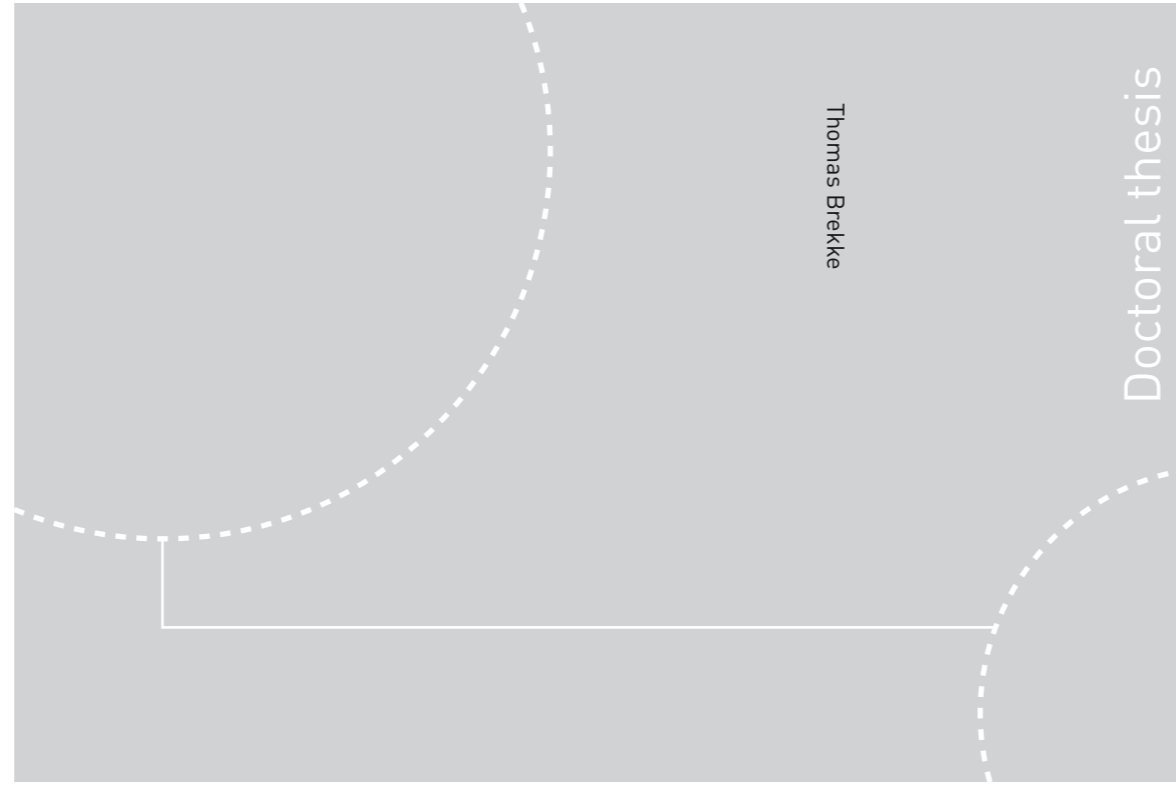


ISBN 978-82-326-4028-7 (printed ver.)
ISBN 978-82-326-4029-4 (electronic ver.)
ISSN 1503-8181



Doctoral theses at NTNU, 2019:216

Thomas Brekke

Higher Education Institutions (HEIs), Innovation, and Regional Economic Development

Enhancing the entrepreneurial discovery process in regional development

 **NTNU**
Norwegian University of
Science and Technology

Doctoral theses at NTNU, 2019:216

 NTNU

NTNU
Norwegian University of Science and Technology
Thesis for the Degree of
Philosophiae Doctor
Faculty of Economics and Management
Department of Industrial Economics and
Technology Management

 **NTNU**
Norwegian University of
Science and Technology

Thomas Brekke

Higher Education Institutions (HEIs), Innovation, and Regional Economic Development

Enhancing the entrepreneurial discovery
process in regional development

Thesis for the Degree of Philosophiae Doctor

Trondheim, August 2019

Norwegian University of Science and Technology
Faculty of Economics and Management
Department of Industrial Economics and Technology
Management



Norwegian University of
Science and Technology

NTNU

Norwegian University of Science and Technology

Thesis for the Degree of Philosophiae Doctor

Faculty of Economics and Management

Department of Industrial Economics and Technology Management

© Thomas Brekke

ISBN 978-82-326-4028-7 (printed ver.)

ISBN 978-82-326-4029-4 (electronic ver.)

ISSN 1503-8181

Doctoral theses at NTNU, 2019:216

Printed by NTNU Grafisk senter

Abstract

Regions and local communities are transformed by the diminishing of old industries and the emergence of new business and technology. Whether due to environmental problems, welfare challenges, or the need for sustainable economic growth in the rapidly changing and increasingly open global economy, science and higher education institutions (HEIs) are being challenged in new ways to respond and contribute with new and more complex knowledge, in the effort to reshape the national and regional economy and to improve the quality of life. Most innovation policies and research into HEIs and regional development focus on the different roles and functions of its potential for building localised collective learning and knowledge sharing processes. Other studies and innovation policies point to the vigour and dynamism of the dependence of regional economies on the ability of local companies to adapt to changing market pressures and technologies by continually introducing commercially viable products, services, and processes; that is, by innovation. Our knowledge of regional growth dynamics and HEI capabilities remains fragmented and lacks robust theoretical foundations. This prompted the overall research question of this dissertation: *How can HEIs enhance regional capabilities for innovation?*

The dissertation pursues two related objectives. From a practical perspective, it aims to increase our knowledge of how the HEI contribution towards innovation and regional development is able to change the regional condition for industry development. From a theoretical perspective, it seeks to increase our understanding of how regions develop and change, with an emphasis on the heterogeneity and complexity of regional path dependent processes and firms' novel ways of searching for knowledge. The dissertation thus contributes to the literature about changes

and regional development in HEIs through the development of concepts and models as part of theory development.

The aforementioned objectives are addressed through four independent research papers and a cover essay. The cover essay provides an overarching theoretical framework for the dissertation, adopting an evolutionary economic geography (EEG) framework and regional innovation system (RIS) approaches to analyse HEI capabilities for innovation and path growth. It consolidates the four individual research papers in a coherent manner that responds to the overall research question of this dissertation. This empirical research is conducted within a critical realist research tradition and follows an explorative approach through the use of a mixed method that combines longitudinal qualitative and quantitative research designs. The work is a case study of the transformation processes of Vestfold University College between 1994 and 2014. The qualitative data consists of 44 interviews. Twenty-one interviews represent company informants and 23 interviews represent people working at Vestfold University College. In addition to interviews, the data consists of reports, formal and informal documents, notes, websites, correspondence through e-mails, workshops, project meetings and steering committee meetings. The data was manually coded and further supported by using software analytical tools. A survey analysis consisting of 28 company informants and a literature review consisting of 193 articles was conducted to support the qualitative data.

The first research paper presents a case study of path dependent industrial development in Horten/Tønsberg (County of Vestfold), characterised by a specialised high-tech industry cluster and the transformation of a vocational university college (Vestfold University College). The study finds that the growth of the high-tech industry cluster follows different development paths

and processes due to the composition of regional branching mechanisms and the quest for the knowledge characteristics of high-tech companies. Findings from the study shows that path creation and the branching of existing industry into new industry sectors does not happen automatically, instead path creation and renewal may require purposeful policy intervention through the use of target innovation policies, such as RIS and technology transfer policies, and access to external investment to avoid path stagnation. The study also shows that the role of the university college and its functions (teaching, research and outreach activity of third mission) varied in each of the distinct phases. The development of path creation in high-tech companies shows the importance of access to advanced scientific knowledge located outside the region, which leaves the role of the local university college as a provider of vocational teaching. The process of path renewal and diversification shows that the university college was challenged to modernise its three main functions and renew its traditional role (vocational education) through the pursuit of research excellence, and by taking a broader regional development role. The paper shows that increased industry mobilisation through interactive learning and collective knowledge sharing made modernisation of the university college research and educational program possible. The findings indicate the importance of mobilising close industry cooperation as an important mechanism for university change.

The second research paper analyses how science and educational institutions can respond to the challenges of knowledge base complexities and globalisation. It contributes to the discussion of cluster building policies, knowledge complexities, and regional innovation systems by recognising the firm's endogenous development processes search for knowledge as a key driver of regional economic development and industry HEI interaction. The study finds that firms increasingly transcend the boundaries of a region in their search for technology and knowledge, which decouples them from the local knowledge system. The local environment does play a

role, however, as these companies are highly dependent on their internal absorptive capacity and the capability of the immediate surrounding environment to utilise cross-sectorial knowledge opportunities. The study finds that there is potential for new regional development paths in the intersection between the research-based - science and technology innovation (STI) - and experienced based - doing using interacting (DUI) - modes of innovation where new combinations of knowledge originates in different industries supported by broad-based innovation policies. These findings point to the importance of local knowledge and the diffusion ecology consisting of a stable and committed infrastructure, which operates independently of inter-firm collaboration. As shown by the study, this can be provided by regional science and educational system actors. The paper concludes by claiming that HEIs may play a vital role in regional development by acknowledging firms' endogenous development processes as drivers for innovation and knowledge diffusion. Colleges that interact with regional industries dominated by combined innovation modes, are in a particularly demanding position due to the challenges of finding the best match between different modes of innovation and right composition of research, teaching and third mission activities. The development of educational programs thus appears to be critical, because they are the main mechanisms for industry mobilisation and knowledge diffusion. This finding demonstrates that education itself is a key mechanism with which to build entrepreneurial competence and other third-mission activities of HEIs, which contribute to capabilities for innovation and regional path development.

