demonstrates how the contextualization of existing symbolic knowledge in new contexts can result in unrelated diversification. However, it also showed that this kind of development is comparatively rare, as cumulative knowledge dynamics were guiding the direction of knowledge base evolution. As chapter 4 demonstrates, the majority of knowledge dynamics are based on the existing sector-specific knowledge base. The institutionally based differentiation of knowledge dynamics provided in chapter 4 can point to the many reasons for path creation/unrelated diversification being relatively rare.

Quadrant IV shows forms of path development associated with an interplay of cumulative and combinatorial knowledge dynamics. Here, pre-existing, localized knowledge bases are combined with external ones. In many contexts of this thesis, the interaction of cumulative and combinatorial knowledge dynamics was observed, which leads to processes of related diversification or path modernization. In the field of symbolic knowledge creation, the interplay of different knowledge dynamics has proven to be very prevalent. The existing knowledge bases shaped by cumulative knowledge dynamics provide the available resources that can be combined or with which external, mobile knowledge can be anchored (Crevoisier & Jeannerat 2009).

However, combinatorial knowledge dynamics do not automatically result from the existing accumulation of knowledge. As the relative scarcity of combinatorial knowledge dynamics in different contexts of this thesis shows there are many obstacles for them to occur. Furthermore, as chapter 6 displays, not specialization or diversity but the accumulation of a variety of related knowledge (Frenken et al. 2007; Boschma & Iammarino 2009) promotes the emergence of combinatorial knowledge dynamics in symbolic knowledge bases. This is especially interesting, as many studies on related variety do not identify the actual mechanisms that lead to its many beneficial effects on economic development (Content & Frenken 2016). In this thesis, however, the role of related variety in facilitating new combinations of knowledge by the provision of a wealth of complementary resources, is observed empirically.

8.2 Implications for Policy

Of course, from the results of this thesis, implications for regional policy can and should be derived. Regional economic policy that intends to foster the adaptation, diversification, or renewal of regional paths should follow a platform-oriented strategy (Cooke 2010; Asheim et al. 2011a) that aims at bringing together a variety of actors under a common objective or topic. In general, this thesis suggests that policies aimed at specialization in pre-defined industries or sectors may not prepare regions for the challenges ahead. The results of this thesis suggest and support the following principles.

Know your strengths. Cumulative knowledge dynamics are still important and provide a requisite for the combination of knowledge. In order to create successful platforms, regional policy should first identify the knowledge space (Rigby 2015) of its jurisdiction to find the available accumulated, complementary knowledge. This way, possible diversification routes and combinatorial avenues could be identified (for examples on the national level, see Hidalgo & Hausmann 2013). As this thesis demonstrates, it is important to keep track of technological and non-technological knowledge alike. Hence, knowledge spaces should not only be constructed for technological knowledge but also for non-technological, symbolic knowledge. For this, new indicators based on digital social data, as used in this thesis, may become increasingly relevant.

Know the strengths of others. In different contexts, this thesis has shown that knowledge dynamics rarely remain on the local scale, but are characterized by multi-scalarity. In order to make the anchoring (Crevoisier & Jeannerat 2009; Dahlström & James 2012) of extralocal, mobile knowledge work, the identification of complementary, mobile, extralocal knowledge is equally important. As achieving this may be unfeasible for individual regions, national or supranational organizations (e.g. the EU) may be best equipped to identify the complementarity between local/regional knowledge bases.

Cross borders. Political efforts should not stop at administrative borders, as neither do knowledge dynamics. The development of cross-sectoral and cross-regional initiatives is useful to avoid path extension or lock-in. One of the most important interfaces that has to be created is the one between technological and symbolic knowledge. Still, many policies put emphasis on innovation and entrepreneurship in scientific and technological contexts, while the policy landscape for non-technological, symbolic knowledge creation remains meager (Fraunhofer-Zentrum für Internationales Management und Wissensökonomie 2016).

Acknowledge the social dimension of technological change. The complexity of combinatorial knowledge dynamics does not originate from combining technology, but from combining institutional contexts. Consequently, the social and institutional mechanisms promoting organizational and institutional change move to the center of regional policy. Developing platforms around common topics promotes the generation of a shared understanding between participating actors of the objective and economic value of the future outcome Furthermore, like in the diversification of firms, regional policy actors are well-advised to identify excess or redundant resources or organizations that can be restructured or redeployed towards new purposes. Furthermore, policy actors should be aware of the path plasticity (Strambach 2010c) that can be explored by local actors and if possible, contribute actively to the use of peripheral institutional elements of the path or the functional reorientation of existing institutions.

Measure non-technological creativity. In this thesis, several methods were demonstrated that measure innovation in areas usually hidden from innovation indicators such as R&D expenditures or patents. Typically, the mere existence of the creative economy (measured by employees, firms, or revenue statistics) suffices to identify cities or regions as "creative". Yet It is worth analyzing the actual activities existing in local creative economies to determine existing symbolic knowledge bases and innovativeness of creatives. As this thesis demonstrates, the composition of local scenes affects the possibilities to create and combine symbolic knowledge. Consequently, especially an over-specialization should be prevented to promote the necessary adaption to new trends, which are essential for the long-run success of creative cities/regions (Brandellero & Kloosterman 2010).

8.3 Limitations

Certainly, this thesis also has some limitations. From a theoretical perspective, the concept of knowledge dynamics is still very young. Especially the differentiation between cumulative and combinatorial knowledge dynamics has rarely been used, especially in empirical research. This points to difficulties in clearly distinguishing both types of knowledge dynamics from each other. While this thesis has demonstrated the flexibility of knowledge dynamics by the application of the concept in different contexts, it may also be too flexible and fuzzy to be applied by a wider scholarly audience. As can be seen by the critique of the knowledge base literature (Boschma 2017; Manniche et al. 2017), using ideal types in the context of quantitative studies is troublesome as the distinction between types is blurry. The problem is enhanced, as the distinction of different forms of path development has also entered scholarly debate fairly recently. Hence, theoretically, this thesis has to deal with a lot of moving parts that may change their meaning in the next years.

Furthermore, linking knowledge dynamics to regional path development points out the difficulties of linking processes on the micro-level to the behavior of aggregates (such as territories) on the meso- or macro- level. Even though observing and analyzing processes on the respective levels is feasible, constructing linkages between observations on different levels lacks a consistent theoretical foundation. In the other direction, from the meso to the micro level, there are the same problems, as the lack of micro-level mechanisms to explain the benefits of relatedness and related variety shows (Content &

Frenken 2016). The framework of this thesis can only be understood as a first step to identify and handle systemic relationships between interactions, elements, and institutions of economic landscapes. An integration of more formal complex adaptive system models with regional innovation systems theory may lead to more precise arguments on the relationship between the actions of creative agents and the behavior of regional economies.

In addition to that, especially chapters 6 and 7 of this thesis move on relatively uncharted methodological territory by using digital social data. As Crang (2015) notes, the use of digital social data raises several questions on the relationship between human action and its digital representation as texts. Even though data like those from last.fm can provide insights unachievable by other data sources, there are still some open questions regarding their validity and representativeness, which can only be answered by the proprietors of the companies collecting these data. Researchers also have to be aware of the possibility of the quality of digital social data being tainted by non-human users such as bots or automated systems (Crampton et al. 2013) or by the social practices emerging on social platforms (Ames & Naaman 2007). In the case of using last.fm for this thesis, several countermeasures were taken to reduce noise in the data by setting up limits and conditions which tags or artists had to satisfy. From the author's perspective, an unsupervised collection of data is not recommended.

Finally, the question remains to what extent the findings of this thesis can be generalized. Fortunately, the EURODITE project provided a rich collection of case studies in multiple sectors and regions. For instance, chapter 4 shows that the geography of knowledge dynamics has sector-specific characteristics. However, as above mentioned, there are also some commonalities across sectors or knowledge bases. Regarding the empirical findings of chapters 6 and 7, it has to be acknowledged that the field of music is only one example of creative industries and non-technological innovation. While other creative industries are also associated with symbolic knowledge bases, there may be differences in their relationship to space and place. While performances of music are bound to physical locations and also help to construct the identity of places (Leyshon et al. 1995), other creative industries, such as the video games industry, may not have such a performative element in geographic, but in virtual space. Further research in other creative industries is recommended. Furthermore, this thesis has mainly focused on processes in economically successful regions within developed countries, except for some case studies in chapter 4. In developing countries, however, the role of external, global knowledge may be considerably higher, as to a great extent, innovative efforts are concerted by multinational corporations (Bruche 2009; Strambach & Klement 2012b). There are also socio-economic systems in which national policy has a more direct role in shaping the extent and direction of diversification processes (Altenburg et al. 2016), even in the field of music (Lena 2012). This may imply that the exploration of path plasticity (Strambach & Klement 2013) by creative actors could be more difficult or discouraged in these countries. If institutional and organizational change were less attainable in these countries, the emergence of combinatorial knowledge dynamics could also be limited.

8.4 Avenues for Further Research

The results of this thesis also provide some promising avenues for further research. First of all, there is potential in further exploring the new organizational forms and routines playing a role in combinatorial knowledge dynamics. In the knowledge base literature, a recent turn towards the analysis of the combination of knowledge can be detected (Boschma 2017; Manniche et al. 2017) that should be continued. It is especially suitable to find out more about the transfer and transformation of organizational routines. While their transfer and replication behaviors provide a main theoretical foundation of EEG (Frenken & Boschma 2007; Boschma & Frenken 2011a), EEG studies rarely analyze these processes explicitly. Thereby the interactions between organizational and institutional change may be of particular interests. As the case of Kodak shows, restructuring and redeployment require also the change of formal and especially informal institutions (Lucas & Goh 2009).

In general, a more qualitative perspective on the processes identified by quantitative EEG studies may help to understand some dynamics currently hidden from quantitative analysis. In the context of EEG, knowledge dynamics, especially combinatorial ones, can be a useful tool to explore the dynamics of relatedness, which are currently underexplored (Castaldi et al. 2015; Boschma 2016). Combinatorial knowledge dynamics and the accompanying institutional/organizational change processes may result in unrelated activities becoming related. For instance, chapter 5 illustrates how combinatorial knowledge dynamics between two rather unrelated industries, the software/new media industry and the automotive industry, support routine transfer and replication, during which both industries become a bit closer. This can also be considered an example for the geographic differentiation of relatedness and the need to apply more "geographic wisdom" (Boschma 2016) to its study. While in the Stuttgart region, software firms appear to be rather related to the automotive industry due to supplier relations (Strambach & Klement 2013), in other regions software firms may be more related to other sectors, such as finance (e.g. as in newly developing Fintech clusters). Further studies could explore these hybrid sectors and their spatial agglomerations through the lens of dynamic relatedness.

At the same time, it may also be time for more quantitative analysis of regional innovation systems. Despite providing arguments on the systemic relationships between elements, institutions, and interactions that promote innovation, these systems are usually not formalized mathematically. As the framework of this thesis illustrates, the processes on the different levels and their interfaces are worth analyzing empirically. The concept of complex adaptive systems may be especially valuable to formally analyze currently underexplored processes of adaptation and transformation of regional innovation systems (see also Cooke 2012; Boschma 2015). Herein, modeling the creativity of agents and the behavior-guiding function of relevant institutions is the main challenge.

Regarding the institutional dimension of economic landscapes, this thesis has contributed to explore the significance of path plasticity (Strambach 2010c) for dynamics within paths. However, little is known about in which institutional environments actors tend to explore path plasticity and in which they do not. The varieties of capitalism approach (Hall & Soskice 2001) may provide an interesting perspective on the ability of actors to deviate from established paths, as first studies on diversification processes (Boschma & Capone 2015; Cortinovis et al. 2017) show.

Furthermore, the structure of knowledge spaces appears as a promising field of study. There are now many knowledge space studies in different contexts, but what does actually influence their structure and network characteristics? Key to an answer to this question may be to analyze why some knowledge bits/industries/technologies are more complementary than others, as this study has identified accumulated, complementary knowledge as seeding point from which new symbolic knowledge was created. This can also improve the quality of policy recommendations that can be made from this type of studies. This is also recommended, as dendritic evolutionary patterns along the branches of spaces may lead to their fragmentation that limits diversification processes (Howells 2012).

8.4 Avenues for Further Research

In the area of music geography, this thesis may provide the basis for further studies of the evolutionary processes of urban music scenes. The new quantitative database that identifies new genres and the characteristics of different music scenes can inform qualitative case studies on the emergence of specific genres. Thereby, the interactions between different actors and their origins could be studied and analyzed, e.g. by the innovation biography method to gain a more complete picture of the creative processes involved the combination and creation of symbolic knowledge. For example, the personal characteristics of artists identified here as pioneers in different music genres could enrich migration or innovation studies.

Finally, this thesis may inspire further quantitative research of hidden innovation by the use of resonance indicators derived from digital social data. The methods and approach of chapters 6 and 7 could certainly be replicated in other creative industries to test whether the evolution of symbolic knowledge bases behaves similarly to the example of music. It would be most interesting to find examples of industries in which the mobility of knowledge, and consequently the importance of extralocal knowledge sources can be assumed to be higher. Furthermore, other creative industries with less stage-bound performative aspects (e.g. publishing, design) may be of interest, as their relation to space may be different than in music which is performed at physical locations. As Hracs (2013) shows, the relation to space can even be different within music, as some musicians can entirely work with headphones, while others need noise-tolerant environments.

Finally, it has to be acknowledge that - while the field of music certainly provides an attractive research topic - other similar forms of innovation may refer to more pressing socio-economic issues. For instance, sustainable and social innovation also have a strong social component, which is hidden from traditional innovation indicators. Symbolic knowledge, hereby broadly understood as the understanding of the social world, may also play a major role in the changes of social practices underlying these new forms of innovation. Digital social data with geographic footprints may be available in these domains as well. An improved understanding of the social practices of consumers and other societal groups may also be instrumental in analyzing and promoting processes of sustainability transitions (Coenen & Truffer 2012).