The third research paper provides new insight into the entrepreneurial discovery process (EDP) and university capabilities for innovation and regional development. The paper contributes with a greater understanding of Vestfold University College and the joint effort of regional industry mobilisation to build regional innovation capacities based on an entrepreneurial discovery process. The paper concludes that by responding to new and conflicting policy schemes,

adapting to company searches for knowledge in the global-local context, transforming its culturally embedded beliefs and norms, and mobilising industry resources, the university college developed new third-mission capabilities and thus gradually changed the institutional setup of the region. Despite the overall positive experience and opportunities of EDP, the university college faced several challenges in their effort to respond to policy schemes and reforms. These challenges partly reflect the shifting circumstances following the entrance of new policy schemes, different culture and operational objectives, and lack of entrepreneurial experiences. These difficulties suggest the need for universities to continuously invest in their activities, and to build relevant and legal administrative capacities. Universities also call for greater reflection on the distinct regional formative processes by which a region diversifies and grows.

Finally, in the fourth paper, the dissertation contributes with a critical perspective on the rapid number of scientific studies in the last decade, that analyse the role of universities and higher educational institutions in regional development. The study identifies four key topics in the literature: organisational capacity, intermediary functions, knowledge dynamics, and innovation policies. The paper concludes by providing a proposition to guide framework for future research studies. The study shows how conflicting RIS policies create dilemmas between pursuing regional competitive advantages based on a research practice approach to regional development while pursuing relevance to the wider regional business life. These types of policies challenge HEI priorities of resources and competence, and the strategic focus, and there are different views on the value of knowledge and organisational culture between academia and HEIs which impact the role of HEIs in path dependent regional development processes. Finally, the paper proposes a critical perspective on the existing literature, which seem to neglect firm

complexity and their endogenous search for knowledge as key drivers for innovation and regional development.

Overall, this thesis contributes with novel perspectives on HEI capabilities for innovation and regional growth and firms' novel ways of searching for knowledge, which have been overlooked by the RIS approaches of the previous decade. Through the longitudinal study of Vestfold University College, this research demonstrates that HEIs can build capabilities for innovation by reorienting a region's knowledge base and the regional framework conditions for industrial development within a specific region and industry in four ideal ways: 1) stimulating the spin-off and commercialisation of knowledge; 2) attracting external investment, 3) diversifying existing industry structure, and 4) upgrading the existing industry structure knowledge base. Further, HEI capability to reorient regional conditions for industrial development are shown to be primarily discontinuous and shaped by technological and market breakthroughs from entrepreneurial actors and new policy schemes. The dissertation draws attention to the effect of a firm's novel means of searching for knowledge, in the global-local context, on local path dependent processes and HEI capabilities for innovation. The conceptual arguments from this dissertation is that; HEI capabilities for innovation depend on the manner of interaction, response and correction given to the on-going path processes by mobilising industry resources in joint efforts to create new work forms for teaching, and combining teaching and research in new ways linked to third mission activities. The study shows how HEIs can play a regional development role by rigorous diversifying the region's knowledge base, and strengthening innovation capabilities, and competencies; including those embedded in its own departments as well as local businesses, through joint industry cooperation. that is, enhancing the entrepreneurial discovery process.

The main contributions of this thesis are:

- Knowledge of HEI contributions to innovation and regional path development;
- Knowledge of the way in which HEIs respond to the challenges of knowledge-based complexities and globalisation;
- A greater understanding of the dilemmas between different research policies that challenge the regional roles and functions of HEIs;
- The proposal of a critical realism framework to offer a better understanding of the system dynamics in regional innovation system constructs.

Preface

This thesis is submitted to the Norwegian University of Science and Technology (NTNU) in partial fulfilment of the requirements for the degree of Philosophiae Doctor.

The thesis consists of a summary of four research papers. The summary introduces the topic, describes the research methodology, and discusses and evaluates the answers to the research questions. A complete description of the research outcome is given in Appendix A. The reader is advised to study both parts to gain a full understanding of the topics and research answers presented in this work.

The doctoral work was undertaken at the Department of Industrial Economics and Technology Management, Norwegian University of Science and Technology, Trondheim, and the University College of Southeast Norway, under the supervision of Professor Sverre Herstad.

The thesis was financed by Vestfold University College (today the University of South-Eastern Norway). The research was conducted as part of the research project, “*Regional R&D and Innovation*” (2007–2016) in Vestfold, and the research project “*Different modes of innovation and challenges for stimulating university–industry cooperation*” (2009–2011) with the objective of analysing STI- and DUI-based regional industries in Norwegian regions.

Horten, February 2019

Thomas Brekke

Acknowledgements

Working on this thesis has been an individual and sometimes lonely journey. It has tested my endurance and staying capacity, but most of all it has been a challenge to remain motivated.

Despite the loneliness, several people have contributed to this research project and the process of writing this thesis. First, I would like to thank my supervisor Professor Sverre Herstad, for his support. He supported me throughout my PhD by sharing his competence and knowledge about how to reflect on, discuss, and write scientific work. Thank you, Sverre, for believing in my research project and encouraging me to finish my PhD. Thank you very much Roger Klev, who guided me in the finale phase of the work.

I wish to thank all my informants for the time and thoughts that they have shared with me, for giving me the opportunities to ask questions, and for trusting me with information.

My gratitude is also due to the Department of Industrial Economics and Technology Management NTNU for the administration of the PhD and for creating a good learning environment for the doctoral students participating in the EDWOR II programme. My thanks are also expressed to all the staff members involved in the EDWOR II programme, and especially Professor Morten Levin, who created a challenging learning arena in the EDWOR seminars, independent of place and space. Thanks also to all my fellow doctoral students participating in the EDWOR II programme.

My appreciation also goes out to my colleagues at the University of Southeast of Norway, for waiting patiently for me to finish my PhD thesis journey and for all the valuable discussions. I would like to thank Anne H. Gausdal, Are Branstad and Birgit A. Solem for their constructive and important discussions, and for their wise and inspiring attitudes.

The processes of finalising this study would have been impossible without the support of my family, Olav, Maja, Lars, and my wife Inger Marie. Thank you for being who you are, and for your endurance and the encouragement to finish my thesis. Finally, it is ended!

PART 1: COVER ESSAY

Contents

Abstract	ii
Preface	ix
Acknowledgements	x
Contents.....	xii
List of tables and figures.....	xiii
1 Introduction.....	1
1.1 Research questions	3
1.2 Context and case description	4
1.3 Outcome of the thesis	6
1.4 Structure of the thesis	13
2 Theoretical framework.....	15
2.1 Evolutionary economic geography framework (EEG).....	16
2.2 Regional innovation system (RIS) approach	24
2.3 Higher education institutions in the regional innovation system approach.....	29
2.4 Conceptual framework and identified theoretical gaps	31
3 Research methodology and research design	35
3.1 Scientific positioning: Critical realism	36
3.2 Research design and methods.....	41
3.3 Research implications for data collection and analysis	45
3.4 Threats to validity.....	51
3.5 Science ethics	55
3.6 Summary and limitations.....	56
4 Summary of findings from research papers	59
4.1 <i>Research Question 1</i> . How can regional science and knowledge institutions interact with and influence evolutionary process at play in the economy?	62
4.2 <i>Research Question 2</i> . What types of mechanisms transform university capabilities for innovation and growth?	70
4.3 <i>Research Question 3</i> . How has prior research addressed the question of HEI contributions to regional economic development and what do we know from this research?	74
5 Discussion, conclusion and implication.....	77
5.1 Research contributions, key findings and theoretical development	80
5.2 Methodological aspects and limitations	86
5.3 Practical applications for policy and HEIs	88
5.4 Further work	90
6 References	91

List of tables and figures

Table 1. Publications included in the thesis	7
Table 2. Theoretical gaps addressed in the thesis.....	34
Table 3. Theory gaps addressed and contribution of the research papers	61
Table 4. The dissertation's overall summary of key findings.	79
Figure 1. Structure of the thesis and relationships between the papers and the research questions	8
Figure 2. Conceptual framework positioning the dissertation, its theoretical foundations, and focus of the thesis	33
Figure 3. Relationship between the real, the actual, and the empirical in the thesis	40
Figure 4 Description of the thesis mix-method design process.....	48
Figure 5. The dissertation's overall conceptual framework, context, theory and result	78

PART 2: RESEARCH PAPERS

PAPER 1: ‘Entrepreneurship and path development in regional development’	101
PAPER 2: ‘Globalization, modes of innovation, and regional knowledge diffusion infrastructure’	129
PAPER 3: ‘Building entrepreneurial discovery process from university – industry interaction. Challenges and opportunities’	167
PAPER 4: ‘What do we know about university contribution to regional economic development? A conceptual framework’	197

1 Introduction

Regions and local communities are transformed with the diminishing of old industries and emergence of new business and technology. Whether through environmental problems, welfare challenges, or the need for sustainable economic growth in the rapidly changing and increasingly open global economy, science and higher education institutions are being challenged to respond and contribute with new and more complex knowledge in the effort to reshape the national and regional economy and to improve the quality of life. Norway has experienced a remarkable transformation in the last century, which has reshaped it into one of the richest in Europe. The transformation and wealth creation are related to successful specialisation in resource-based sectors, in particular oil and gas, shipbuilding, fisheries, and aquaculture. The revenue generated from these sectors became a driving force in the growth and technological upgrading of these sectors and helped to establish a national and regional science and educational system. More than 100 HEIs emerged between the 1960s and 1980s, most of which were small university colleges (UCs) located in rural areas, driven by regional needs and the upgrading of upper-secondary professional schools. In recent decades, the fragmentation and robustness of the national higher education system was called into question, including their financial viability, sufficient student enrolment, and meaningful research output for innovation purposes (Bleiklie & Kogan, 2007). According to an OECD (2017) report, Norway is facing an imperative transition concerning its regional industry structure and science and higher educational system. The imperative transition relates to a shift towards a more diversified economy, and the transformation of its research and innovation system to support the structural transition, and to build research and innovation capacities that can solve an array of societal challenges. In other words, the transformation of the science and higher educational system to support the transition of the national economy is evident, and is the phenomenon under study in this dissertation.

The most recent Cohesion Policy of the European Union, the ‘Smart Specialisation Platform’, emphasise the knowledge triangle and policy domains – education, research, and innovation – as a strategic area in which national and regional authorities are challenged to mobilise HEIs to support regional development strategies. According to McCann and Ortega-Argilés (2015), HEIs are assumed to play key roles by contributing to a rigorous assessment of the region’s knowledge assets, capabilities, and competencies, including those embedded in their own departments as well as local businesses. Theoretical arguments for localised interaction and the spatial knowledge flow between industry and HEIs are embedded in the regional innovation system (RIS) approach and the evolutionary economic geography (EEG) framework. Scholars claim that previous research has been limited regarding relevant issues such as the way in which regions diversify and grow, the mechanisms that shape the paths of regional development in a long-term economic development process, the role of firms as the principal agents of economic change, and the way in which HEIs contribute to innovation and regional development (Boschma, Neffke, & Henning, 2010; Martin & Sunley, 2006).

According to Storper (1993), regions have complex economic development processes that are shaped by a range of forces. Earlier thinkers identified and emphasised several factors, such as home market effects, the concentration of workers and firms, and trade costs, as explanatory factors for spatial economic development. As Storper (2011) stated in response to the core question of what drives regional change: ‘people go to jobs, and jobs go to people, more or less simultaneously’. This statement highlights one of the central forces – what moves the spatial economy forward is the creation of new production possibility frontiers or the improvement of those that already exist; that is, people go to work to learn and to share knowledge, which is the key to building regional capabilities for innovation. Innovation (be it new products and services, the birth of new sectors, the application or creation of new processes, or the development of

new organisational capacities) has a propensity to agglomerate, because it involves forms of place-specific untraded interdependencies that coordinate the learning and knowledge creation of actors under conditions of uncertainty. Illustrating the strong path dependencies and untraded interdependencies at play in regional economic development, recent research has argued that the performance of individual firms depends more on international connections than local ones, as firms become more embedded in global innovation networks (Cooke et al., 1998; Piore & Sabel, 1984). Other research studies have found evidence that new firms are more likely to be established and survive when they are ‘related’ in terms of knowledge bases, skills, and organisational practice to the current industrial configuration of regions (Neffke, et al., 2011). For this reason, regions are seen as important bases for economic coordination, local learning, knowledge spillovers, and contexts of formal rules, norms, and conventions. All these factors appear to shape spatial dynamic processes, which involve knowledge transfer between a multiplicity of different actors that continually reshape and reconfigure their past industrial trajectories into future growth dynamism (Cooke et al., 1998; Martin & Sunley, 2010). Addressing such issues is relevant to understanding the regional economic development dynamics and increasing our knowledge of HEI capabilities for innovation and regional development. This motivated the overall research question of this dissertation: How can HEIs enhance regional capabilities for innovation?

1.1 Research questions

The idea of this study originated in 2007, inspired by the experience that ‘something’ was changing in the relationship between Vestfold University College, regional business life, and government support for building regional innovation capabilities when VRI Vestfold was launched in 2006 (the application process), which triggered the question of what was responsible for those events or changes over time. This study aims to build new theoretical

knowledge of HEI contributions toward innovation and regional development. This thesis contributes with new knowledge to the existing theoretical framework of the regional innovation system (RIS) approach by substantiating the role played by HEIs in path dependent regional economic development processes by applying an evolutionary economic geography (EEG) approach. The research question proposed for the thesis is: *How do higher education institutions enhance regional capabilities for innovation?* To investigate the overall research question in details, three more specific questions will be addressed:

1. How can regional science and knowledge institutions interact with and influence the evolutionary processes at play in the economy?
2. What types of mechanisms transform university capabilities for innovation and growth?
3. How has prior research addressed the question of HEI contributions to regional economic development and what do we know from this research?

The following section provides an overview of the study and structures the results in relation to the proposed research questions.

1.2 Context and case description

The study derives from VRI (Programme for Regional R&D and Innovation), a 10-year national research and development project (2006-2016) with the primary goal of encouraging innovation, knowledge development, and benefits through regional cooperation, and strengthening research and development efforts within and for the regions. The overall objective of the VRI Vestfold project was to develop a regional innovation infrastructure through close cooperation between regional actors, such as the County Council of Vestfold, Confederation of Norwegian Enterprise (NHO), Norwegian Confederation of Trade Unions (LO), business life, and Vestfold University College. The research was conducted in

cooperation with the external research project, supported by the Research Council of Norway, – “*Different modes of innovation and challenges for stimulating university–industry cooperation*” (2009–2011). The aim of the research project was to analyse regional industry development using the concept of science, technology and innovation (STI mode), and the doing, using and interacting (DUI) mode of innovation in the Norwegian regions of Agder, Vestfold, Buskerud, and Innlandet. The thesis was financed by Vestfold University College (today the University of South-Eastern Norway).

The empirical case context is Vestfold, which is a medium-sized Norwegian region, located approximately 100 km southwest of the capital city of Oslo. The region, which constitutes a county, has about 250 000 inhabitants, who mostly live in the major cities along the coast of the Oslofjord. The region has a long history of important ports for ferries, shipbuilding, and maritime activities. The region’s business life consists of two main groups of industrial branches. The first group contains diverse companies within wholesale business, trade, logistics and transport, food, and forestry. The second group consists of a specialised R&D-intensive production system, denoted as an organisationally thick and specialised RIS (Isaksen et al., 2018), within electronics and ICT, which evolved in the 1960s as part of a national strategy to build a research-based industry in emerging technologies. The organisational thick and specialised RIS consists of technology-intensive manufacturing companies that are embedded in national or global knowledge networks serving the industry with science and technology-based knowledge. These companies operate in the international market for defence, maritime, offshore, and electronics products, health and medical equipment, and communication software (Asheim, Boschma, & Cooke, 1999; Brekke, 2015), and are mainly clustered in a 40 km circle around the university college. Such spatial proximity of firms represents innovation power, explained as knowledge spillovers between related companies and higher education institutions

(Asheim et al., 2006; Gausdal, 2008). As is typical for organisationally thick and specialised RIS, the region is characterised by poor conditions for entrepreneurial discovery and the potential for the lock-in of existing industry strongholds. In recent decades, the region has focused on strengthening its institutional infrastructure, by emphasising closer network-based collaboration between the only knowledge organisation located in the region, University College of Vestfold, with industrial firms. The objective of this initiative is to reduce the risk of lock-in and strengthen the entrepreneurial discovery process of the region. University College has its roots in a School of Engineering founded in 1855 and a School of Nautical Studies founded in 1859, both affiliated to the Naval Base and Wharf in Horten. In 1994, University College went through a merger with other schools, such as a Teacher Training College and Nurses' Training School. The foundation of University College was the result of a political reform in which numerous small higher education institutions all over Norway were conglomerated into fewer and larger units. In 2013, Vestfold University College was organised into four faculties: Health Science, the Faculty of Humanities and Education, the Faculty of Technology and Maritime Sciences, and the Faculty of Social Science. The university college offered several bachelor's (20) and master's (8) degrees and a PhD programme in nano- and micro-electronics.

1.3 Outcome of the thesis

The thesis consists of four papers which have been published in, or submitted to, international peer-reviewed journals; see Table 1. The first paper was published in *European Planning Studies* and the second paper in *Entrepreneurship & Regional Development*. The third and fourth papers are to be revised for publication. The papers are not intended to be read in chronological order, but are organised thematically. The first paper explores regional change processes by analysing path dependent regional development. The second paper analyses

different modes of innovation and endogenous development forces at firm level, and the third paper focus on the role of HEIs in regional development. The fourth paper is a critical paper on the rapidly growing number of scientific studies and literature, focusing on HEI and regional development. Findings from the fourth paper will be discussed in the cover essay in light of findings from the three papers in the discussion part of the thesis (Chapter 5).