VI REFERENCES

A

Ahas, R., Aasa, A. & Yuan, Y. et al. (2015): Everyday space–time geographies: Using mobile phone-based sensor data to monitor urban activity in Harbin, Paris, and Tallinn. *International Journal of Geographical Information Science* **29** (11), 2017–2039. DOI:10.1080/13658816.2015.1063151.

Ahrweiler, P., Pyka, A. & Gilbert, N. (2004): Simulating knowledge dynamics in innovation networks (SKIN). In: Leombruni, R. & Richiardi, M. (eds.): *Industry and Labor Dynamics*. WORLD SCIENTIFIC, 284–296.

Albors-Garrigós, J., Martinez Monzo, J. & Garcia-Segovia, P. (2017): Knowledge dynamics as drivers of innovation in Haute Cuisine and culinary services. *Industry and Innovation* **47** (2), 1–28. DOI:10.1080/13662716.2016.1268950.

Altenburg, T., Schamp, E. W. & Chaudhary, A. (2016): The emergence of electromobility: Comparing technological pathways in France, Germany, China and India. *Science and Public Policy* **43** (4), 464–475. DOI:10.1093/scipol/scv054.

Ames, M. & Naaman, M. (2007): Why We Tag: Motivations for Annotation in Mobile and Online Media. In: Rosson, M. B. (ed.): *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, New York, NY.

Amin, A. (1998): Globalisation and Regional Development: A Relational Perspective. *Competition & Change* **3** (1-2), 145–165. DOI:10.1177/102452949800300106.

Amin, A. & Cohendet, P. (2004): *Architectures of knowledge: Firms, capabilities, and communities,* [reprint]. Oxford Univ. Press, Oxford.

Androutsopoulos, J. & Scholz, A. (2003): Spaghetti Funk: Appropriations of Hip-Hop Culture and Rap Music in Europe. *Popular Music and Society* **26** (4), 463–479. DOI:10.1080/0300776032000144922.

Antonelli, C. (2005): Models of knowledge and systems of governance. *Journal of Institutional Economics* **1** (1), 51–73. DOI:10.1017/S1744137405000044.

Antonelli, C. (2006): The Business Governance of Localized Knowledge: An Information Economics Approach for the Economics of Knowledge. *Industry and Innovation* **13** (3), 227–261. DOI:10.1080/13662710600858118.

Antonelli, C. & Calderini, M. (2008): The Governance of Knowlege Compositeness and technological performance: The Case of The Automotive Industry in Europe.

Economics of Innovation and New Technology **17** (1), 23–41. DOI:10.1080/10438590701279243.

Antonelli, C., Krafft, J. & Quatraro, F. (2010): Recombinant knowledge and growth: The case of ICTs. *Structural Change and Economic Dynamics* **21** (1), 50–69. DOI:10.1016/j.strueco.2009.12.001.

Aristoteles (2015): *Über die Seele: Griechisch-deutsch,* [reprint]. Reclam, Stuttgart.

Arthur, W. B. (1989): Competing technologies, increasing returns, and lock-in by historical events. *The economic journal the journal of the Royal Economic Society* (99), 116–131.

Arthur, W. B. (2009): *The nature of technology: What it is and how it evolves*. Free Press, New York.

Asheim, B. T. (2007): Differentiated Knowledge Bases and Varieties of Regional Innovation Systems. *Innovation: The European Journal of Social Science Research* **20** (3), 223–241. DOI:10.1080/13511610701722846.

Asheim, B. T. (2012): The Changing Role of Learning Regions in the Globalizing Knowledge Economy: A Theoretical Re-examination. *Regional Studies* **46** (8), 993–1004. DOI:10.1080/00343404.2011.607805.

Asheim, B. T. (2016): Regional innovation systems: past – present – future. In: Shearmur, R., Carrincazeaux, C. & Doloreux, D. (eds.): *Handbook on the geographies of innovation*. Edward Elgar Publishing, Cheltenham, 45–62.

Asheim, B. T., Boschma, R. A. & Cooke, P. (2011a): Constructing Regional Advantage: Platform Policies Based on Related Variety and Differentiated Knowledge Bases. *Regional Studies* **45** (7), 893–904. DOI:10.1080/00343404.2010.543126.

Asheim, B. T. & Coenen, L. (2005): Knowledge bases and regional innovation systems: Comparing Nordic clusters. *Research Policy* **34** (8), 1173–1190. DOI:10.1016/j.respol.2005.03.013.

Asheim, B. T. & Coenen, L. (2006): Contextualising Regional Innovation Systems in a Globalising Learning Economy: On Knowledge Bases and Institutional Frameworks. *Journal of Technology Transfer* **33**, 163–173.

Asheim, B. T., Coenen, L. & Vang, J. (2007): Face-to-face, buzz, and knowledge bases: Sociospatial implications for learning, innovation, and innovation policy. *Environment and Planning C: Government and Policy* **25** (5), 655–670. DOI:10.1068/c0648.

Asheim, B. T. & Gertler, M. S. (2005): The Geography of Innovation: Regional Innovation Systems. In: Fagerberg, J., Mowery, D. C. & Nelson, R. R. (eds.): *Oxford Handbook of*

Innovation // The Oxford handbook of innovation. Oxford University Press, Oxford, UK, 291–317.

Asheim, B. T. & Hansen, H. K. (2009): Knowledge Bases, Talents, and Contexts: On the Usefulness of the Creative Class Approach in Sweden. *Economic Geography* **85** (4), 425–442. DOI:10.1111/j.1944-8287.2009.01051.x.

Asheim, B. T. & Isaksen, A. (2002): Regional Innovation Systems: The Integration of Local 'Sticky' and Global 'Ubiquitous' Knowledge. *The Journal of Technology Transfer* **27** (1), 77–86. DOI:10.1023/A:1013100704794.

Asheim, B. T., Smith, H. L. & Oughton, C. (2011b): Regional Innovation Systems: Theory, Empirics and Policy. *Regional Studies* **45** (7), 875–891. DOI:10.1080/00343404.2011.596701.

Atkinson, W. (2011): The context and genesis of musical tastes: Omnivorousness debunked, Bourdieu buttressed. *Poetics* **39** (3), 169–186. DOI:10.1016/j.poetic.2011.03.002.

B

Baden-Württemberg Ministry of Economics (2009): Regional Cluster Atlas Baden-Württemberg 2008: Inventory of cluster-related networks and initiatives. Baden-Württemberg Ministry of Economics, Stuttgart. https://www.clusterportal-bw.de/en/cluster-data/cluster-atlas-baden-wuerttemberg/. Accessed 12/7/2017.

Bader, I. & Scharenberg, A. (2010): The Sound of Berlin: Subculture and the Global Music Industry. *International Journal of Urban and Regional Research* **34** (1), 76–91. DOI:10.1111/j.1468-2427.2009.00927.x.

Balconi, M., Breschi, S. & Lissoni, F. (2004): Networks of inventors and the role of academia: An exploration of Italian patent data. *Research Policy* **33** (1), 127–145. DOI:10.1016/S0048-7333(03)00108-2.

Balland, P.-A., Boschma, R. A. & Frenken, K. (2015): Proximity and Innovation: From Statics to Dynamics. *Regional Studies* **49** (6), 907–920. DOI:10.1080/00343404.2014.883598.

Balland, P.-A. & Rigby, D. (2016): The Geography of Complex Knowledge. *Economic Geography*, 1–23. DOI:10.1080/00130095.2016.1205947.

Bathelt, H. & Glückler, J. (2012): *Wirtschaftsgeographie: Ökonomische Beziehungen in räumlicher Perspektive ; 22 Tabellen*, 3., vollst. überarb. und erw. Aufl. Ulmer, Stuttgart.

Bathelt, H., Malmberg, A. & Maskell, P. (2004): Clusters and knowledge: Local buzz, global pipelines and the process of knowledge creation. *Progress in Human Geography* **28** (1), 31–56. DOI:10.1191/0309132504ph469oa.

Bathelt, H., Munro, A. K. & Spigel, B. (2013): Challenges of Transformation: Innovation, Re-bundling and Traditional Manufacturing in Canada's Technology Triangle. *Regional Studies* **47** (7), 1111–1130. DOI:10.1080/00343404.2011.602058.

Beaudry, C. & Schiffauerova, A. (2009): Who's right, Marshall or Jacobs? The localization versus urbanization debate. *Research Policy* **38** (2), 318–337. DOI:10.1016/j.respol.2008.11.010.

Becker, M. C. (2004): Organizational routines: A review of the literature. *Industrial and Corporate Change* **13** (4), 643–678. DOI:10.1093/icc/dth026.

Becker, M. C., Knudsen, T. & March, J. G. (2006): Schumpeter, Winter, and the sources of novelty. *Industrial and Corporate Change* **15** (2), 353–371. DOI:10.1093/icc/dtl003.

Bell, T. (1998): Why Seattle? An Examination of an Alternative Rock Culture Hearth. *Journal of Cultural Geography* **18** (1), 35–47. DOI:10.1080/08873639809478311.

Bennett, A. (2004): Consolidating the music scenes perspective. *Poetics* **32** (3-4), 223–234. DOI:10.1016/j.poetic.2004.05.004.

Berg, S.-H. & Hassink, R. (2014): Creative Industries from an Evolutionary Perspective: A Critical Literature Review. *Geography Compass* **8** (9), 653–664. DOI:10.1111/gec3.12156.

Bergek, A. & Bruzelius, M. (2010): Are patents with multiple inventors from different countries a good indicator of international R&D collaboration? The case of ABB. *Research Policy* **39** (10), 1321–1334. DOI:10.1016/j.respol.2010.08.002.

Berger, P. L. & Luckmann, T. (1966): *The social construction of reality: A treatise in the sociology of knowledge*. Doubleday & Co, Garden City, NY.

Binz, C. & Anadon, L. D. (2016): Transplanting clean-tech paths from elsewhere: The emergence of the Chinese solar PV industry. Papers in Innovation Studies 2016/29. CIRCLE, Lund University.

Binz, C., Truffer, B. & Coenen, L. (2015): Path Creation as a Process of Resource Alignment and Anchoring: Industry Formation for On-Site Water Recycling in Beijing. *Economic Geography* **92** (2), 172–200. DOI:10.1080/00130095.2015.1103177.

Blöcker, A. & Jürgens, U. (2009): Eurodite, WP6 Final Report, Berlin.

Blush, S. & Petros, G. (2010): *American Hardcore: A Tribal History,* 2nd ed. Feral House, Port Townsend, WA.

Böhm, A. (2000): Theoretisches Codieren. Textanalyse in der Grounded Theory. In: Flick, U., Kardorff, E. von & Steinke, I. (eds.): *Qualitative Forschung: Ein Handbuch*, Original-Ausgabe. Rowohlt Taschenbuch Verlag, Reinbek bei Hamburg, 475–785.

Boix, R., Capone, F., Propris, L. de, Lazzeretti, L. & Sanchez, D. (2016): Comparing creative industries in Europe. *European Urban and Regional Studies* **23** (4), 935–940. DOI:10.1177/0969776414541135.

Boschma, R. A. (2005): Proximity and Innovation: A Critical Assessment. *Regional Studies* **39** (1), 61–74. DOI:10.1080/0034340052000320887.

Boschma, R. A. (2015): Towards an Evolutionary Perspective on Regional Resilience. *Regional Studies* **49** (5), 733–751. DOI:10.1080/00343404.2014.959481.

Boschma, R. A. (2016): Relatedness as driver of regional diversification: A research agenda. *Regional Studies* **51** (3), 351–364. DOI:10.1080/00343404.2016.1254767.

Boschma, R. A. (2017): A concise history of the knowledge base literature: challenging questions for future research. Papers in Evolutionary Economic Geography # 17.21. Urban & Regional research centre, Utrecht.

Boschma, R. A., Balland, P.-A. & Kogler, D. F. (2015): Relatedness and technological change in cities: The rise and fall of technological knowledge in US metropolitan areas from 1981 to 2010. *Industrial and Corporate Change* **24** (1), 223–250. DOI:10.1093/icc/dtu012.

Boschma, R. A. & Capone, G. (2015): Institutions and diversification: Related versus unrelated diversification in a varieties of capitalism framework. *Research Policy* **44** (10), 1902–1914. DOI:10.1016/j.respol.2015.06.013.

Boschma, R. A., Coenen, L., Frenken, K. & Truffer, B. (2017): Towards a theory of regional diversification: Combining insights from Evolutionary Economic Geography and Transition Studies. *Regional Studies* **51** (1), 31–45. DOI:10.1080/00343404.2016.1258460.

Boschma, R. A. & Frenken, K. (2011a): Technological relatedness and regional branching. In: Bathelt, H., Feldman, M. P. & Kogler, D. F. (eds.): *Beyond territory: Dynamic geographies of knowledge creation, diffusion, and innovation*. Routledge, London, 64–81.

Boschma, R. A. & Frenken, K. (2011b): The emerging empirics of evolutionary economic geography. *Journal of Economic Geography* **11** (2), 295–307. DOI:10.1093/jeg/lbq053.

Boschma, R. A. & Fritsch, M. (2009): Creative Class and Regional Growth: Empirical Evidence from Seven European Countries. *Economic Geography* **85** (4), 391–423. DOI:10.1111/j.1944-8287.2009.01048.x.

Boschma, R. A., Heimeriks, G. & Balland, P.-A. (2014): Scientific knowledge dynamics and relatedness in biotech cities. *Research Policy* **43** (1), 107–114. DOI:10.1016/j.respol.2013.07.009.

Boschma, R. A. & Iammarino, S. (2009): Related Variety, Trade Linkages, and Regional Growth in Italy. *Economic Geography* **85** (3), 289–311. DOI:10.1111/j.1944-8287.2009.01034.x.

Boschma, R. A. & Martin, R. (2010a): The Aims and Scope of Evolutionary Economic Geography. In: Boschma, R. A. & Martin, R. (eds.): *The Handbook of Evolutionary Economic Geography*. Edward Elgar Publishing.

Boschma, R. A. & Martin, R. (eds.) (2010b): *The Handbook of Evolutionary Economic Geography*. Edward Elgar Publishing.

Boschma, R. A., Minondo, A. & Navarro, M. (2011): Related variety and regional growth in Spain*. *Papers in Regional Science* **91** (2), 241-256. DOI:10.1111/j.1435-5957.2011.00387.x.

Boschma, R. A., Minondo, A. & Navarro, M. (2013): The Emergence of New Industries at the Regional Level in Spain: A Proximity Approach Based on Product Relatedness. *Economic Geography* **89** (1), 29–51. DOI:10.1111/j.1944-8287.2012.01170.x.

Bottà, G. (2009): The city that was creative and did not know: Manchester and popular music, 1976-97. *European Journal of Cultural Studies* **12** (3), 349–365. DOI:10.1177/1367549409105368.

Bourdieu, P. (1984): *Distinction: A social critique of the judgement of taste*. Harvard University Press, Cambridge, Mass.

Boy, J. D. & Uitermark, J. (2016): How to Study the City on Instagram. *PloS one* **11** (6), e0158161. DOI:10.1371/journal.pone.0158161.

Braczyk, H.-J., Schienstock, G. & Steffensen, B. (1996): Die Regionalökonomie Baden-Württembergs. Ursachen und Grenzen des Erfolges. In: Braczyk, H.-J. (ed.): *Kurswechsel in der Industrie: Lean Production in Baden-Württemberg*. Kohlhammer, Stuttgart, 24–51.

Brandellero, A. & Pfeffer, K. (2015): Making a scene: Exploring the dimensions of place through Dutch popular music, 1960-2010. *Environment and Planning A* **47** (7), 1574–1591. DOI:10.1177/0308518X15595781.

Brandellero, A. M. C. & Kloosterman, R. C. (2010): Keeping the market at bay: Exploring the loci of innovation in the cultural industries. *Creative Industries Journal* **3** (1), 61–77. DOI:10.1386/cij.3.1.61_1.

Breschi, S. & Lissoni, F. (2005): Knowledge Networks from Patent Data. In: Moed, H. F., Glänzel, W. & Schmoch, U. (eds.): *Handbook of Quantitative Science and Technology Research: The Use of Publication and Patent Statistics in Studies of S&T Systems*. Springer Science + Business Media Inc, Dordrecht, 613–643.

Breschi, S., Lissoni, F. & Malerba, F. (2003): Knowledge-relatedness in firm technological diversification. *Research Policy* **32** (1), 69–87. DOI:10.1016/S0048-7333(02)00004-5.

Bristow, G. & Healy, A. (2014): Regional Resilience: An Agency Perspective. *Regional Studies* **48** (5), 923–935. DOI:10.1080/00343404.2013.854879.

Bristow, G. & Healy, A. (2017): Innovation and regional economic resilience: An exploratory analysis. *The Annals of Regional Science* **49** (5), 733. DOI:10.1007/s00168-017-0841-6.

Bruche, G. (2009): The Emergence of China and India as New Competitors in MNCs' Innovation Networks. *Competition & Change* **13** (3), 267–288. DOI:10.1179/102452909X451378.

Brydges, T., Gilligan, S., Matheson, Z., Morgan, G. & Stolarick, K. (2013): *The Geography of Myspace: Part Three*, Toronto.

Buenstorf, G., Fritsch, M. & Medrano, L. F. (2012): Regional Knowledge, Organizational Capabilities and the Emergence of the West German Laser Systems Industry, 1975–2005. *Regional Studies* **49** (1), 59–75. DOI:10.1080/00343404.2012.711947.

Bugge, M. M. & Øiestad, S. (2014): The Micro-foundations of Regional Branching—the Case of Digitization of Publishing. *European Planning Studies* **23** (4), 764–784. DOI:10.1080/09654313.2014.970131.

Butzin, A. (2009): Innovationsbiographien als Methode der raum-zeitlichen Erfassung von Innovationsprozessen. In: Dannenberg, P., Köhler, H., Lang, Thilo, Utz, Judith, Zakirova, B. & Zimmermann, T. (eds.): *Innovationen im Raum - Raum für Innovationen. 11. Junges Forum der ARL, 21. bis 23. Mai in Berlin*. Verlag der ARL, Hannover, 189–198.

Butzin, A. (2012): Aufbau und Forschungsprozess von Innovationsbiographien. In: Butzin, A., Rehfeld, D. & Wiedmaier, B. (eds.): *Innovationsbiographien: Räumliche und sektorale Dynamik*, 1st edn. Nomos, Baden-Baden, 123–138.

Butzin, A. & Rehfeld, D. (2013): The balance of change and continuity in the German construction sector's development path. *Zeitschrift für Wirtschaftsgeographie* **57** (1-2). DOI:10.1515/zfw.2013.0002.

Butzin, A., Rehfeld, D. & Wiedmaier, B. (eds.) (2012): *Innovationsbiographien: Räumliche und sektorale Dynamik,* 1st edn. Nomos, Baden-Baden.

Butzin, A. & Widmaier, B. (2009): Tourism Development in the Ruhr Area. Knowledge Dynamics, Activities, Trends: Eurodite Final WP6 Report, Gelsenkirchen.

Butzin, A. & Widmaier, B. (2010): How to study the time-space dynamics of knowledge with innovation biographies: Final Eurodite WP7 Report, Gelsenkirchen.

Butzin, A. & Widmaier, B. (2012): The study of time-space dynamics of knowledge with innovation biographies. Working Papers on Innovation and Space, Marburg.

Butzin, A. & Widmaier, B. (2015): Exploring Territorial Knowledge Dynamics through Innovation Biographies. *Regional Studies* **50** (2), 220–232. DOI:10.1080/00343404.2014.1001353.

C

Campagna, M. (2016): Social Media Geographic Information: Why social is special when it goes spatial? In: Capineri, C., Haklay, M. & Huang, H. et al. (eds.): *European Handbook of Crowdsourced Geographic Information*. Ubiquity Press, 45–54.

Campbell, J. L. (2010): Institutional reproduction and change. In: Morgan, G. (ed.): *The Oxford handbook of comparative institutional analysis: [Annual Conference of the Society for the Advancement of Socio-Economic (SASE) ... June 2007 ... Copenhagen Business School (CBS)*. Oxford Univ. Press, Oxford, 87–115.

Capello, R. (2009): Space, growth and development. In: Capello, R. & Nijkamp, P. (eds.): *Handbook of regional growth and development theories*. Elgar, Cheltenham, 33–52.

Capineri, C., Haklay, M. & Huang, H. et al. (eds.) (2016): *European Handbook of Crowdsourced Geographic Information*. Ubiquity Press.

Caragliu, A., Dominicis, L. de & Groot, H. L. de (2015): Both Marshall and Jacobs were Right! *Economic Geography* **92** (1), 87–111. DOI:10.1080/00130095.2015.1094371.

Carlile, P. R. (2004): Transferring, Translating, and Transforming: An Integrative Framework for Managing Knowledge Across Boundaries. *Organization Science* **15** (5), 555–568. DOI:10.1287/orsc.1040.0094.

Casper, S., Hollingsworth, J. R. & Whitley, R. (2005): Varieties of Capitalism: Comparative institutional approaches to economic organization and innovation. In: Casper, S. & van

Waarden, F. (eds.): *Innovation and institutions: A multidisciplinary review of the study of innovation systems*. Elgar, Cheltenham, 193–228.

Castaldi, C., Frenken, K. & Los, B. (2015): Related Variety, Unrelated Variety and Technological Breakthroughs: An analysis of US State-Level Patenting. *Regional Studies* **49** (5), 767–781. DOI:10.1080/00343404.2014.940305.

Chesbrough, H. W. (2006): Open innovation: a new paradigm for understanding industrial innovation. In: Chesbrough, H. W., Vanhaverbeke, W. & West, J. (eds.): *Open innovation: Researching a new paradigm*. Oxford University Press, Oxford, 1–12.

Chesbrough, H. W. (2007): Business model innovation: It's not just about technology anymore. *Strategy & Leadership* **35** (6), 12–17. DOI:10.1108/10878570710833714.

Chesbrough, H. W., Vanhaverbeke, W. & West, J. (eds.) (2006): *Open innovation: Researching a new paradigm*. Oxford University Press, Oxford.

Christensen, C. M. (1997): *The innovator's dilemma: When new technologies cause great firms to fail*. Harvard Business School Press, Boston MA.

Clavé, S. A. & Wilson, J. (2016): The evolution of coastal tourism destinations: A path plasticity perspective on tourism urbanisation. *Journal of Sustainable Tourism* **25** (1), 96–112. DOI:10.1080/09669582.2016.1177063.

Coe, N. M., Dicken, P. & Hess, M. (2008): Global production networks: Realizing the potential. *Journal of Economic Geography* **8** (3), 271–295. DOI:10.1093/jeg/lbn002.

Coenen, L., Asheim, B., Bugge, M. M. & Herstad, S. J. (2017): Advancing regional innovation systems: What does evolutionary economic geography bring to the policy table? *Environment and Planning C: Politics and Space* **35** (4), 600–620. DOI:10.1177/0263774X16646583.

Coenen, L., Benneworth, P. & Truffer, B. (2012): Toward a spatial perspective on sustainability transitions. *Research Policy* **41** (6), 968–979. DOI:10.1016/j.respol.2012.02.014.

Coenen, L., Moodysson, J. & Asheim, B. T. (2004): Nodes, networks and proximities: on the knowledge dynamics of the Medicon Valley biotech cluster. *European Planning Studies* **12** (7), 1003–1018.

Coenen, L., Moodysson, J. & Martin, H. (2015): Path Renewal in Old Industrial Regions: Possibilities and Limitations for Regional Innovation Policy. *Regional Studies* **49** (5), 850–865. DOI:10.1080/00343404.2014.979321.

Coenen, L. & Truffer, B. (2012): Places and Spaces of Sustainability Transitions: Geographical Contributions to an Emerging Research and Policy Field. *European Planning Studies* **20** (3), 367–374. DOI:10.1080/09654313.2012.651802.

Cohen, S. (2013): Musical memory, heritage and local identity: Remembering the popular music past in a European Capital of Culture. *International Journal of Cultural Policy* **19** (5), 576–594. DOI:10.1080/10286632.2012.676641.

Cohen, W. M. & Levinthal, D. A. (1990): Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly* **35** (1), 128. DOI:10.2307/2393553.

Cohendet, P., Grandadam, D., Simon, L. & Capdevila, I. (2014): Epistemic communities, localization and the dynamics of knowledge creation. *Journal of Economic Geography* **14** (5), 929–954. DOI:10.1093/jeg/lbu018.

Coleman, D. J., Georgiadou, Y. & Labonte, J. (2009): Volunteered Geographic Information: The Nature and Motivation of Produsers. *International Journal of Spatial Data Infrastructures Research* **4**, 332–358. DOI:10.2902/1725-0463.2009.04.art16.

Colombelli, A., Krafft, J. & Quatraro, F. (2013): Properties of knowledge base and firm survival: Evidence from a sample of French manufacturing firms. *Technological Forecasting and Social Change* **80** (8), 1469–1483. DOI:10.1016/j.techfore.2013.03.003.

Colombelli, A., Krafft, J. & Quatraro, F. (2014): The emergence of new technology-based sectors in European regions: A proximity-based analysis of nanotechnology. *Research Policy* **43** (10), 1681–1696. DOI:10.1016/j.respol.2014.07.008.

Content, J. & Frenken, K. (2016): Related variety and economic development: A literature review. *European Planning Studies* **24** (12), 2097–2112. DOI:10.1080/09654313.2016.1246517.

Cooke, P. (1992): Regional innovation systems: Competitive regulation in the new Europe. *Geoforum* **23** (3), 365–382. DOI:10.1016/0016-7185(92)90048-9.

Cooke, P. (2005): Regionally asymmetric knowledge capabilities and open innovation. *Research Policy* **34** (8), 1128–1149. DOI:10.1016/j.respol.2004.12.005.

Cooke, P. (ed.) (2010): *Platforms of innovation: Dynamics of new industrial knowledge flows*. Edward Elgar, Cheltenham.

Cooke, P. (2012): Transversality and Transition: Green Innovation and New Regional Path Creation. *European Planning Studies* **20** (5), 817–834. DOI:10.1080/09654313.2012.667927.

Cooke, P. (ed.) (2013): *Reframing Regional Development: Evolution, Innovation and Transition*. Routledge, London/New York.

Cooke, P., Gomez Uranga, M. & Etxebarria, G. (1997): Regional innovation systems: Institutional and organisational dimensions. *Research Policy* **26** (4-5), 475–491. DOI:10.1016/S0048-7333(97)00025-5.

Cooke, P. & Heidenreich, M. (eds.) (2004): *Regional innovation systems: The role of governance in a globalized world,* 2. ed. Routledge, London.

Cooke, P. & Kaiser, R. (2012): Kapitel 12 Innovationsbiographien in öffentlichen und privaten Forschungskontexten am Beispiel der Biotechnologie. In: Butzin, A., Rehfeld, D. & Wiedmaier, B. (eds.): *Innovationsbiographien: Räumliche und sektorale Dynamik*, 1st edn. Nomos, Baden-Baden, 231–250.

Coombs, R. (2003): Analysing distributed processes of provision and innovation. *Industrial and Corporate Change* **12** (6), 1125–1155. DOI:10.1093/icc/12.6.1125.