	Author	Title	Journal
Paper 1.	Brekke (2015)	Entrepreneurship and path dependency in regional development	<i>Entrepreneurship & Regional Development</i>
Paper 2.	Herstad and Brekke (2012)	Globalization, modes of innovation, and regional knowledge diffusion infrastructure	<i>European Planning Studies</i>
Paper 3.	Brekke (to be revised for publication)	Building entrepreneurial discovery process from university–industry interaction. Challenges and opportunities	<i>Industry and Higher Education</i>
Paper 4.	Brekke (to be revised for publication)	What do we know about university contributions to regional economic development? A conceptual framework	<i>International Regional Science Review</i>

Table 1. Publications included in the thesis

The papers are closely interconnected and respond to the research question and the sub-questions, as shown in Figure 1. The remainder of this chapter contains a short summary of the papers organised thematically; see Figure 1. A complementary discussion of the research findings from the papers is presented in Section 4.

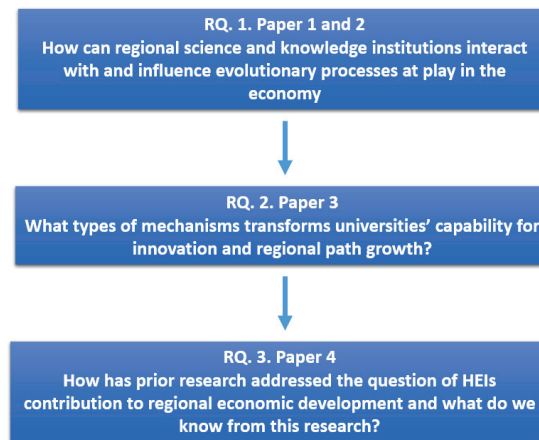


Figure 1. Structure of the thesis and relationships between the papers and the research questions

The paper titled ‘Entrepreneurship and path dependency in regional development’ presents a case study of path dependent industrial development in Vestfold, characterised by a specialised high-tech industrial cluster. The *purpose* of the study was to examine the path dependent process of new industries arising from technology-related industries through specific regional branching mechanisms and different path dependent processes. A single case study *method* was used to analyse the university’s role in regional path development and entrepreneurship. Personal interviews (qualitative semi-structured) with 13 company managers, conducted in two rounds, were recorded and analysed in combination with document analysis. The interviewees received transcripts as a quality check. The paper *contributes* to the discussion raised by Boschma and Martin (2010), Martin and Sunley (2006), and Tödtling and Trippel (2005) about what drives path dependency and regional branching. The study finds that the growth of the high-tech industry cluster follows different development paths and processes due to the composition of regional branching mechanisms and the quest for the knowledge characteristics of high-tech companies. The findings from the study show that path creation and the branching

of existing industry into new industry sectors does not happen automatically, instead path creation and renewal may require purposeful policy intervention through the use of target innovation policies, such as RIS and technology transfer policies, and access to external investment to avoid path stagnation. The study also shows that the role of the university college, and its functions (teaching, research and outreach activity of the third mission), varied in each of the distinct phases. The development of path creation in high-tech companies shows the importance of access to advanced scientific knowledge located outside the region, which leaves the role of the university college as a provider of vocational teaching institute. The process of path renewal and diversification shows that the university college was challenged to modernise its three main functions and renew its traditional role (vocational education) by pursuing research excellence and by taking a broader regional development role. Increased interactive learning, collective knowledge sharing, and the modernisation of the university college research and educational program mobilised the regional industry to collaborate with the university college. The study also shows that the ability of HEIs to introduce new and unrelated knowledge to an old industrial region (path upgrading and renewal) is hampered by the existing industrial knowledge base, weak functional proximity, and firms' absorptive capacity for utilising localised knowledge. The paper also determines how functional, political, and regional cognitive lock-ins preserve the existing industrial structure and hamper regional branching processes. An early version of the paper was presented at the Regional Studies Association European Conference (2013): The Future Dynamics of Regional Development Tampere, Finland, entitled 'Regional economic change, entrepreneurship, and regional path dependency in a non-metropolitan region'.

The paper 'Globalization, modes of innovation, and regional knowledge diffusion infrastructure' discusses how science and educational institutions can respond to the challenges

of knowledge base complexity and globalisation. It contributes to the discussion of cluster-building policies, knowledge base complexity (Isaksen & Karlsen, 2010), untraded interdependencies (Storper, 2011), and thus regional innovation systems in a broad sense (Verspagen & Schoenmakers, 2004). The concept of different modes of innovation is used as an analytical framework to gain a better understanding of how firms increasingly transcend the boundaries of regional innovation systems in their search for technology and complementary capabilities, and shows that these companies can only rarely build their knowledge base on science system output alone. The empirical analysis is based on interviews and a survey with managing directors and the R&D executives of 11 firms. The interviews were conducted in two rounds. The first explorative round with interviews of managers covered the largest actors of the electronic cluster and focused on issues from overall competence upgrading to the organisation of specific innovation projects. The second round, based on the interviews from the first round, contained a survey questionnaire distributed to 42-member firms of the Electronic Cluster and Engineering Coast Network. The study found that firms increasingly transcend the boundaries of a region in their search for technology and knowledge, which decouples them from the local knowledge system. The decoupling raises questions concerning the ability of HEIs to support industry-specific knowledge dynamics (different innovation modes) and regional branching processes, as HEI routines and cognitive knowledge capacities are fundamentally different from those of industrial firms. The local environment does play a role, however, as these companies are highly dependent on their internal absorptive capacity and the ability of the immediate surrounding environment to utilise cross-sectorial knowledge opportunities. The study finds that there is potential for new regional development paths at the intersection between STI modes of innovation and DUI, where new combinations of knowledge originate in different industries. These findings suggest the importance of a local knowledge and diffusion ecology consisting of stable and committed infrastructure which operates

independently of inter-firm collaboration. The study shows that this can be provided by regional science and educational system actors. The paper concludes by claiming that HEIs may play a vital role in regional development through the establishment of legitimacy within a broad range of professional communities and the institutionalising of the third-mission functions of HEIs. The development of educational programs thus appears to be critical, because these are the main mechanisms for industry mobilisation. This finding demonstrates that education itself is therefore seen as a key mechanism for building entrepreneurial competence and other third-mission activities of HEIs, which contribute to innovation and regional path development. The paper shows how a region necessitates innovation behaviour that contradicts traditional RIS approaches and contemporary technology push reasoning, which opens up new roles for higher education institutions. These involve the exploration of technological complementarities between the existing knowledge bases of different globally linked sectors as a starting point for regional branching and new roles for the science and education system. The paper contributes with a new understanding of policy- and action-oriented conceptualisations of regional innovation system constructions, in which globalisation and knowledge base complexities are placed at the core. An early version of this paper was presented at the 5th International Seminar on Regional Innovation Policies, 14–15 October 2010, Grimstad, Norway, entitled ‘Science and experience; global and local: Building regional knowledge diffusion infrastructures.

The third paper, ‘Building entrepreneurial discovery processes from university-industry interaction: Challenges and opportunities’ provides new insight into the entrepreneurial system level role of universities and regional entrepreneurial discovery process capabilities. In recent decades, universities have been called into action to provide regions with innovation capabilities. The latest European policy Strategies for Smart Specialisation (RIS3) calls universities into action to identify new areas of opportunity based on the existing knowledge

base of a region. The analysis focuses on the region of Vestfold, which contains an institutionally thick and specialised industry of electronic and microelectronic companies supported by a university college. The author examines in depth the entrepreneurial discovery process of the long involvement of the university college in constructing a regional innovation system. Using a longitudinal case study (2007-2014) with quantitative and qualitative data in the form of semi-structured interviews and document analysis, the paper analyses the mechanisms of the involvement of the university college in regional economic development. The study is based on two rounds of interviews with key informants (the provost, deans, department managers, and academic staff) that were conducted in 2008 and 2013. The total number of interviews conducted was 23. In addition to the interviews, the study draws on notes from meetings, documents and reports. The paper contributes to the discussion of different roles of HEIs in regional innovation systems (Gunasekara, 2006; Uyarra, 2010b; Vallance, 2016) and the entrepreneurial discovery process (Foray, 2014). It contributes with a greater understanding of University College and the region's industrial mobilisation of joint effort to build regional innovation capacities based on an entrepreneurial discovery process that presupposed a regional entrepreneurial system level actor, such as HEIs, to create new path growth. An early version of the paper was presented at the KORFU-Conference (2014), *The Dean in the University of the Future, Learning from and Progress with Each Other*, Universität des Saarlandes, Saarbruecken, Germany, with the title 'The adaption of faculties on regional development'. A reviewed version of the paper was later presented at the *Regional Innovation Policy Conference*, Cardiff, November, 2016 conference with the title 'University-industry adaptation. How do small regional university colleges adapt to new industrial knowledge needs?'

The *purpose* of the fourth paper, 'What do we know about universities' contributions to regional economic development? A conceptual framework' is to review the rapidly growing body of

research within this research area. A second purpose (which is discussed in Chapter 5 of the thesis) is to compare findings from the literature review in light of the findings from the three other papers which discovered gaps in the existing research literature on HEI and regional development. The paper discusses several influential theories and studies to build a coherent knowledge base of the phenomenon concerning universities and regional economic development, and acts as a starting point for new theory development on regional innovation systems. It applies a systematic literature review process (SLR) consisting of a five-stage procedure of the formal and manual delimitation and expansion of 178 selected articles (Pittaway and Cope 2007) combined with statistical descriptive analysis with an in-depth study approach. It demonstrates that the research field is associated with several shortcomings, such as fragmented approaches, a lack of sound theoretical grounding, and method plurality, which have resulted in weak theorising, vague definitions, and imperfect measurement tools. The 193 articles identified in the study are organised into four key categories or dimensions of research areas, and 13 sub-streams of research topics, which are used to identify shortcomings and provide guidance for future research.

1.4 Structure of the thesis

The thesis consists of the following five sections:

The introductory section (Chapter 1) gives the context for the work, presents the research questions, and outlines the outcome of the thesis by briefly describing the content of the research papers and how they are linked internally and to the research questions. Chapter 2 is devoted to the *theoretical framework* used in the research. The methodology section (Chapter 3) presents the research design adopted and the different methodological approaches followed in this research. Chapter 4 presents a summary of research findings from the selected papers.

Finally, Chapter 5 contains the discussion and conclusion section. The major findings and the contribution of the study are summarised and discussed in relation to the practical implications for HEI management, policy making, and theory building for future research. The thesis *papers* are presented in the appendix.

2 Theoretical framework

The purpose of this study is to contribute new knowledge about the way that HEIs build capabilities for innovation and regional path growth, as studied through four separate papers. This chapter provides an account of the theoretical insights guiding the work and develops conceptual arguments asserting that HEI capabilities for innovation in regional economic growth depend on how they interact with, amplify, and correct the ongoing evolutionary process, which is driven and conditioned by the structure of industries and the intrinsic ways that firms search for knowledge. The theoretical insight used in this thesis is based on two main theoretical discussions.

The first theoretical discussion in this thesis involves the new turn in evolutionary economic geography (EEG), focusing on the micro-foundations of firm behaviour as the constituents and drivers of innovation. EEG emphasises the processes and mechanisms that explain regional economic development as a twin process of continuation and change that evolves over time, which is formed by dynamic and irreversible processes that recombine existing and related knowledge into new business opportunities (Boschma & Martin, 2010). Coenen et al. (2016) argued that the policy implication of EEG has mostly been implicit, rather than explicit, as EEG is mainly used as an analytical framework to study regional path dependency and firm behaviour.

The second theoretical discussion concerns the regional innovation system (RIS) literature. The RIS approach interprets structures for regional innovation and development as a function of the systematic interaction between industry and HEIs that continuously reconfigures existing knowledge into new combinations in the local context. The RIS concept has been widely used

as a guiding framework for the design and implementation of regional innovation policies and as a framework for innovation-based policies that address science institutions, such as HEIs, as sources of innovation and knowledge creation (Coenen et al., 2016). The RIS approach, however, has included the micro-behaviour of the firm search process as a starting point for regional economic analysis to a lesser extent. The role of HEIs in regional development based on an EEG framework has largely been neglected in research studies and policy design (Coenen et al., 2016; Vallance, 2016). Thus, while EEG and RISs are highly complementary, they also differ in their conceptual focus on the elementary processes at play in the spatial economy and the way in which they can (or cannot) be influenced.

The chapter is organised in the following way. There is a brief presentation of the evolutionary economic geography framework and then the regional innovation system approach is described, and the role of HEIs in regional development is presented in light of the RIS approach and EEG framework.

2.1 Evolutionary economic geography framework (EEG)

According to Boschma and Martin (2010, p. 6), the basic concern of evolutionary economy geography (EEG) is ‘the processes by which the landscape – the spatial organisation of economic production, circulation, exchange, distribution and consumption – is transformed from within over time’. Boschma and Martin (2010) argued that EEG has renewed interest in how the spatiality of economies emerges from the micro-behaviour of economic agents (individuals, firms, and organisations), leading to economic change, adaptation, and novelty that shapes and reshapes the spatial economy of places through path dependent processes (Martin & Sunley, 2006). The EEG view sees agglomeration economics and path dependency

as constituting an endogenous and dynamic change process whereby the inherited distinct knowledge base of a regional economy can push technology, industry, or the spatial economy in certain directions at the expense of others (Herstad, 2018). Reflecting this, economic transformation proceeds differently in different places, and the mechanisms involved neither originate nor operate evenly across space due to the micro-behaviour of firms, which continually shapes and reshapes the composition of the regional dynamics, collaborative pattern, and distinct knowledge base of a region. Despite increasing numbers of articles and books on path dependency and regional growth (Fagerberg, David, & Verspagen, 2009; Isaksen & Trippel, 2014; Martin, 2012), the problem remains of defining what it is about regional economies that follows path dependent trajectories of development – the region's firms, the industry structure, the knowledge base, or the collaborative pattern of spatial interaction (Boschma & Martin, 2010).

Path development theory distinguishes between three main path developments (Isaksen 2014, Neffke, Henning, and Boschma 2011); path extension, path renewal or diversification, and path creation. Path extension is characterised by incremental product and process innovation in the existing industry, along prevailing technology paths based on an existing regional knowledge base. A lack of inflowing supplementary knowledge might push a regional industry into stagnation or decline. Path renewal or diversification occurs when industry diversifies or branches into related sectors through a mutation process. According to Isaksen et al. (2018), path diversification occurs when existing knowledge in different firms and industries is connected and results in new economic relevant knowledge. Regions characterised as having path renewal are therefore most likely to branch into industries that are technologically related to the existing industries in the regions (Neffke et al., 2011). The last path development, creation, is the most comprehensive means of regional industrial change. Change occurs when

firms and industries are transplanted into a region, or through the commercialisation of knowledge and competence already developed and existing in the region (Tödtling and Trippl 2013). Regardless of the direction of development taken by the region, knowledge and ideas must have some kind of support, such as from HEIs, in the existing or updated regional innovation system in order to initiate new regional industrial path development (Isaksen et al., 2018).

Several authors within the EEG literature have used the concept of different modes of innovation and forms of knowledge to explain the complex, diverse, and interdependent process of knowledge creation occurring at the regional level, and the firm nature of the specific knowledge on which the innovation activity is based (Asheim & Gertler, 2005; Asheim, Boschma, & Cooke, 2011). A knowledge base is explained by the distinction between synthetic, analytic, and symbolic knowledge, which entails different mixes of tacit and codified knowledge (Asheim & Gertler, 2005; Jensen, Johnson, Lorenz, & Lundvall, 2007). Synthetic knowledge refers to the industrial setting in which innovation takes place, mainly through the application or novel combination of existing knowledge. Such knowledge often results from experience gained in the workplace through face-to-face communication in the form of tacit information (Jensen et al., 2007). Synthetic knowledge refers to know-how and is tacit and problem driven. Typically, it is used to design an artefact or solve a practical problem through interactive learning with customers and suppliers. This form of knowledge creation through problem solving relies on informal processes of learning and experience sharing, which are termed the doing, using, and interacting (DUI) mode of innovation. HEI-industry collaboration is relevant in terms of embodying such synthetic knowledge through practical case examples in which teaching is linked to a particular customer problem. However, HEI-industry research collaboration has been found to be more important and frequent in the analytical knowledge

base, in which knowledge creation is based on codified information and science and technology-based innovation (STI mode) processes. To understand codified or written knowledge, it is necessary to have some prior knowledge and competence; for example, scientific text only has meaning to other scientists, which emphasises the question of how codified knowledge becomes embodied in organisations. Typical companies within an analytical knowledge base have their own R&D department, but they rely on the research output of university and science institutions as a source of new knowledge. The third type of knowledge base is symbolic knowledge, which is related to aesthetics, culture, and design and is highly localised, as it is narrowly tied to a deep understanding of habits and norms and 'every day culture' (Asheim et al., 2011; Jensen et al., 2007). All three forms of knowledge bases and innovation modes are more or less assumed to be used and produced to a certain extent in every industry, as knowledge becomes more complex and firms become more embedded in network organised innovation processes, which address the absorptive capacity of firms to utilise different forms and sources of knowledge. Three points are relevant here. First, it is worth noting that firms are becoming more embedded in external knowledge networks rather than relying on their own R&D capacities, which exposes them to a greater variety of knowledge bases and innovation modes that can be utilised. The second point addresses the absorptive capacity of firms for such a variety of knowledge bases and sources that are not necessarily related to their core knowledge base but have the potential to innovate in new areas of opportunity (incremental or radical in form), be it new technologies or new market entrances. The third point concerns the regional capacity (the regional branching mechanism) to exploit and spur on opportunities for new knowledge across industries in a new domain of collective opportunities (e.g. path diversification and creation).