Cortinovis, N. & van Oort, F. (2015): Variety, economic growth and knowledge intensity of European regions: A spatial panel analysis. *The Annals of Regional Science* **55** (1), 7–32. DOI:10.1007/s00168-015-0680-2.

Cortinovis, N., Xiao, J., Boschma, R. A. & van Oort, F. G. (2017): Quality of government and social capital as drivers of regional diversification in Europe. *Journal of Economic Geography* **17** (6), 1179–1208. DOI:10.1093/jeg/lbx001.

Crampton, J. W., Graham, M. & Poorthuis, A. et al. (2013): Beyond the Geotag: Deconstructing 'Big Data' and Leveraging the Potential of the Geoweb. *Cartography and Geographic Information Science* **40** (2), 130–139. DOI:10.2139/ssrn.2253918.

Crang, M. (2015): The promises and perils of a digital geohumanities. *cultural geographies* **22** (2), 351–360. DOI:10.1177/1474474015572303.

Crespo, J. & Vicente, J. (2015): Proximity and Distance in Knowledge Relationships: From Micro to Structural Considerations based on Territorial Knowledge Dynamics (TKDs). *Regional Studies* **50** (2), 202–219. DOI:10.1080/00343404.2014.984671.

Crevoisier, O. (2016): The Economic Value of Knowledge: Embodied in Goods or Embedded in Cultures? *Regional Studies* **50** (2), 189–201. DOI:10.1080/00343404.2015.1070234.

Crevoisier, O. & Jeannerat, H. (2009): Territorial Knowledge Dynamics: From the Proximity Paradigm to Multi-location Milieus. *European Planning Studies* **17** (8), 1223–1241. DOI:10.1080/09654310902978231.

D

Dahlström, M., Hedin, S. & Smed Olsen, L. (2010): Knowledge dynamics in moving media in Skåne - cross-sectorial innovations in game development and film tourism 2010:1. Nordregio, Stockholm.

Dahlström, M. & James, L. (2012): Regional Policies for Knowledge Anchoring in European Regions. *European Planning Studies* **20** (11), 1867–1887. DOI:10.1080/09654313.2012.723425.

David, P. A. (1985): Clio and the economics of QWERTY. *The American economic review* **75** (2), 332–337.

Davids, M. & Frenken, K. (2017): Proximity, knowledge base and the innovation process: Towards an integrated framework. *Regional Studies* **86** (3), 1–12. DOI:10.1080/00343404.2017.1287349.

Dawkins, R. (2009): *The Greatest Show on Earth: The Evidence for Evolution*. Free Press.

Dawley, S. (2013): Creating New Paths? Offshore Wind, Policy Activism, and Peripheral Region Development. *Economic Geography* **90** (1), 91–112.

DCMS (2016): *Creative Industries Economic Estimates: January 2016*, London.

Desrochers, P. & Leppala, S. (2011): Opening up the 'Jacobs Spillovers' black box: Local diversity, creativity and the processes underlying new combinations. *Journal of Economic Geography* **11** (5), 843–863. DOI:10.1093/jeg/lbq028.

Dicken, P. & Malmberg, A. (2001): Firms in Territories: A Relational Perspective. *Economic Geography* **77** (4), 345–363. DOI:10.1111/j.1944-8287.2001.tb00169.x.

DiMaggio, P. (1987): Classification in Art. *American Sociological Review* **52** (4), 440–455.

D'Ippolito, B. & Timpano, F. (2016): The Role of Non-Technological Innovations in Services: The Case of Food Retailing. *Creativity and Innovation Management* **25** (1), 73–89. DOI:10.1111/caim.12156.

Doloreux, D. & Porto Gomez, I. (2016): A review of (almost) 20 years of regional innovation systems research. *European Planning Studies* **25** (3), 371–387. DOI:10.1080/09654313.2016.1244516.

Dosi, G., Faillo, M. & Marengo, L. (2008): Organizational Capabilities, Patterns of Knowledge Accumulation and Governance Structures in Business Firms: An Introduction. *Organization Studies* **29** (8-9), 1165–1185. DOI:10.1177/0170840608094775.

DPA (2016): Kamerahersteller Leica mit Rekordumsatz. *FAZ,* April 05. http://www.faz.net/agenturmeldungen/dpa/kamerahersteller-leica-mit-rekordumsatz-14161862.html. Accessed 12/7/2017.

Drucker, P. F. (1969): *The age of discontinuity: Guidelines to our changing society*. Harper & Row, New York.

Dulupçu, M. A., Sezgin, A. & Demirel, O. et al. (2009): Eurodite, Final WP6 Report, Isparta.

Dunn, S. (2004): Lands of Fire and Ice: An Exploration of Death Metal Scenes. *Public* **29**, 106–125.

E

Edquist, C. (2005): Systems of Innovation: Perspectives and Challenges. In: Fagerberg, J., Mowery, D. C. & Nelson, R. R. (eds.): *Oxford Handbook of Innovation // The Oxford handbook of innovation*. Oxford University Press, Oxford, UK.

EEA (2015): *The European environment: State and outlook 2015 assessment of global megatrends*. Publications Office, Luxembourg.

Eltham, B. (2013): Three arguments against 'soft innovation': Towards a richer understanding of cultural innovation. *International Journal of Cultural Policy* **19** (5), 537–556. DOI:10.1080/10286632.2012.658044.

Elwood, S., Goodchild, M. F. & Sui, D. Z. (2012): Researching Volunteered Geographic Information: Spatial Data, Geographic Research, and New Social Practice. *Annals of the Association of American Geographers* **102** (3), 571–590. DOI:10.1080/00045608.2011.595657.

Elzinga, K. G., Tremblay, C. H. & Tremblay, V. J. (2015): Craft Beer in the United States: History, Numbers, and Geography. *Journal of Wine Economics* **10** (3), 242–274. DOI:10.1017/jwe.2015.22.

Engineering Institute of Canada (1964): *Engineering Journal: Revue de L'ingénierie*. Engineering Institute of Canada.

Ennis, P. H. (1992): *The seventh stream: The emergence of rocknroll in American popular music*. Wesleyan Univ. Press, Hanover, NH.

Ernst, D. & Kim, L. (2002): Global production networks, knowledge diffusion, and local capability formation. *Research Policy* **31** (8-9), 1417–1429. DOI:10.1016/S0048-7333(02)00072-0.

Ernstsson, U. & Larsson, A. (2009): Eurodite WP6 Final Report, Gothenburg.

Essletzbichler, J. (2015): Relatedness, Industrial Branching and Technological Cohesion in US Metropolitan Areas. *Regional Studies* **49** (5), 752–766. DOI:10.1080/00343404.2013.806793.

Etscheit, G. (2011): Manche schwören drauf: Der Kamerahersteller Leica stand mehrmals vor der Pleite. Sein Mythos trug das Unternehmen durch jede Krise. *Die Zeit,* March 24. http://www.zeit.de/2011/13/Unternehmen-Leica/komplettansicht?print. Accessed 12/7/2017.

F

Fassio, C. & Grilli, L. (2016): From technological to symbolic innovation? Open source, Maker Movement and global demand for 3D printers. Papers in Innovation Studies 2016/7. CIRCLE, Lund University.

Feldman, M. P. & Kogler, D. F. (2010): Stylized Facts in the Geography of Innovation. In: Hall, B. H. & Rosenberg, N. (eds.): *Handbook of the economics of innovation - Vol. 1*. Elsevier, Amsterdam, 381–410.

Feldman, M. P., Kogler, D. F. & Rigby, D. L. (2015): rKnowledge: The Spatial Diffusion and Adoption of rDNA Methods. *Regional Studies* **49** (5), 798–817. DOI:10.1080/00343404.2014.980799.

Fitjar, R. D. & Timmermans, B. (2016): Regional skill relatedness: Towards a new measure of regional related diversification. *European Planning Studies*, 1–23. DOI:10.1080/09654313.2016.1244515.

Fitjar, R. D. & Timmermans, B. (2017): Knowledge bases and relatedness: A study of labour mobility in Norwegian regions. Papers in Evolutionary Economic Geography # 17.12. Urban & Regional research centre, Utrecht.

Flick, U. (2014): *An introduction to qualitative research,* Ed. 5. Sage, Los Angeles, Calif., London, New Delhi, Singapore, Washington, DC.

Florida, R. & Jackson, S. (2010): Sonic City: The Evolving Economic Geography of the Music Industry. *Journal of Planning Education and Research* **29** (3), 310–321. DOI:10.1177/0739456X09354453.

Florida, R., Mellander, C. & Stolarick, K. (2010): Music Scenes to Music Clusters: The Economic Geography of Music in the US, 1970–2000. *Environment and Planning A* **42** (4), 785–804. DOI:10.1068/a4253.

Florida, R. L. (2012): *The rise of the creative class, revisited*. Basic Books, New York.

Foray, D. (2004): *Economics of knowledge*. MIT Press, Cambridge, Mass.

Foray, D. (2014): From smart specialisation to smart specialisation policy. *European Journal of Innovation Management* **17** (4), 492–507. DOI:10.1108/EJIM-09-2014-0096.

Fraunhofer-Zentrum für Internationales Management und Wissensökonomie (2016): *Wege zur Stärkung der wirtschaftlichen Verwertung aus der Wissenschaft: Lehren aus der förderpolitischen Praxis*. Fraunhofer Verlag, Stuttgart.

French, K. (2017): Geography of American rap: Rap diffusion and rap centers. *GeoJournal* **82** (2), 259–272. DOI:10.1007/s10708-015-9681-z.

Frenken, K. & Boschma, R. A. (2007): A theoretical framework for evolutionary economic geography: Industrial dynamics and urban growth as a branching process. *Journal of Economic Geography* **7** (5), 635–649. DOI:10.1093/jeg/lbm018.

Frenken, K., van Oort, F. & Verburg, T. (2007): Related Variety, Unrelated Variety and Regional Economic Growth. *Regional Studies* **41** (5), 685–697. DOI:10.1080/00343400601120296.

Fuchs, G. & Wassermann, S. (2005): Path dependency in Baden-Württemberg. Lock-in or breakthrough? In: Fuchs, G. & Shapira, P. (eds.): *Rethinking Regional Innovation and Change: Path Dependency or Regional Breakthrough?* Springer Science + Business Media Inc, New York, NY, 232–248.

G

Garud, R., Kumaraswamy, A. & Karnøe, P. (2010): Path Dependence or Path Creation? *Journal of Management Studies* **47**. DOI:10.1111/j.1467-6486.2009.00914.x.

Gertler, M. S. (2003): Tacit knowledge and the economic geography of context, or The undefinable tacitness of being (there). *Journal of Economic Geography* **3** (1), 75–99. DOI:10.1093/jeg/3.1.75.

Gertler, M. S. (2008): "Being there": Proximity, organization, and culture in the development and adoption of advanced manufacturing technologies. In: Martin, R. (ed.): *Economy: Critical essays in human geography*. Ashgate, Aldershot, 351–375.

Gertler, M. S. & Levitte, Y. M. (2005): Local Nodes in Global Networks: The Geography of Knowledge Flows in Biotechnology Innovation. *Industry and Innovation* **12** (4), 487–507. DOI:10.1080/13662710500361981.

Gilg, A., Barr, S. & Ford, N. (2005): Green consumption or sustainable lifestyles? Identifying the sustainable consumer. *Futures* **37** (6), 481–504. DOI:10.1016/j.futures.2004.10.016.

Glaser, B. G. & Strauss, A. L. (1967): *The discovery of grounded theory: Strategies for qualitative research*. Aldine, Chicago.

Gong, H. & Hassink, R. (2017): Exploring the clustering of creative industries. *European Planning Studies* **25** (4), 583–600. DOI:10.1080/09654313.2017.1289154.

Goodchild, M. F. (2007): Citizens as sensors: The world of volunteered geography. *GeoJournal* **69** (4), 211–221. DOI:10.1007/s10708-007-9111-y.

Google Books (2017): Ngram Viewer: What does the Ngram Viewer do? https://books.google.com/ngrams/info. Accessed 9/28/2017.

Grabher, G. (ed.) (1993a): *The embedded firm: On the socioeconomics of industrial networks,* 1. publ. Routledge, London.

Grabher, G. (1993b): The weakness of strong ties: The lock-in of regional development in the ruhr area. In: Grabher, G. (ed.): *The embedded firm: On the socioeconomics of industrial networks*, 1. publ. Routledge, London, 255–277.

Granger, R. C. (2013): Spatial–Relational Mapping in Socio-Institutional Perspectives of Innovation. *European Planning Studies* **22** (12), 2477–2489. DOI:10.1080/09654313.2013.790591.

Grant, R. M. (1996): Prospering in Dynamically-Competitive Environments: Organizational Capability as Knowledge Integration. *Organization Science* **7** (4), 375–387. DOI:10.1287/orsc.7.4.375.

Grillitsch, M. & Trippl, M. (2016): Innovation Policies and New Regional Growth Paths: A place-based system failure framework. Papers in Innovation Studies 2016/26. CIRCLE, Lund University.

Grosz, A. (2008): Automotive clusters in the BeLCAR project. An analysis, Györ.

Grupp, H. & Mogee, M. E. (2004): Indicators for national science and technology policy: How robust are composite indicators? *Research Policy* **33** (9), 1373–1384. DOI:10.1016/j.respol.2004.09.007.

Guinet, J., Backer, K. de, Teirlinck, P. & van der Zwan, A. (2008): *The internationalisation of business R&D: Evidence, impacts and implications*. OECD Publ, Paris.

H

Haithcoat, R. (2012): What the Hell is Trap Music (and Why Is Dubstep Involved)? *LA Weekly,* October 04. http://www.laweekly.com/music/what-the-hell-is-trap-music-and-why-is-dubstep-involved-2408170. Accessed 12/7/2017.

Halkier, H. (2012): Knowledge Dynamics and Policies for Regional Development: Towards a New Governance Paradigm. *European Planning Studies* **20** (11), 1767–1784. DOI:10.1080/09654313.2012.723420.

Halkier, H. & Cooke, P. (2010): Knowledge and Policies for Regional Development: European Trends. In: Halkier, H., Dahlström, M., James, L., Manniche, J. & Olsen, L. S. (eds.): *Knowledge Dynamics, Regional Development and Public Policy*. Institut for Historie, Internationale Studier og Samfundsforhold, Aalborg Universitet, Aalborg, 17-26.

Halkier, H., Dahlström, M., James, L., Manniche, J. & Olsen, L. S. (eds.) (2010): *Knowledge Dynamics, Regional Development and Public Policy*. Institut for Historie, Internationale Studier og Samfundsforhold, Aalborg Universitet, Aalborg.

Halkier, H., Henriksen, P. F., Olsen, L. S. & Therkelsen, A. (2009): Knowledge Dynamics in North Jutland. Case Studies of Knowledge Events Within Coastal and Cultural Tourism: Eurodite WP6 FKD Final Report, Aalborg.

Halkier, H. & Therkelsen, A. (2013): Exploring tourism destination path plasticity. *Zeitschrift für Wirtschaftsgeographie* **57** (1-2), 521. DOI:10.1515/zfw.2013.0004.

Hall, P. A. & Soskice, D. W. (2001): *Varieties of capitalism: The institutional foundations of comparative advantage*.

Hantschel, F. & Bullerjahn, C. (2016): The Use of Prototype Theory for Understanding the Perception and Concept Formation of Musical Styles. In: Vokalek, G. (ed.): *Proceedings of the 14th International Conference on Music Perception and Cognition, JULY 5 - 9, 2016, San Francisco, Chapter: The Use of Prototype Theory for Understanding the Perception and Concept Formation of Musical Styles*. Causal productions, 151–156.

Hassink, R. (2010a): Locked in decline? On the role of regional lock-ins in old industrial areas. In: Boschma, R. A. & Martin, R. (eds.): *The Handbook of Evolutionary Economic Geography*. Edward Elgar Publishing, 450–468.

Hassink, R. (2010b): Regional resilience: A promising concept to explain differences in regional economic adaptability? *Cambridge Journal of Regions, Economy and Society* **3** (1), 45–58. DOI:10.1093/cjres/rsp033.

Hassink, R., Plum, O. & Rickmers, A. (2014): On the Implications of Knowledge Bases for Regional Innovation Policies in Germany. *Quaestiones Geographicae* **33** (4). DOI:10.2478/quageo-2014-0045.

Hatch, C. J. (2013): Competitiveness by Design: An Institutionalist Perspective on the Resurgence of a "Mature" Industry in a High-Wage Economy. *Economic Geography* **89** (3), 261–284. DOI:10.1111/ecge.12009.

Hatch, C. J. (2014): Geographies of Production: The Institutional Foundations of a Design-Intensive Manufacturing Strategy. *Geography Compass* **8** (9), 677–689. DOI:10.1111/gec3.12158.

Haupt, J. (2009): Last.fm: People-Powered Online Radio. *Music Reference Services Quarterly* **12** (1-2), 23–24. DOI:10.1080/10588160902816702.

Hautala, J. & Höyssä, M. (2017): Knowledge rationales in human geography: Economic, policy, empowerment, and methodological. *Norsk Geografisk Tidsskrift - Norwegian Journal of Geography* **97**, 1–19. DOI:10.1080/00291951.2017.1340907.

Hawlitschek, A. (2011): 125 Jahre Automobil: Bedeutung der Automobilindustrie für die Wirtschaft Baden-Württembergs im Spiegel der Umsatzsteuerstatistik. *Statistisches Monatsheft Baden-Württemberg* (10), 31–35.

Heidenreich, M. & Krauss, G. (1998): The Baden-Württemberg production and innovation regime: Past successes and new challenges. In: Braczyk, H.-J. & Heidenreich, M. (eds.): *Regional innovation systems: The role of governances in a globalized world*. UCL Press, London, 186–213.

Heimeriks, G. & Boschma, R. A. (2014): The path- and place-dependent nature of scientific knowledge production in biotech 1986-2008. *Journal of Economic Geography* **14** (2), 339–364. DOI:10.1093/jeg/lbs052.

Henderson, J., Dicken, P., Hess, M., Coe, N. & Yeung, H. W.-C. (2002): Global production networks and the analysis of economic development. *Review of International Political Economy* **9** (3), 436–464. DOI:10.1080/09692290210150842.

Henning, M., Stam, E. & Wenting, R. (2013): Path Dependence Research in Regional Economic Development: Cacophony or Knowledge Accumulation? *Regional Studies* **47** (8), 1348–1362. DOI:10.1080/00343404.2012.750422.

Hermelin, B., Dahlström, M. & Smas, L. (2014): Geographies of Knowledge and Learning: The Example of Medical Technology. *Growth and Change* **45** (3), 450–470. DOI:10.1111/grow.12054.

Herstad, S. J., Aslesen, H. W. & Ebersberger, B. (2014): On industrial knowledge bases, commercial opportunities and global innovation network linkages. *Research Policy* **43** (3), 495–504. DOI:10.1016/j.respol.2013.08.003.

Hibbett, R. (2005): What Is Indie Rock? *Popular Music and Society* **28** (1), 55–77. DOI:10.1080/0300776042000300972.

Hidalgo, C. A. & Hausmann, R. (eds.) (2013): *The atlas of economic complexity: Mapping paths to prosperity,* Updated edition. The MIT Press, Cambridge, MA.

Hidalgo, C. A., Klinger, B., Barabási, A.-L. & Hausmann, R. (2007): The product space conditions the development of nations. *Science (New York, N.Y.)* **317** (5837), 482–487. DOI:10.1126/science.1144581.

Hippel, E. von (2010): Open User Innovation. In: Hall, B. H. & Rosenberg, N. (eds.): *Handbook of the economics of innovation - Vol. 1*. Elsevier, Amsterdam, 410–427.

Hochgerner, J. (2011): Die Analyse sozialer Innovationen als gesellschaftliche Praxis. In: Zentrum für soziale Innovation (ed.): *Pendeln zwischen Wissenschaft und Praxis: ZSI-Beiträge zu sozialen Innovationen*. Lit-Verl., Wien, 173–189.

Hollenstein, L. & Purves, R. (2010): Exploring place through user-generated content: Using Flickr to describe city cores. *Journal of Spatial Information Science* **1** (1), 21–48. DOI:10.5311/JOSIS.2010.1.3.

Horkheimer, M. & Adorno, T. W. (1944): *Philosophische Fragmente*. Institute of Social Research, New York.

Howells, J. (2012): The geography of knowledge: Never so close but never so far apart. *Journal of Economic Geography* **12** (5), 1003–1020. DOI:10.1093/jeg/lbs027.

Howells, J. R. L. (2002): Tacit Knowledge, Innovation and Economic Geography. *Urban Studies* **39** (5-6), 871–884. DOI:10.1080/00420980220128354.

Hracs, B. J. (2013): Cultural Intermediaries in the Digital Age: The Case of Independent Musicians and Managers in Toronto. *Regional Studies* **49** (3), 461–475. DOI:10.1080/00343404.2012.750425.

Humphrey, J. & Schmitz, H. (2002): How does insertion in global value chains affect upgrading in industrial clusters? *Regional Studies* **36** (9), 1017–1027. DOI:10.1080/0034340022000022198.

I

Ibert, O. (2007): Towards a Geography of Knowledge Creation: The Ambivalences between ‘Knowledge as an Object’ and ‘Knowing in Practice’. *Regional Studies* **41** (1), 103–114. DOI:10.1080/00343400601120346.

Ibert, O. (2010): Relational Distance: Sociocultural and Time–Spatial Tensions in Innovation Practices. *Environment and Planning A* **42** (1), 187–204. DOI:10.1068/a4247.

Ibert, O. & Müller, F. C. (2015): Network dynamics in constellations of cultural differences: Relational distance in innovation processes in legal services and biotechnology. *Research Policy* **44** (1), 181–194. DOI:10.1016/j.respol.2014.07.016.

Ingstrup, M. B., Jensen, S. & Christensen, P. R. (2017): Cluster evolution and the change of knowledge bases: The development of a design cluster. *European Planning Studies* **25** (2), 202–220. DOI:10.1080/09654313.2016.1276885.

Isaksen, A. (2015): Industrial development in thin regions: Trapped in path extension? *Journal of Economic Geography* **15** (3), 585–600. DOI:10.1093/jeg/lbu026.

Isaksen, A. & Trippl, M. (2014): Regional industrial path development in different regional innovation systems: A conceptual analysis. Papers in Innovation Studies 2014/17. CIRCLE, Lund University.

Isaksen, A. & Trippl, M. (2016): Exogenously Led and Policy-Supported New Path Development in Peripheral Regions: Analytical and Synthetic Routes. *Economic Geography* **9**, 1–22. DOI:10.1080/00130095.2016.1154443.

J

Jacobs, J. (1969): *The economy of cities*. Vintage Books, New York.

James, L., Vissers, G., Larsson, A. & Dahlström, M. (2015): Territorial Knowledge Dynamics and Knowledge Anchoring through Localized Networks: The Automotive Sector in Västra Götaland. *Regional Studies* **50** (2), 233–244. DOI:10.1080/00343404.2015.1007934.

Jeannerat, H. & Crevoisier, O. (2011): Non-technological innovation and multi-local territorial knowledge dynamics in the Swiss watch industry. *International Journal of Innovation and Regional Development* **3** (1), 26. DOI:10.1504/IJIRD.2011.038061.

Jeannerat, H. & Crevoisier, O. (2015): Editorial: From 'Territorial Innovation Models' to 'Territorial Knowledge Dynamics': On the Learning Value of a New Concept in Regional Studies. *Regional Studies* **50** (2), 185–188. DOI:10.1080/00343404.2015.1105653.

Johansson, O. & Bell, T. L. (2009): Where Are the New US Music Scenes? In: Bell, T. L. & Johansson, O. (eds.): *Sound, Society, and the Geography of Popular Music*. Ashgate Publishing Group, 219–239.

Johnson, B. (2002): Why all this fuss about codified and tacit knowledge? *Industrial and Corporate Change* **11** (2), 245–262. DOI:10.1093/icc/11.2.245.

Jürgens, U., Blöcker, A. & MacNeill, S. (2010): Knowledge Processes and Networks in the Automotive Sector. In: Cooke, P. (ed.): *Platforms of innovation: Dynamics of new industrial knowledge flows*. Edward Elgar, Cheltenham, 205–232.

Jurowetzki, R. & Hain, D. (2014): *Mapping the (R-)Evolution of Technological Fields: A Semantic Network Approach: In Springer's Lecture Note Series in Computer Science*.

K

Kaiser, R. (2008): Governance and the knowledge economy: Relevance and potentialities of the "analytical governance concept" within the EURODITE project, Hamburg.

Kaiser, R. & Liecke, M. (2009): Regional knowledge dynamics in the biotechnology industry: A conceptual framework for micro-level analysis. *International Journal of Technology Management* **46** (3/4), 371. DOI:10.1504/IJTM.2009.023386.

Kelle, U. (2007): *Die Integration qualitativer und quantitativer Methoden in der empirischen Sozialforschung: Theoretische Grundlagen und methodologische Konzepte,* 1st edn. VS, Verl. für Sozialwiss, Wiesbaden.

Kerbusk, K.-P. (2004): "Nur ein Intermezzo": Hanns-Peter Cohn, 56, Vorstandschef der Mythenmarke Leica, über den Boom und die Zukunft digitaler Fotografie. *Der Spiegel,* September 20. http://www.spiegel.de/spiegel/print/d-32205196.html. Accessed 12/7/2017.

Kietzmann, J. H., Hermkens, K., McCarthy, I. P. & Silvestre, B. S. (2011): Social media? Get serious! Understanding the functional building blocks of social media. *Business Horizons* **54** (3), 241–251. DOI:10.1016/j.bushor.2011.01.005.

Kinder, S. & Radwan, L. (2010): Arbeit an der Routine. Zum Passungsverhältnis zwischen organisationalen Routinen und ihrem territorialen Umfeld. *Geographische Zeitschrift* **98** (1), 41–59.

Klepper, S. (2007): Disagreements, Spinoffs, and the Evolution of Detroit as the Capital of the U.S. Automobile Industry. *Management Science* **53** (4), 616–631. DOI:10.1287/mnsc.1060.0683.

Knoben, J. & Oerlemans, L. (2006): Proximity and inter-organizational collaboration: A literature review. *International Journal of Management Reviews* **8** (2), 71–89. DOI:10.1111/j.1468-2370.2006.00121.x.

Kogler, D. F., Rigby, D. L. & Tucker, I. (2013): Mapping Knowledge Space and Technological Relatedness in US Cities. *European Planning Studies* **21** (9), 1374–1391. DOI:10.1080/09654313.2012.755832.

Kogut, B. & Zander, U. (1992): Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology. *Organization Science* **3** (3), 383–397. DOI:10.1287/orsc.3.3.383.

Kogut, B. & Zander, U. (2003): Knowledge of the firm and the evolutionary theory of the multinational corporation. *Journal of International Business Studies* **34** (6), 516–529. DOI:10.1057/palgrave.jibs.8400058.

Krafft, J. & Quatraro, F. (2011): The Dynamics of Technological Knowledge: From Linearity to Recombination. In: Antonelli, C. (ed.): *Handbook on the economic complexity of technological change*. Edward Elgar Pub, Cheltenham England, 181–200.