Kogut and Zander (1996) argue that 'what firms do' is to identify, coordinate, and integrate diverse external knowledge inputs, which direct attention to the internal dynamics of firms' absorptive capacities (Cohen & Levinthal, 1990), their boundary-spanning activities of information searching, and the stage of the innovation process at which they are searching for knowledge. Evolutionary theorists have argued that the more diverse the information search process and the diversity of information sources used, the better the effects on the company innovation behaviour (Laursen & Salter, 2004; Nelson & Winter, 1982). According to Cohen and Levinthal (1990), firms can understand, absorb, and implement external knowledge from other firms with very similar knowledge bases, but only when they are related (but not too much) in terms of shared competence, which allows effective communication and understanding to evolve (Nooteboom, 2000). The successful absorption and development of related knowledge is explained by proximity (cognitive, social, institutional, organisational, and geographical) among firms, such that there is interactive learning and knowledge collaboration (Boschma, 2005). This is defined by the existence of prior related knowledge in the firm and partly by the firm's routines for identifying relevant knowledge, the legitimate participants in the organisational learning, and the codes to be used during internal and external communication (Herstad & Sandven, 2017; Nelson & Winter, 1982). New knowledge can also flow into a region through individual firms that are more dependent on international connections than local ones, as the process of interdependency and diversification of labour among firms takes place on an international scale rather than through geographically-bounded search and collaboration (Asheim et al., 2011; Bathelt, Malmberg, & Maskell, 2004; Cooke et al., 1998; Nonaka, 1994; Piore & Sabel, 1984). A growing number of studies are therefore focusing on the local knowledge dynamics that may remain in play under the condition of value chain globalisation and the effect on regional growth and path dependency processes.

The discourse on path dependency and regional growth can be traced back to the seminal work by Marshall (1919) on localisation economies of specialisation, and Jacobs (1969) on the analysis of variety as a driver of economic change (urbanisation economies). These two types of externalities are usually recognised as playing a major role in regional economic development and path dependency. According to the hypotheses of Marshall and Jacobs, diversified regions (urbanisation economies) offer different benefits to diverse knowledge spill overs and networks from specialised regions (localisation economies), which provide access to specialised industrial and knowledge domains. Marshall claimed that industries specialise geographically because proximity favours knowledge flows, reduces transport costs, and increases competence specialisation (Beaudry & Schifffauerova, 2009). Marshallian knowledge externalities affect the ability of firms to innovate and disseminate knowledge by working on similar tasks and hence benefiting from each other's knowledge and resources. Frenken, Van Oort, and Verburg (2007) argued that Marshallian externalities are expected to spur incremental innovation and process innovation, as knowledge spill overs originate from similar firms producing similar products, which lead to the continuation of the regional industry structure and knowledge base (e.g. path extension). Jacobs (1969), by contrast, asserted that it is related variety that drives economic change and growth, because knowledge may spill over between complementary rather than similar industries, as ideas developed by one actor can be applied in other industries. Jacobs's externalities assume that a high degree of relatedness indicates more learning opportunities, more knowledge spill overs across industries, and greater opportunities for recombining knowledge into radical innovation and market opportunities, which in turn spur path diversification and creations by broadening the economic base of the region (Boschma, 2014).

According to Boschma and Frenken (2011), the processes by which new variety (industries) arises from related industries is termed regional branching. Regional branching describes how a regional economy diversifies into new industries through place-specific knowledge transfer mechanisms that connect new industries to existing ones. Taking into consideration the importance of knowledge externalities, the EEG literature emphasises three main regional branching mechanisms of concern: entrepreneurship in the form of spin-offs or by attracting new start-ups, labour mobility, and social networking (Arthur, 1994; Neffke et al., 2011). Spin-offs, or the entrance of new start-ups aiming to commercialise ideas originating in an industry, tend to cluster around their parent company. Another source is science institutions, such as HEIs, which are a means of technology transfer by commercialising academic research in the form of new firm spin-offs (Baltzopoulos & Brostrom, 2013; Drucker, 2016; Steffensen, Rogers, & Speakman, 2000). In their study of the location of start-ups, Calcagnini et al. (2016) found that the prospect of university-industry collaboration is a fruitful driver of innovation and entrepreneurship due to the source of human capital and research quality coming from HEIs. Access to those who produce codified knowledge is seen as an important location factor for companies that are dependent on applying scientific knowledge practically (Asheim, 2007). The issue of access to human capital directs attention to the movement of labour. Regional branching and knowledge diffusion through labour mobility are often regarded as regional phenomena, as firms appear to be more able to absorb, transform, and exploit diverse competences if they are recruited locally (Boschma & Iammarino, 2009; Cohen & Levinthal, 1990), and related economic activities enhance the degree of labour mobility (Eriksson & Lindgren, 2009). Herstad, Sandven, and Ebersberger (2015) argued that recruitment from universities, research institutions, and higher education institutions increases the capacity of firms to generate technical inventions, however, their study pointed out labour mobility between related companies as a more important source of innovation output than academic labour

movement. The latter regional branching mechanism is the social network mechanism, which is considered a major channel for tacit knowledge diffusion and learning among firms. Several research studies from the perspective of industry have shown that the most important sources are often related to less visible engagement, such as network-based collaboration. The social network mechanisms address the third-mission activities of universities, such as (a) innovation, technology and knowledge transfer, (b) continuing lifelong learning and (c) broader social engagement. Such social networking has the capacity to share knowledge and to build a trust-based relationship between regional actors, which in turn can spur new economic opportunities (Audretsch, Leyden, & Link, 2013; Goddard & Chatterton, 2003; Lester & Sotarauta, 2007).

To summarise, the EEG approach views path dependency and regional growth as being closely connected to the regional industry knowledge base and the micro-behaviour of firms searching for knowledge. In accordance with the EEG approach, we can assume that regional development and innovation are determined by path dependent processes following a firm's novel ways of searching for knowledge and the capabilities of the regional knowledge infrastructure to exploit and spur opportunities in order to recombine knowledge across industries into new domains of collective opportunities. The EEG approach raises several questions concerning the responsiveness of HEIs, as part of the regional knowledge infrastructure, to react to the firm's dynamics and different path processes identified in EEG studies. Conversely, however, the EEG literature seems to imply that regional growth and path dependency are likely to emerge as patterns of the micro-behaviour of economic agents, such as firms, and it has not paid much attention to the aggregated level of systematic interaction and collective learning that characterises a regional innovation system. EEG also seems to neglect the role of the science system as a source of path dependency, and the role collective learning and knowledge sharing play in regional economic development. This issue addresses the

governance structure of the regional innovation system which is discussed further in the RIS literature.

2.2 Regional innovation system (RIS) approach

The regional innovation system (RIS) literature (Cooke et al., 1998), which emerged in the mid-to late 1990s, has become one of the dominant conceptual points of reference for policies aiming to strengthen innovation-based regional development and firm searches for knowledge (Doloreux & Parto, 2005). The RIS concept assumes that technology and organisational change are driven by systematic and complex patterns of knowledge diffusion and information feedback across the boundaries of firms and other organisations, such as HEIs, which can be fostered through active policy intervention (Asheim & Isaksen, 1996; Edquist, 2005; Herstad & Sandven, 2017). According to Doloreux and Parto (2005), the RIS literature argues that firm-specific competence and learning processes can lead to regional competitive advantages if they are based on localised capabilities, such as specialised resources, skills and competence, knowledge bases, institutions, and the sharing of a common culture and values. The interactive model implies a sort of collective learning and development process that extends beyond the reach of a single actor, institution, or enterprise, which enhances the systemic character of knowledge collaboration towards a collective network-based innovation process based on the regional industry structure (Cooke et al., 1998). The RIS approach has its origin in two main bodies of theories and research. The first is the system of innovation, which conceptualises innovation as an evolutionary and social process. The innovation system is regarded as a social system, in which innovation is the result of social interaction between economic actors that can be planned and governed (Cooke et al., 1998; Edquist, 2005). The systemic perspective implies that an RIS can be conceptualised in terms of: (a) system components, (b) system connections, and (c) system boundaries. System components refer to different types of organisations

involved in localised knowledge sharing and the institutions guiding their behaviour. System connections refer to the interdependency of the relationship between the components, and system boundaries draw attention to the demarcation, overlap, and relationship with extra-regional actors, networks, and institutions. The second body of RIS studies is based on findings from regional science that emphasise the socio-institutional environment comprising norms, values, trust, and cultures as unique localised competitive assets. From this point of view, innovation is a localised and locally embedded process, not a placeless one.

Reflecting this, RISs can be narrowly and broadly defined (Edquist, 2005). The broad definition considers the wider system of organisations and institutions supporting learning and innovation in a region (Asheim, 1996; Asheim et al., 2011). It emphasises regional development and inter-firm collaboration for knowledge diffusion and interactive learning, which involve close interaction between regional actors, such as government, industry, and academia. The narrow definition sees RISs as consisting of two sub-systems, the knowledge exploration and diffusion sub-system (such as HEIs and research institutions and technology transfer offices) and the knowledge exploitation sub-system (firms), as well as the systematic interaction between them. According to the narrow definition, an RIS exists only if and when the regional production structure (the knowledge exploitation sub-system) and the regional support infrastructure (the knowledge generation sub-system) are systematically engaged in innovation-based interactive learning and knowledge sharing. Conversely, the narrow definition largely emphasises the use of analytical knowledge from the research function of HEIs as a driver of innovation-based development in a more or less linear R&D understanding of knowledge spill overs.