Krafft, J., Quatraro, F. & Saviotti, P. P. (2014): The Dynamics of Knowledge-intensive Sectors' Knowledge Base: Evidence from Biotechnology and Telecommunications. *Industry and Innovation* **21** (3), 215–242. DOI:10.1080/13662716.2014.919762.

Krauss, G. (2009): Baden-Württemberg als Prototyp eines regionalen Innovationssystems: Eine organisationssoziologische Betrachtungsweise. In: Blättel-Mink, B. & Ebner, A. (eds.): *Innovationssysteme: Technologie, Institutionen und die Dynamik der Wettbewerbsfähigkeit*, 1st edn. VS Verl. für Sozialwiss, Wiesbaden, 229–248.

Krims, A. (2014): What is a Musically Creative City? In: Barber-Kersovan, A., Kirchberg, V. & Kucher, R. (eds.): *Music city: Musikalische Annäherungen an die "kreative Stadt" = Musical approaches to the "creative city"*. Transcript, Bielefeld, 33–44.

Kuckartz, U. (2010): *Einführung in die computergestützte Analyse qualitativer Daten*, 3rd edn. VS Verl. für Sozialwiss, Wiesbaden.

Kurzweil, R. (2005): *The singularity is near: When humans transcend biology*. Viking, New York.

Kusunoki, K., Nonaka, I. & Nagata, A. (1998): Organizational Capabilities in Product Development of Japanese Firms: A Conceptual Framework and Empirical Findings. *Organization Science* **9** (6), 699–718. DOI:10.1287/orsc.9.6.699.

L

Laestadius, S. (1998): Technology Level, Knowledge Formation, and Industrial Competence in Paper Manufacturing. In: Eliasson, G. & Green, C. (eds.):

Microfoundations of economic growth: A Schumpeterian perspective ; [selected papers from the sixth biennial conference of the International Schumpeter Society, held in Stockholm, June 3 - 5, 1996]. Univ. of Michigan Press, Ann Arbor, 212–226.

Laestadius, S. (2000): Biotechnology and the Potential for a Radical Shift of Technology in Forest Industry. *Technology Analysis & Strategic Management* **12** (2), 193–212. DOI:10.1080/713698464.

Lamere, P. (2008): Social Tagging and Music Information Retrieval. *Journal of New Music Research* **37** (2), 101–114. DOI:10.1080/09298210802479284.

Lange, B. & Bürkner, H.-J. (2013): Value Creation in Scene-based Music Production: The Case of Electronic Club Music in Germany. *Economic Geography* **89** (2), 149–169. DOI:10.1111/ecge.12002.

Langley, P. & Leyshon, A. (2017): Platform capitalism: The Intermediation and capitalisation of digital economic circulation. *Finance and Society* **3** (1), 11.31. DOI:10.2218/finsoc.v3i1.1936.

Last.fm (2016): 100 Billion - The world according to Last.fm. 100 Billion plays and counting… https://www.last.fm/100-billion. Accessed 12/7/2017.

Lazzeretti, L., Innocenti, N. & Capone, F. (2017): The impact of related variety on the creative employment growth. *The Annals of Regional Science* **45** (7), 893. DOI:10.1007/s00168-016-0805-2.

Lee, N. & Rodríguez-Pose, A. (2014a): Creativity, cities, and innovation. *Environment and Planning A* **46** (5), 1139–1159. DOI:10.1068/a46202.

Lee, N. & Rodríguez-Pose, A. (2014b): Innovation in Creative Cities: Evidence from British Small Firms. *Industry and Innovation* **21** (6), 494–512. DOI:10.1080/13662716.2014.983748.

Lena, J. C. (2012): *Banding Together: How Communities Create Genres in Popular Music*. Princeton University Press, Princeton.

Lena, J. C. & Peterson, R. A. (2008): Classification as Culture: Types and Trajectories of Music Genres. *American Sociological Review* **73** (5), 697–718. DOI:10.1177/000312240807300501.

Leslie, D., Brydges, T. & Brail, S. (2015): Qualifying aesthetic values in the experience economy: The role of independent fashion boutiques in curating slow fashion. In: Lorentzen, A., Topsø Larsen, K. & Schrøder, L. (eds.): *Spatial dynamics in the experience economy*. Routledge Taylor and Francis Group, London, New York, 88–102.

Leyshon, A. (2001): Time–Space (and Digital) Compression: Software Formats, Musical Networks, and the Reorganisation of the Music Industry. *Environment and Planning A* **33** (1), 49–77. DOI:10.1068/a3360.

Leyshon, A., Matless, D. & Revill, G. (1995): The Place of Music: [Introduction]. *Transactions of the Institute of British Geographers* **20** (4), 423. DOI:10.2307/622973.

Lloyd, R. (2014): Differentiating Music City: Legacy Industry and Scene in Nashville. In: Barber-Kersovan, A., Kirchberg, V. & Kucher, R. (eds.): *Music city: Musikalische Annäherungen an die "kreative Stadt" = Musical approaches to the "creative city"*. Transcript, Bielefeld, 139–168.

Los, B. (2000): The empirical performance of a new inter-industry technology spillover measure. In: Saviotti, P. P. & Nooteboom, B. (eds.): *Technology and knowledge: From the firm to innovation systems*. Elgar, Cheltenham.

Lucas, H. C. & Goh, J. M. (2009): Disruptive technology: How Kodak missed the digital photography revolution. *The Journal of Strategic Information Systems* **18** (1), 46–55. DOI:10.1016/j.jsis.2009.01.002.

Lundvall, B.-Å. (1992): *National systems of innovation: Toward a theory of innovation and interactive learning*. Anthem, London, New York NY.

Lundvall, B.-Å. & Johnson, B. (1994): The Learning Economy. *Journal of Industry Studies* **1** (2), 23–42. DOI:10.1080/13662719400000002.

M

MacKinnon, D., Cumbers, A., Pike, A., Birch, K. & McMaster, R. (2009): Evolution in Economic Geography: Institutions, Political Economy, and Adaptation. *Economic Geography* **85** (2), 129–150. DOI:10.1111/j.1944-8287.2009.01017.x.

Mahoney, J. & Thelen, K. (2010): A Theory of Gradual Institutional Change. In: Mahoney, J. & Thelen, K. (eds.): *Explaining institutional change: Ambiguity, agency, and power*. Cambridge Univ. Press, Cambridge, 1–37.

Malerba, F. (2005): Sectoral systems of innovation. How and why innovation differs across sectors. In: Fagerberg, J., Mowery, D. C. & Nelson, R. R. (eds.): *Oxford Handbook of Innovation // The Oxford handbook of innovation*. Oxford University Press, Oxford, UK, 380–406.

Malerba, F. & Orsenigo, L. (2000): Knowledge, innovative activities and industrial evolution. *Industrial and Corporate Change* **9** (2), 289–314. DOI:10.1093/icc/9.2.289.

Malmberg, A. & Maskell, P. (2006): Localized Learning Revisited. *Growth and Change* **37** (1), 1–18. DOI:10.1111/j.1468-2257.2006.00302.x.

Manniche, J. (2012): Combinatorial Knowledge Dynamics: On the Usefulness of the Differentiated Knowledge Bases Model. *European Planning Studies* **20** (11), 1823–1841. DOI:10.1080/09654313.2012.723423.

Manniche, J. & Larsen, K. T. (2013): Experience staging and symbolic knowledge: The case of Bornholm culinary products. *European Urban and Regional Studies* **20** (4), 401–416. DOI:10.1177/0969776412453146.

Manniche, J., Moodysson, J. & Testa, S. (2017): Combinatorial Knowledge Bases: An Integrative and Dynamic Approach to Innovation Studies. *Economic Geography* **93** (5), 480–499. DOI:10.1080/00130095.2016.1205948.

Markides, C. (2006): Disruptive Innovation: In Need of Better Theory. *Journal of Product Innovation Management* **23** (1), 19–25. DOI:10.1111/j.1540-5885.2005.00177.x.

Martin, H. & Martin, R. (2016): Policy capacities for new regional industrial path development - The case of new media and biogas in southern Sweden. *Environment and Planning C: Government and Policy*. DOI:10.1177/0263774X16665845.

Martin, R. (2010): Roepke Lecture in Economic Geography-Rethinking Regional Path Dependence: Beyond Lock-In to Evolution. *Economic Geography* **86** (1), 1–27.

Martin, R. (2012): Measuring Knowledge Bases in Swedish Regions. *European Planning Studies* **20** (9), 1569–1582. DOI:10.1080/09654313.2012.708022.

Martin, R. & Moodysson, J. (2011): Innovation in Symbolic Industries: The Geography and Organization of Knowledge Sourcing. *European Planning Studies* **19** (7), 1183–1203. DOI:10.1080/09654313.2011.573131.

Martin, R. & Moodysson, J. (2013): Comparing knowledge bases: On the geography and organization of knowledge sourcing in the regional innovation system of Scania, Sweden. *European Urban and Regional Studies* **20** (2), 170–187. DOI:10.1177/0969776411427326.

Martin, R. & Sunley, P. (2006): Path dependence and regional economic evolution. *Journal of Economic Geography* **6** (4), 395–437. DOI:10.1093/jeg/lbl012.

Martin, R. & Sunley, P. (2014): On the notion of regional economic resilience: Conceptualization and explanation. *Journal of Economic Geography* **15** (1), 1–42. DOI:10.1093/jeg/lbu015.

Mateos-Garcia, J., Bakshi, H. & Lenel, M. (2014): A Map of The UK Games Industry. Nesta, London.

https://www.nesta.org.uk/sites/default/files/map_uk_games_industry_wv.pdf. Accessed 12/7/2017.

Mattes, J. (2012): Dimensions of Proximity and Knowledge Bases: Innovation between Spatial and Non-spatial Factors. *Regional Studies* **46** (8), 1085–1099. DOI:10.1080/00343404.2011.552493.

Mauch, M., MacCallum, R. M., Levy, M. & Leroi, A. M. (2015): The evolution of popular music: USA 1960-2010. *Royal Society open science* **2** (5), 150081. DOI:10.1098/rsos.150081.

Mayntz, R. & Scharpf, F. W. (eds.) (1995): *Gesellschaftliche Selbstregelung und politische Steuerung*. Campus-Verl., Frankfurt am Main.

Mayring, P. (2000): Qualitative Content Analysis. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research* **1** (2).

McLeod, K. (2001): Genres, Subgenres, Sub-Subgenres and More: Musical and Social Differentiation Within Electronic/Dance Music Communities. *Journal of Popular Music Studies* **13** (1), 59–75. DOI:10.1111/j.1533-1598.2001.tb00013.x.

McNamee, R. C. (2013): Can't see the forest for the leaves: Similarity and distance measures for hierarchical taxonomies with a patent classification example. *Research Policy* **42** (4), 855–873. DOI:10.1016/j.respol.2013.01.006.

Meeus, M. T. H. & Hage, J. (2006): Product and Process Innovation, Scientific Research, Knowledge Dynamics, and Institutional Change: An Introduction. In: Hage, J., Meeus, M. T. H. & Edquist, C. (eds.): *Innovation, science, and institutional change*. Oxford University Press, Oxford, New York, 1–22.

Miles, I. & Green, L. (2008): Hidden innovation in the creative industries. Nesta, London.

Miörner, J. & Trippl, M. (2016): Paving the way for new regional industrial paths: Actors and modes of change in Scania's games industry. *European Planning Studies* **25** (3), 481–497. DOI:10.1080/09654313.2016.1212815.

Miozzo, M. & Grimshaw, D. (2005): Modularity and innovation in knowledge-intensive business services: IT outsourcing in Germany and the UK. *Research Policy* **34** (9), 1419–1439. DOI:10.1016/j.respol.2005.06.005.

Moodysson, J. (2008): Principles and Practices of Knowledge Creation: On the Organization of "Buzz" and "Pipelines" in Life Science Communities. *Economic Geography* **84** (4), 449–469. DOI:10.1111/j.1944-8287.2008.00004.x.

Moodysson, J., Coenen, L. & Asheim, B. T. (2008): Explaining Spatial Patterns of Innovation: Analytical and Synthetic Modes of Knowledge Creation in the Medicon

Valley Life-Science Cluster. *Environment and Planning A* **40** (5), 1040–1056. DOI:10.1068/a39110.

Moodysson, J. & Sack, L. (2016): Institutional stability and industry renewal: Diverging trajectories in the Cognac beverage cluster. *Industry and Innovation* **23** (5), 448–464. DOI:10.1080/13662716.2016.1167014.

Moodysson, J., Trippl, M. & Zukauskaite, E. (2017): Policy learning and smart specialization: Balancing policy change and continuity for new regional industrial paths. *Science and Public Policy* **44** (3), 382-391. DOI:10.1093/scipol/scw071.

Moßig, I. & Klein, J. (2003): Das Produktionscluster der optischen Industrie im Raum Wetzlar. *Raumforschung und Raumordnung* **61** (4), 237–251. DOI:10.1007/BF03182959.

Moulaert, F. & Sekia, F. (2003): Territorial Innovation Models: A Critical Survey. *Regional Studies* **37** (3), 289–302. DOI:10.1080/0034340032000065442.

Mukherjee, S., Uzzi, B., Jones, B. & Stringer, M. (2016): A New Method for Identifying Recombinations of Existing Knowledge Associated with High-Impact Innovation. *Journal of Product Innovation Management* **33** (2), 224–236. DOI:10.1111/jpim.12294.

N

Neffke, F. & Henning, M. (2013): Skill relatedness and firm diversification. *Strategic Management Journal* **34** (3), 297–316. DOI:10.1002/smj.2014.

Neffke, F., Henning, M. & Boschma, R. A. (2011): How Do Regions Diversify over Time? Industry Relatedness and the Development of New Growth Paths in Regions. *Economic Geography* **87** (3), 237–265. DOI:10.1111/j.1944-8287.2011.01121.x.