The broad RIS concept stresses an understanding of innovation and competitiveness as a function of firms and other organisations that are systematically engaged in spatial interactive learning through knowledge-sharing networks underpinned by a socio-institutional environment characterised by proximity and embeddedness (Morgan, 2004; Thune, 2007). The emphasis on embeddedness addresses the question of proximity (cognitive, social, institutional, organisational, and geographical), which enables people to meet face to face (e.g. networking) and to share tacit knowledge. Tacit knowledge is a key determinant of spatial proximity, as it is best transferred face to face and is imbued with meaning arising from the social and institutional context in which it is produced (Gertler, 2003; Polanyi, 1966), which is fundamental for learning through interaction (Lundvall, 1992). The argument is that innovation has increasingly become based on the interaction and knowledge flow between economic agents (such as firms, research organisations, and HEIs) and public agencies (science parks, technology transfer centres, development agencies, etc.). This spatial stickiness of knowledge demonstrates the importance of the personal relations and networks ingrained in the local social and cultural context (Granovetter, 1973). The emphasis on the social and cultural context can be related to Storper's (1993) 'untraded interdependencies', taking the form of connections, informal rules, routines, and norms that coordinate actors under conditions of uncertainty (e.g. innovation); these relations constitute region-specific assets or distinctions that reinforce the regional innovation capability and competitiveness in a path dependent manner.

Three types of RISs are described in the RIS literature. These are organisationally thick and diversified RISs, organisationally thick and specialised RISs, and organisationally thin RISs. According to Isaksen and Trippel (2016), organisationally thin RISs have little knowledge and support organisation, and weakly developed network-based cooperation. These RISs are often found in peripheral regions. The inflow of new knowledge through external links or attracting

knowledge organisations is assumed to be important for innovation and regional development. Organisationally thick and diversified RIS is often found in large core and advanced technology regions. These RISs are characterised by a relatively large number of different firms, a heterogeneous industrial structure, and a number of knowledge and supporting organisations. Regions that host strong clusters in one or a few industries only, and knowledge and support organisations, are mostly tailored to supporting their narrow industrial base. The industrial environment of Vestfold, described in this dissertation, is assumed to have similar characteristic as organisationally thick and specialised RISs, as the region hosts an industrial cluster within electronic and microelectronic companies that is supported by a local university college (Vestfold University College). This type of RIS is supposed to have poor conditions for entrepreneurship and more possibilities for the lock-in of existing industrial strongholds which might at worst lead to path extension where the industry becomes stagnated or declines if nothing is done (Grabher, 1993).

The RIS approach has been used to justify the development of specifically targeted policies emphasising the capabilities and performance of local firms, as well as improving local capabilities for knowledge spill overs by promoting greater interaction between different innovative actors that have good reason to interact, such as between firms and HEIs or research institutions (Doloreux & Parto, 2005). Trippel, Sinozic, and Smith (2015) and Nauwelaers and Wintjes (2002) argue that the RIS concept in recent decades has been marked by a narrow technology-oriented policy interpretation, based on a narrow definition of RISs, in which most policies are focused on individual firms in the form of R&D subsidies (STI innovation), rather than selecting policy instruments in relation to the actual problems identified in the innovation system. Uyarra (2008) and Morgan (2004) suggested that the problem with these policy strategies and measurements is the tendency to focus on a static landscape of actors and

institutions rather than one of functions, roles, and relationships, thereby neglecting the diversity and heterogeneity found in the regional knowledge base. There is similar criticism of an innovation policy that focuses on R&D infrastructure and technology transfer based on analytical knowledge, as if these will automatically lead to innovation in regions (Uyarra, 2008). In reality, these narrow technology-oriented R&D-based policies favour regions with a strongly specialised R&D sector or organizationally thick regions (Martin & Simmie, 2008).

As shown above, different RISs have different potentials to impact path dependent processes (e.g. path creation, diversification or extension). Different RISs have different localised capabilities in terms of the presence of regional actors, the composition of internal and external connections for knowledge flow, and characteristics of the regional knowledge base. Conversely, however, different uses of RIS definitions and the new acknowledgement of regional knowledge dynamics have created a plethora of different understandings of the supposed role of RISs in regional development. Herstad and Sandven (2017, p. 13) summarised the debate by defining three main roles of RISs in regional development. The first role is to broaden and strengthen inter-sectorial knowledge diffusion and expand the diversity of knowledge inflow into the region, and secondly to ensure that the localised symbolic and synthetic knowledge bases are enriched by analytical knowledge through more explorative efforts. Finally, their third role is to support internationalisation and the capturing of spill overs from global network nodes and to ensure that they are diffused throughout the local economy. A key question remaining after the debate on the different RISs asks which of the regional actors are in a favourable position to incorporate these roles into their main mission and create new path growth.

2.3 Higher education institutions in the regional innovation system approach

The RIS framework views innovation and growth as a collective interactive learning and knowledge sharing process that involves regional actors, through formal and informal networking-based collaboration, which is supported by an institutional infrastructure that includes formal regulations, legislation, and economic systems as well as informal social norms that stimulate or hamper knowledge flow and innovation cooperation within and between actors in the subsystem. The emergence and relevance of the RIS framework has prompted policy makers to pay more attention to the supposed role(s) of HEIs in regional development.

Uyarra (2010a) differentiated between five characteristic roles that HEIs can take in RISs. These are the ‘knowledge factory’, which emphasises the production of scientific methods and analytical knowledge; the ‘relational university’, which concerns the exchange of knowledge through problem-solving; the ‘systemic university’, focusing on the boundary-spanning role linked to network-based development; the ‘engaged university’, which takes on a broader development role; and finally the role most often cited in the literature, which is related to the commercialisation of knowledge, that is, the ‘entrepreneurial university’ (Clark, 1998, Gibb, Haskins, & Robertson, 2013; Gulbrandsen & Slipersæter, 2007). The commercialisation of knowledge for economic purposes is often linked to the third mission of HEIs’ entrepreneurial function (Clark, 1998). The literature does not provide a unifying definition of the exact characteristics of HEIs’ entrepreneurial role; instead, a plethora of different definitions are used. The entrepreneurial role includes academic activity at academic institutions: patenting, technology licensing, spinning off new ventures, and so on. Some authors argue that an HEI is an organisation with special character (Levin, 2007; Sporn, 1999). Academics are more or less acting on behalf of themselves rather than the organisation they represent. The research findings of Clark (1998) partly supports this view: he recognised that the academics themselves, who

pursue scholarship and funding, differentiate organisational networks as well as ideas and literature, and thereby specialise in their interests and academic commitments. In line with these thoughts, we can assume that the self-interest of an academic pursuing their own interest might hamper HEIs role(s) and affect regional development processes.

Foray (2015) argues that new growth paths can begin with an entrepreneurial discovery process made by an individual entrepreneur, a firm, organisations or a regional leader and so on. The discovery can, for example, include new inventions, new products or services, new knowledge for a region, or an institutional change that allows the system to reorient and renew itself through spill over from one actor to another that can stimulate economic growth and development. In this line of thought, we can assume that new growth paths or path changes are initiated by firm level entrepreneurs, who introduce new activities to a region at the same time as the innovation system is further developed or restructured by system level entrepreneurs, such as HEIs, or other support organisations (Isaksen et al. 2018). According to Isaksen et al. (2018), system level entrepreneurs are able to change the framework conditions or the 'wider' settings that affect industrial development within a specific region and industry. System level entrepreneurs mobilise resources, competences and have the power to create new institutions or transform existing institutions. One of the system level entrepreneurs that can enhance this entrepreneurial discovery process is HEIs. Conversely, although HEIs have a tradition of cooperating and serving society with knowledge, this new entrepreneurial system level role through entrepreneurial discovery is relatively new in nature for HEIs, and thereby challenges their three functions of education, research, and third-mission activities.

As Nilsson (2006) argues, the main role of HEIs is to produce qualified labour for the private and public sectors, which addresses whether the teaching and research function of HEIs stimulates innovation and regional growth. By using the concept of modes of innovation and forms of knowledge, we can assume that regions that are dominated by industry applying STI mode of innovation, such as high-tech dense areas, emphasises the formal scientific processes of R&D to produce analytical knowledge. In order to apply the STI mode of innovation and utilise analytical knowledge, however, it is reasonable to assume that adaptation to contexts is required before it can be transformed into commercial innovation, which indicates that putting scientific knowledge (codified knowledge, i.e. papers, books, patents, licenses, etc.) into use often requires a fundamental understanding of the underlying research principles. In this regard, education may prepare students to work with and understand the underlying premises of the codified scientific knowledge used in different disciplines combined with experience-based learning. Experience-based learning generalises and ‘embodies knowledge’ in people or networks of actors through use of synthetic and symbolic knowledge which is related to direct interaction that emphasise the broad development role of HEIs and industry interaction. We can therefore assume that HEIs, through their main functions of education, research and third-mission activities, can mobilise industry to jointly engage in new interactive learning and knowledge-sharing work forms.