Nelson, R. R. & Winter, S. G. (1982): *An evolutionary theory of economic change*, 4. [print.]. Belknap Press of Harvard Univ. Press, Cambridge, Mass.

Nesta, L. & Dibiaggio, L. (2003): Technology Strategy and Knowledge Dynamics: The Case of Biotech[1]. *Industry & Innovation* **10** (3), 331–349. DOI:10.1080/1366271032000141670.

Newman, M. E. J. (2013): *Networks: An introduction*, 1. publ., repr. with corrections. Oxford Univ. Press, Oxford.

Nightingale, P. (1998): A cognitive model of innovation. *Research Policy* **27** (7), 689–709. DOI:10.1016/S0048-7333(98)00078-X.

Nonaka, I. & Takeuchi, H. (1995): *The Knowledge-Creating Company.: How Japanese Companies Create the Dynamics of Innovation*. Oxford Univ. Press, New York.

Nonaka, I., Toyama, R. & Nagata, A. (2000): A Firm as a Knowledge-creating Entity: A New Perspective on the Theory of the Firm. *Industrial and Corporate Change* **9** (1), 1-20.

Nooteboom, B. (2008): Learning, discovery and collaboration. In: Nooteboom, B. & Stam, E. (eds.): *Micro-foundations for innovation policy*. Amsterdam University Press, Amsterdam, 75–102.

Nooteboom, B. (2010): *A cognitive theory of the firm: Learning, governance and dynamic capabilities,* Paperback ed. E. Elgar, Cheltenham (UK), Northampton (MA, USA).

North, D. C. (1990): *Institutions, Institutional Change and Economic Performance*. Cambridge University Press.

North, D. C. (1991): Institutions. *Journal of Economic Perspectives* **5** (1), 97–112. DOI:10.1257/jep.5.1.97.

Notteboom, T., Langen, P. de & Jacobs, W. (2013): Institutional plasticity and path dependence in seaports: Interactions between institutions, port governance reforms and port authority routines. *Journal of Transport Geography* **27**, 26–35. DOI:10.1016/j.jtrangeo.2012.05.002.

O

Obertreis, R. (2014): Von der Fast-Pleite zum Rekordumsatz: Kamera-Hersteller Leica lebt wieder auf. *Der Tagesspiegel,* May 24. http://www.tagesspiegel.de/wirtschaft/kamera-hersteller-leica-lebt-wieder-auf-von-der-fast-pleite-zum-rekord-umsatz/9942228.html. Accessed 12/7/2017.

Opsahl, T., Agneessens, F. & Skvoretz, J. (2010): Node centrality in weighted networks: Generalizing degree and shortest paths. *Social Networks* **32** (3), 245–251. DOI:10.1016/j.socnet.2010.03.006.

Otto, A., Nedelkoska, L. & Neffke, F. (2014): Skill-relatedness und Resilienz: Fallbeispiel Saarland. *Raumforschung und Raumordnung* **72** (2), 133–151. DOI:10.1007/s13147-014-0285-8.

P

Patel, P. & Pavitt, K. (1997): The technological competencies of the world's largest firms: Complex and path-dependent, but not much variety. *Research Policy* **26** (2), 141–156. DOI:10.1016/S0048-7333(97)00005-X.

Pavitt, K. (1984): Sectoral patterns of technical change: Towards a taxonomy and a theory. *Research Policy* **13** (6), 343–373. DOI:10.1016/0048-7333(84)90018-0.

Pelikan, P. (2003): Bringing institutions into evolutionary economics: Another view with links to changes in physical and social technologies. *Journal of Evolutionary Economics* **13** (3), 237–258. DOI:10.1007/s00191-003-0157-9.

Penrose, E. T. (1959): *The theory of the growth of the firm*. Wiley, New York.

Peterson, R. A. & Bennett, A. (2004): Introducing Music Scenes. In: Bennett, A. & Peterson, R. A. (eds.): *Music scenes: Local, translocal and virtual*, 1st ed. Vanderbilt University Press, Nashville, 1–15.

PewInternet (2011): 35% of American adults own a smartphone: One quarter of smartphone owners use their phone for most of their online browsing, Washington, DC. http://www.pewinternet.org/2011/07/11/smartphone-adoption-and-usage/. Accessed 12/7/2017.

Pine, B. J. & Gilmore, J. H. (2011): *The experience economy,* Updated ed. Harvard Business Review Press, Boston, Mass.

Pinheiro, D. L. & Dowd, T. J. (2009): All that jazz: The success of jazz musicians in three metropolitan areas. *Poetics* **37** (5-6), 490–506. DOI:10.1016/j.poetic.2009.09.007.

Plum, O. & Hassink, R. (2013): Knowledge bases, innovativeness and competitiveness in creative industries: The case of Hamburg's video game developers. *Regional Studies, Regional Science* **1** (1), 248–268. DOI:10.1080/21681376.2014.967803.

Polanyi, M. (1966): *The tacit dimension*. Doubleday, Garden City, NY.

Polanyi, M. (1985): *Implizites Wissen,* 1st edn. Suhrkamp, Frankfurt am Main.

Pontello, L. F., Holanda, P. H. F., Guilherme, B., Cardoso, J. P. V., Goussevskaia, O. & Silva, A. P. C. (2016): *Mixtape Application: Last.fm Data Characterization*.

Poorthuis, A., Zook, M., Shelton, T., Graham, M. & Stephens, M. (2016): Using Geotagged Digital Social Data in Geographical Research. In: Clifford, N. J., Cope, M. & Gillespie, T. (eds.): *Key methods in geography*, Third edition. Sage, Los Angeles, London, New Delhi, Singapore, Washington DC, Melbourne, 248–269.

Porter, M. (2010): The Economic Performance of Regions. *Regional Studies* **37** (6-7), 549–578. DOI:10.1080/0034340032000108688.

Powell, W. W. & Snellman, K. (2004): The Knowledge Economy. *Annual Review of Sociology* **30** (1), 199–220. DOI:10.1146/annurev.soc.29.010202.100037.

Prognos AG (2009): Analytische und konzeptionelle Grundlagen zur Clusterpolitik in Baden-Württemberg: Im Auftrag des Wirtschaftsministeriums des Landes Baden-Württemberg. https://www.prognos.com/publikationen/allepublikationen/443/show/039877f172be611611b2c53fe3cce7d9/. Accessed 12/7/2017.

Q

Quatraro, F. (2010): Knowledge coherence, variety and economic growth: Manufacturing evidence from Italian regions. *Research Policy* **39** (10), 1289–1302. DOI:10.1016/j.respol.2010.09.005.

Quatraro, F. (2014): Co-evolutionary Patterns in Regional Knowledge Bases and Economic Structure: Evidence from European Regions. *Regional Studies* **50** (3), 513–539. DOI:10.1080/00343404.2014.927952.

R

Rammert, W. (2000): *National systems of innovation, idea innovation networks, and comparative innovation biographies: some comments on Jerald Hage's and Rogers Hollingsworth's considerations about "The role of institutions and organizations in the innovation process"*, Berlin.

Rehák, Š., Pastor, R. & Suranova, J. (2009): Eurodite, WP6 FKD Report, Bratislava.

Reithmeier, C., Buschbaum, K., Blitz, A. & Kanwischer, D. (2016): "Heaven. #shopping #Frankfurt #weekend #joy" – Hashtags, constructions of space, and geography education. *GI_Forum* **1**, 282–294. DOI:10.1553/giscience2016_01_s282.

Rekers, J. V. (2016): What triggers innovation diffusion? Intermediary organizations and geography in cultural and science-based industries. *Environment and Planning C: Government and Policy* **34** (6), 1058–1075. DOI:10.1177/0263774X15625226.

Rigby, D. L. (2015): Technological Relatedness and Knowledge Space: Entry and Exit of US Cities from Patent Classes. *Regional Studies* **49** (11), 1922–1937. DOI:10.1080/00343404.2013.854878.

S

Saviotti, P., Looze, M.-A. de & Maupertuis, M. A. (2005): Knowledge dynamics, firm strategy, mergers and acquisitions in the biotechnology based sectors. *Economics of Innovation and New Technology* **14** (1-2), 103–124. DOI:10.1080/1043859042000228679.

Scaringella, L. (2016): Knowledge, knowledge dynamics, and innovation. *European Journal of Innovation Management* **19** (3), 337–361. DOI:10.1108/EJIM-05-2015-0031.

Schilt, K. (2004): 'Riot Grrrl is…': Contestation over Meaning in a Music Scene. In: Bennett, A. & Peterson, R. A. (eds.): *Music scenes: Local, translocal and virtual*, 1st ed. Vanderbilt University Press, Nashville, 115–130.

Schmitz, H. & Strambach, S. (2009): The organisational decomposition of innovation and global distribution of innovative activities: Insights and research agenda. *International Journal of Technological Learning, Innovation and Development* **2** (4), 231. DOI:10.1504/IJTLID.2009.026816.

Schneiberg, M. (2007): What's on the path? Path dependence, organizational diversity and the problem of institutional change in the US economy, 1900-1950. *Socio-Economic Review* **5** (1), 47–80. DOI:10.1093/ser/mwl006.

Schoenmakers, W. & Duysters, G. (2010): The technological origins of radical inventions. *Research Policy* **39** (8), 1051–1059. DOI:10.1016/j.respol.2010.05.013.

Schumpeter, J. A. (1934): *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*. Harvard University Press, Cambridge, Mass.

Scott, A. J. (1999): The US recorded music industry: On the relations between organization, location, and creativity in the cultural economy. *Environment and Planning A* **31** (11), 1965–1984. DOI:10.1068/a311965.

Scott, W. R. (2013): *Institutions and Organizations: Ideas, Interests, and Identities*. SAGE Publications.

Sedita, S. R., Noni, I. de & Pilotti, L. (2016): Out of the crisis: An empirical investigation of place-specific determinants of economic resilience. *European Planning Studies* **25** (2), 155–180. DOI:10.1080/09654313.2016.1261804.

Shannon, C. E. (1948): A Mathematical Theory of Communication. *Bell Labs Technical Journal* **27** (3), 379–423. DOI:10.1002/j.1538-7305.1948.tb01338.x.

Shelton, T., Poorthuis, A., Graham, M. & Zook, M. (2014): Mapping the data shadows of Hurricane Sandy: Uncovering the sociospatial dimensions of 'big data'. *Geoforum* **52**, 167–179. DOI:10.1016/j.geoforum.2014.01.006.

Shelton, T., Poorthuis, A. & Zook, M. (2015): Social media and the city: Rethinking urban socio-spatial inequality using user-generated geographic information. *Landscape and Urban Planning* **142**, 198–211. DOI:10.1016/j.landurbplan.2015.02.020.

Shepitsen, A., Gemmell, J., Mobasher, B. & Burke, R. (2008): Personalized Recommendation in Social Tagging Systems Using Hierarchical Clustering. In: Pu, P.

(ed.): *RecSys'08: Proceedings of the 2008 ACM Conference on Recommender Systems Lausanne, Switzerland, October 23-25, 2008*. ACM, New York.

Simmie, J. (2012): Path Dependence and New Technological Path Creation in the Danish Wind Power Industry. *European Planning Studies* **20** (5), 753–772. DOI:10.1080/09654313.2012.667924.

Simmie, J. & Martin, R. (2010): The economic resilience of regions: Towards an evolutionary approach. *Cambridge Journal of Regions, Economy and Society* **3** (1), 27–43. DOI:10.1093/cjres/rsp029.

Sordo, M., Celma, Ò., Blech, M. & Guaus, E. (2008): The Quest for Musical Genres: Do the Experts and the Wisdom of Crowds Agree? In: Bello, J. P., Chew, E. & Turnbull, D. (eds.): *ISMIR 2008: Proceedings of the 9th International Conference on Music Information Retrieval*. [Drexel University], [Philadelphia], 255–260.

Sotarauta, M. (2016): An actor-centric bottom-up view of institutions: Combinatorial knowledge dynamics through the eyes of institutional entrepreneurs and institutional navigators. *Environment and Planning C: Government and Policy*. DOI:10.1177/0263774X16664906.

Spracklen, K., Lucas, C. & Deeks, M. (2012): The Construction of Heavy Metal Identity through Heritage Narratives: A Case Study of Extreme Metal Bands in the North of England. *Popular Music and Society* **37** (1), 48–64. DOI:10.1080/03007766.2012.724605.

Stahlecker, T. & Zenker, A. (2017): Das baden-württembergische Innovationssystem im Wandel. *Standort* **23** (2/3/4), 171. DOI:10.1007/s00548-017-0491-z.

Statistik der Bundesagentur für Arbeit (2012): Arbeitsmarkt in Zahlen. Sozialversicherungspflichtig Beschäftigte nach Wirtschaftszweigen (WZ 2008), Land Baden-Württemberg (Stichtag 31. Dezember 2011). https://statistik.arbeitsagentur.de/Navigation/Statistik/Statistik-nach-Themen/Beschaeftigung/Beschaeftigte/vor-der-Datenrevision/vor-der-Datenrevision-Nav.html.

Stefanidis, A., Crooks, A. & Radzikowski, J. (2013): Harvesting ambient geospatial information from social media feeds. *GeoJournal* **78** (2), 319–338. DOI:10.1007/s10708-011-9438-2.

Stehr, N. (1994): *Arbeit, Eigentum und Wissen: Zur Theorie von Wissensgesellschaften*, 1st edn. Suhrkamp, Frankfurt am Main.

Stehr, N. (2001): *Wissen und Wirtschaften: Die gesellschaftlichen Grundlagen der modernen Ökonomie,* 1st edn. Suhrkamp, Frankfurt am Main.

Stoneman, P. (2010): *Soft innovation: Economics, product aesthetics, and the creative industries*. Oxford University Press, Oxford.

Stoneman, P. (2015): Soft Innovation and Changes in Product Aesthetics: An omitted Dimension in Economic Analyses of Innovation Activities. In: Archibugi, D. & Filippetti, A. (eds.): *The Handbook of Global Science, Technology, and Innovation*. Wiley, 88–108.

Storbeck, O. (2008): Geniale Ingenieure, miese Manager: Teures Spielzeug für Puristen. *Handelsblatt,* March 28. http://www.handelsblatt.com/unternehmen/industrie/teures-spielzeug-fuer-puristen-geniale-ingenieure-miese-manager/2939400-all.html. Accessed 12/7/2017.

Storper, M. & Venables, A. J. (2004): Buzz: Face-to-face contact and the urban economy. *Journal of Economic Geography* **4** (4), 351–370. DOI:10.1093/jnlecg/lbh027.

Storper, M. & Walker, R. (1989): *The capitalist imperative: Territory, technology, and industrial growth*. Blackwell, New York.

Strambach, S. (2002): Change in the Innovation Process: New Knowledge Production and Competitive Cities--The Case of Stuttgart. *European Planning Studies* **10** (2), 215–231. DOI:10.1080/09654310120114508.

Strambach, S. (2008): Knowledge-Intensive Business Services (KIBS) as drivers of multilevel knowledge dynamics. *International Journal of Services Technology and Management* **10** (2/3/4), 152–174. DOI:10.1504/IJSTM.2008.022117.

Strambach, S. (2010a): Knowledge-intensive business services (KIBS). In: Cooke, P. (ed.): *Platforms of innovation: Dynamics of new industrial knowledge flows*. Edward Elgar, Cheltenham, 170-204.

Strambach, S. (2010b): Micro-Dynamics of Knowledge – Firms, Organisations and their Territorial Shaping. In: Halkier, H., Dahlström, M., James, L., Manniche, J. & Olsen, L. S. (eds.): *Knowledge Dynamics, Regional Development and Public Policy*. Institut for Historie, Internationale Studier og Samfundsforhold, Aalborg Universitet, Aalborg, 47–59.

Strambach, S. (2010c): Path Dependence and Path Plasticity: The Co-evolution of Institutions and Innovation – the German Customized Business Software Industry. In: Boschma, R. A. & Martin, R. (eds.): *The Handbook of Evolutionary Economic Geography*. Edward Elgar Publishing.

Strambach, S. (2011): Herausforderungen der Wissensökonomie. Strukturen—Prozesse und neue Dynamiken im globalen Strukturwandel. *RegioPol Zeitschrift für Regionalwirtschaft, Urbane Zukunft in der Wissensökonomie* (1-2), 25–33.

Strambach, S. (2012): Knowledge Dynamics and Knowledge Commodification of KIBS in Time and Space. In: Di Maria, E., Grandinetti, R. & Di Bernardo, B. (eds.): *Exploring Knowledge-Intensive Business Services*. Palgrave Macmillan UK, London, 56–78.

Strambach, S. (2017): Combining Knowledge Bases in Transnational Sustainability Innovation: Microdynamics and Institutional Change. *Economic Geography* **3** (2), 1–27. DOI:10.1080/00130095.2017.1366268.

Strambach, S. & Halkier, H. (2013): Editorial. Reconceptualizing change. *Zeitschrift für Wirtschaftsgeographie* **57** (1-2), 1–14. DOI:10.1515/zfw.2013.0001.

Strambach, S. & Klement, B. (2012a): Cumulative and Combinatorial Micro-dynamics of Knowledge: The Role of Space and Place in Knowledge Integration. *European Planning Studies* **20** (11), 1843–1866. DOI:10.1080/09654313.2012.723424.

Strambach, S. & Klement, B. (2012b): The organizational decomposition of innovation and territorial knowledge dynamics: insights from the German software industry. In: Heidenreich, M. (ed.): *Innovation and institutional embeddedness of multinational companies*. Elgar, Cheltenham, 193–221.

Strambach, S. & Klement, B. (2013): Exploring plasticity in the development path of the automotive industry in Baden-Württemberg: The role of combinatorial knowledge dynamics. *Zeitschrift für Wirtschaftsgeographie* **57** (1-2). DOI:10.1515/zfw.2013.0006.

Strambach, S. & Klement, B. (2016): Resilienz aus wirtschaftsgeographischer Perspektive: Impulse eines „neuen" Konzepts. In: Wink, R. (ed.): *Multidisziplinäre Perspektiven der Resilienzforschung*. Springer, Wiesbaden, 263–294.

Strambach, S. & Stockhorst, J. (2010): Micro-dynamics of Knowledge—Actors, Processes and the Territorial Organization, Final EURODITE WP7 Report, Marburg.

Strambach, S., Stockhorst, J. & Sandmüller, M. (2009): Territorial Knowledge Dynamics in the Automotive Industry of Baden- Württemberg—The Contribution of Engineering Services and Visual Computing Services: Eurodite WP5 Report, Marburg.

Strambach, S. & Storz, C. (2008): Pfadabhängigkeit und Pfadplastizität von Innovationssystemen – Die deutsche und japanische Softwareindustrie. *Vierteljahrshefte zur Wirtschaftsforschung* **77** (2), 142–161. DOI:10.3790/vjh.77.2.142.

Strambach, S. & Surmeier, A. (2013): Knowledge dynamics in setting sustainable standards in tourism – the case of 'Fair Trade in Tourism South Africa'. *Current Issues in Tourism* **16** (7-8), 736–752. DOI:10.1080/13683500.2013.785485.

Streeck, W. & Thelen, K. (2005): Introduction: Institutional Change in Advanced Political Economies. In: Thelen, K. A. & Streeck, W. (eds.): *Beyond continuity: Institutional change in advanced political economies*. Oxford University Press, Oxford, New York, 1–39.

Sydow, J., Schreyögg, G. & Koch, G. (2009): Organizational Path Dependence: Opening the Black Box. *Academy of Management Review* **34** (4), 689–709.

T

Tanner, A. N. (2014): Regional Branching Reconsidered: Emergence of the Fuel Cell Industry in European Regions. *Economic Geography* **90** (4), 403–427. DOI:10.1111/ecge.12055.

Tanner, A. N. (2016): The emergence of new technology-based industries: The case of fuel cells and its technological relatedness to regional knowledge bases. *Journal of Economic Geography* **16** (3), 611–635. DOI:10.1093/jeg/lbv011.

Tavassoli, S. & Carbonara, N. (2014): The role of knowledge variety and intensity for regional innovation. *Small Business Economics* **43** (2), 493–509. DOI:10.1007/s11187-014-9547-7.

Teece, D. J. (2010): Technological innovation and the theory of the firm: The role of enterprise-level knowledge, complementarities, and (dynamic) capabilities. In: Hall, B. H. & Rosenberg, N. (eds.): *Handbook of the economics of innovation - Vol. 1*. Elsevier, Amsterdam, 679–730.

Teece, D. J., Pisano, G. & Shuen, A. (1997): Dynamic Capabilities and Strategic Management. *Strategic Management Journal* **18** (7), 509–533.

Ter Wal, A. L. J. & Boschma, R. A. (2009): Applying social network analysis in economic geography: Framing some key analytic issues. *The Annals of Regional Science* **43** (3), 739–756. DOI:10.1007/s00168-008-0258-3.

Theil, H. (1972): *Statistical Decomposition Analysis: With applications in the social and administrative sciences*. North-Holland Publishing Co., Amsterdam.

Tironi, M. (2012): Enacting Music Scenes: Mobility, Locality and Cultural Production. *Mobilities* **7** (2), 185–210. DOI:10.1080/17450101.2012.654993.

Tödtling, F. & Grillitsch, M. (2015): Does Combinatorial Knowledge Lead to a Better Innovation Performance of Firms? *European Planning Studies* **23** (9), 1741–1758. DOI:10.1080/09654313.2015.1056773.

Tödtling, F. & Trippl, M. (2005): One size fits all? Towards a differentiated regional innovation policy approach. *Research Policy* **34** (8), 1203–1219.

Tödtling, F. & Trippl, M. (2013): Transformation of regional innovation systems: From old legacies to new development paths. In: Cooke, P. (ed.): *Reframing Regional Development: Evolution, Innovation and Transition*. Routledge, London/New York, 29–53.

Tokatli, N. (2015): Single-firm case studies in economic geography: Some methodological reflections on the case of Zara. *Journal of Economic Geography* **15** (3), 631–647. DOI:10.1093/jeg/lbu013.

Tomasi Di Lampedusa, G. (1960): *The leopard,* Pantheon pbk. ed. Pantheon Books, New York.

Torre, A. (2008): On the Role Played by Temporary Geographical Proximity in Knowledge Transmission. *Regional Studies* **42** (6), 869–889. DOI:10.1080/00343400801922814.

Trant, J. (2008): Studying Social Tagging and Folksonomy: A Review and Framework. *Journal of Digital Information* **10** (1).

Treado, C. D. (2010): Pittsburgh's evolving steel legacy and the steel technology cluster. *Cambridge Journal of Regions, Economy and Society* **3** (1), 105–120. DOI:10.1093/cjres/rsp027.

Truffer, B. & Coenen, L. (2012): Environmental Innovation and Sustainability Transitions in Regional Studies. *Regional Studies* **46** (1), 1–21. DOI:10.1080/00343404.2012.646164.

Turvani, M. (2010): Microfoundations of knowledge dynamics within the firm. *Industry and Innovation* **8** (3), 309–323. DOI:10.1080/13662710120104600.

U

Uski, S. & Lampinen, A. (2016): Social norms and self-presentation on social network sites: Profile work in action. *New Media & Society* **18** (3), 447–464. DOI:10.1177/1461444814543164.

Uzzi, B., Mukherjee, S., Stringer, M. & Jones, B. (2013): Atypical combinations and scientific impact. *Science (New York, N.Y.)* **342** (6157), 468–472. DOI:10.1126/science.1240474.

V

Vale, M. & Carvalho, L. (2013): Knowledge Networks and Processes of Anchoring in Portuguese Biotechnology. *Regional Studies* **47** (7), 1018–1033. DOI:10.1080/00343404.2011.644237.

van den Heiligenberg, H. A., Heimeriks, G. J., Hekkert, M. P. & van Oort, F. G. (2017): A habitat for sustainability experiments: Success factors for innovations in their local and regional contexts. *Journal of Cleaner Production*. DOI:10.1016/j.jclepro.2017.06.177.

van Dijck, J. (2009): Users like you? Theorizing agency in user-generated content. *Media, Culture & Society* **31** (1), 41–58. DOI:10.1177/0163443708098245.

van Tuijl, E. & Carvalho, L. (2014): Knowledge sourcing, knowledge bases, and the spatial organisation of car design. *Environment and Planning A* **46** (8), 1966–1982. DOI:10.1068/a46282.

Verboord, M. & Brandellero, A. (2016): The Globalization of Popular Music, 1960-2010: A Multilevel Analysis of Music Flows. *Communication Research*, 1–25. DOI:10.1177/0093650215623834.

Verspagen, B. (1997): Measuring Intersectoral Technology Spillovers: Estimates from the European and US Patent Office Databases. *Economic Systems Research* **9** (1), 47–65. DOI:10.1080/09535319700000004.

Vigliensoni, G. & Fujinaga, I. (2017): The Music Listening Histories Dataset, 18th International Society for Music Information Retrieval Conference, Suzhou, China, 2017.

W

Watson, A. (2008): Global music city: knowledge and geographical proximity in London's recorded music industry. *Area* **40** (1), 12–23.

Watson, A., Hoyler, M. & Mager, C. (2009): Spaces and Networks of Musical Creativity in the City. *Geography Compass* **3** (2), 856–878. DOI:10.1111/j.1749-8198.2009.00222.x.

Weinstein, D. (2014): Birmingham's Postindustrial Metal. In: Lashua, B., Spracklen, K. & Wagg, S. (eds.): *Sounds and the City*. Palgrave Macmillan UK, London, 38–54.

Weitzman, M. L. (1998): Recombinant Growth. *The Quarterly Journal of Economics* **113** (2), 331–360. DOI:10.1162/003355398555595.

Wengraf, T., Chamberlayne, P. & Bornat, J. (2016): A Biographical Turn in the Social Sciences? A British-European View. *Cultural Studies ↔ Critical Methodologies* **2** (2), 245–269. DOI:10.1177/153270860200200215.

WIPO (2017): WIPO Statistics - Intellectual property rights: Total applications. https://www3.wipo.int/ipstats/keyLineChart. Accessed 12/7/2017.

X

Y

Z

Zalan, T. & Lewis, G. (2004): Writing about methods in qualitative research: Towards a more transparent approach. In: Marschan-Piekkari, R. (ed.): *Handbook of qualitative research methods for international business*. Elgar, Cheltenham, 507–528.

Zeileis, A. (2004): Econometric Computing with HC and HAC Covariance Matrix Estimators. *Journal of Statistical Software* **11** (10). DOI:10.18637/jss.v011.i10.

Zook, M. & Poorthuis, A. (2014): Offline Brews and Online Views: Exploring the Geography of Beer Tweets. In: Patterson, M. & Hoalst-Pullen, N. (eds.): *The Geography of Beer: Regions, Environment, and Societies*. Springer Netherlands, Dordrecht, s.l., 201–209.

Zukauskaite, E. & Moodysson, J. (2015): Multiple paths of development: Knowledge bases and institutional characteristics of the Swedish food sector. *European Planning Studies* **24** (3), 589–606. DOI:10.1080/09654313.2015.1092502.

Zwaan, K., ter Bogt, T. F. & Raaijmakers, Q. (2009): So you want to be a Rock 'n' Roll star? Career success of pop musicians in the Netherlands. *Poetics* **37** (3), 250–266. DOI:10.1016/j.poetic.2009.03.004.