2.4 Conceptual framework and identified theoretical gaps

As highlighted in the theoretical framework, and summarised in Figure 2 and Table 2, research into HEI contributions to regional innovation and growth from an EEG and RIS perspective has taken some major steps forward in providing knowledge about how a spatial economy emerges and changes. Based on the above elaboration of the EEG and RIS framework, we expect that thick and specialised RISs, such as the Vestfold region, generally have less variation in

innovative firms who can diffuse knowledge to other actors. This demonstrates the ability of the system level entrepreneur (such as Vestfold University College) to change the wider setting of the knowledge base and transform existing institutions. This thesis proposes that HEIs, as system level entrepreneurs, contribute to innovation and regional development in four ideal ways (Figure 2), with each calling for stronger awareness of the entrepreneurial discovery process. One type of contribution is to stimulate path creation through creating new industries based on analytical knowledge and the STI-mode of innovation, where academic knowledge is commercialised through academic spin-off (academic entrepreneurship). This type of approach entails that HEIs have excellent research and commercial competence, which can lead to new firm formation within new but related sectors of the regional economy. Another contribution is to attract external investment, new knowledge resources, and companies to the region by adapting its educational and research function towards industry needs. This type of contribution presumes that HEIs undertake high quality education and research, and that they benefit from being part of a wider knowledge network from which knowledge can be disseminated to the regional industry base. The third form of HEI contribution is to stimulate the path diversification of the existing industry in relation to the new industrial sectors. Within this type of regional diversification, HEIs can act as an entrepreneurial system level actor by enhancing the entrepreneurial discovery process that bridges disconnected actors and diffuses knowledge into related industry sectors that cannot be handled by a single firm alone. The last contribution is related to a situation where the regional industry is more or less characterised by incremental innovation in existing industries along prevailing technology paths. HEIs can upgrade the existing industry through research collaboration and by upgrading its educational program. When regional path development is characterised as path extension, it is expected that HEIs contribute with problem-solving competence, carrying out contract research and consultancy, and developing industry relevant degrees.

The investigation of the path dependent processes of the region of Vestfold and the University College interaction with industry explores the relevance and usefulness of the conceptual framework developed in Figure 2. The understanding of regional development dynamics and HEIs in such conditions clearly requires further research.

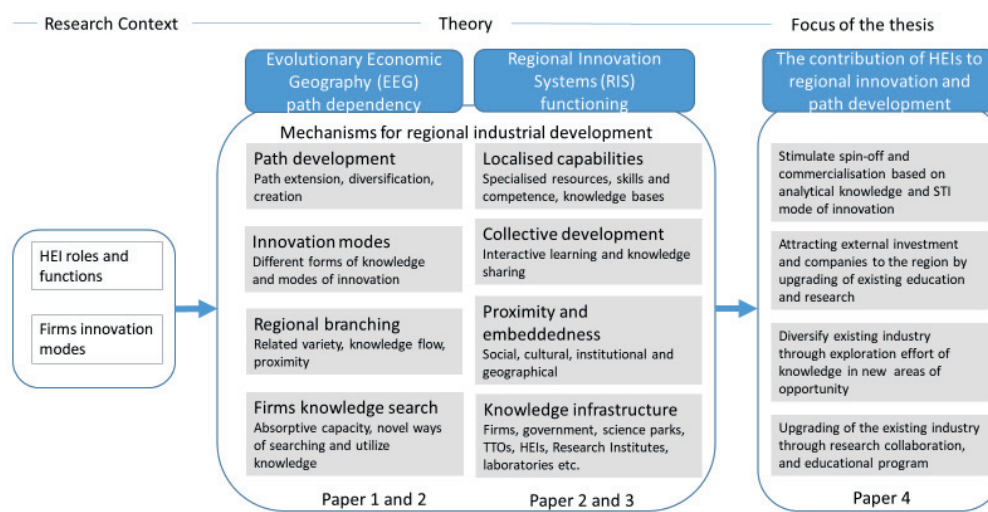


Figure 2. Conceptual framework positioning the dissertation, its theoretical foundations, and focus of the thesis.

Research questions	Paper	Level of analysis	Literature/theory	Gaps
1. How can regional science and knowledge institutions interact with and influence the evolutionary processes at play in the economy?	Entrepreneurship and path dependency in regional development. Paper 1 Globalisation, modes of innovation, and regional knowledge diffusion infrastructure. Paper 2	System level, RIS construct Firm knowledge dynamics	Evolutionary economic geography, path dependency, regional branching, related variety Regional innovation system, knowledge bases, innovation modes, untraded interdependencies, knowledge diffusion infrastructure	EEG studies have to a lesser extent analysed policy intervention and the role of science systems in path dependent evolutionary processes The conceptualisation of RIS construction has to a lesser extent placed globalisation and firm knowledge complexities at the core of firm-HEI interaction analyses
2. What types of mechanisms transform university capabilities for innovation and growth?	Building entrepreneurial discovery process from university-industry interaction. Challenges and opportunity. Paper 3	Higher education institutions	Regional innovation system, university change, innovation policy, knowledge bases, related variety, and untraded interdependencies	Firm knowledge dynamics exert an impact on the organisational capabilities of HEIs for innovation and regional growth that have been explored to a lesser extent in the HEI and RIS literature
3. How has prior research addressed the question of HEI contributions to regional economic development and what do we know from this research?	What do we know about universities' contribution to regional economic development? A conceptual framework Paper 4	Literature review	University change, regional innovation system, research policy, knowledge diffusion infrastructure	The literature on university change has focused to a lesser extent on firm knowledge dynamics as a driver of organisational changes. The literature is characterised by shortcomings, weak definitions, and imperfect measurement tools

Table 2. Theoretical gaps addressed in the thesis

3 Research methodology and research design

The present research work is a longitudinal in-depth intensive case study (Sayer, 2000) of the transformation process of Vestfold University College between 1994 and 2016. Vestfold University College and the regional business life were selected because the region has participated in several national innovation policy and regional development programs since the 1990s. These policies, in different ways, were designed to increase firm innovation competitiveness and regional growth by strengthening the relationship between industry and the higher educational system. As a regional embedded University College, Vestfold University College was targeted to take a more active role in supporting companies with new knowledge. The idea of this study originated in 2006, inspired by the experience that ‘something’ is changing in the relationship between Vestfold University College, regional business life, and government policy support for constructing regional innovation systems, which triggered the curiosity about the mechanisms responsible for the transformation of HEIs and the regional innovation system.

The definition and understanding of structural changes, what causes events and regularities that occur have received considerable attention and have been debated in social science or the philosophy of science in recent decades (Archer, 1998, Hedström & Ylikoski, 2010). Driven by theoretical considerations, two methodological objectives were initially important for this doctoral research; identifying industry-HEI interactions (events) and the mechanisms that cause events that create certain outcomes (structural change). The first objective was to identify the entities and events of interaction between the industry and HEIs. The second objective was to identify mechanisms causing events. The aim was to uncover and describe the mechanisms that produce observed events and specific outcomes. Events or outcomes are defined by Easton

(2010) as the external and visible behaviours of people, systems and things as they occur, or as they have happened. Events arise from the working of mechanisms derived from the structure of objects. Events are not predetermined, but depend on contingent conditions, implying an open future – things could proceed in many different ways. Sometimes changes occur quickly, sometimes slowly; in some cases, the change is reflected in institutional and organisational changes, sometimes in the form of direct and or non-observable changes.

Instead of aiming to generalise at the level of events, an explorative research design is thus used to create a theoretical description of mechanisms and structures in order to hypothesise how the observed events can be explained. Such an explorative research design will take a critical realism perspective (Archer, 1998; Bhaskar, 1998; Sayer, 2000) by applying an intensive case study approach to systematically analyse, describe and explore in order to better understand the interplay between events, mechanisms and structure. It is methodologically challenging to study the transformation processes of HEIs and regions from a critical realism approach, since the phenomenon under study is embedded in a long-term and complexed development processes and the individuals (organisations or people) are not necessarily conscious of what is going on.

3.1 Scientific positioning: Critical realism

All research is based on basic assumptions about what we study and how it can be studied. A discussion of such assumptions is important, especially when we research social phenomena. Questions of ontology and epistemology are central to the philosophy of science. Ontology is the study of the form and nature of reality and addresses questions of what entities exist and how they are related to each other in hierarchies (Denzin & Lincoln, 2005). A major ontological discourse in the social sciences involves whether an independent “real” world exists without

human intervention (Guba & Lincoln, 1994). Epistemology involves the theory of knowledge, and refers to how knowledge is created (context of discovery) and relates to truth and beliefs (context of justification).

The research described in this thesis adopts a worldview corresponding to critical realism, which is a distinct version of the realist philosophy (Easton, 2010; Sayer, 2000). The critical realism ontology assumes that a world (reality) exists independent of our knowledge of it. Reality is whatever exists, be it natural or social, and has certain structures, causal powers, and tendencies which are unobservable. Reality contains objects with structures and mechanisms that provide very different causal potentials and tendencies. These causal potentials may or may not materialise in actual events and phenomena, depending on the interaction with other conditions and mechanisms. Following from these assumptions, events and phenomena are the result of contingent combinations of many underlying structures and mechanisms. Reality is an open system and causalities can only be understood as tendencies; empirical regularities are therefore rare and closed systems can generally only be created artificially (Bhaskar, 1998). This is what Bhaskar (1998) defines as the intransitive object of knowledge. Critical realism is epistemological relativist or methodological pluralism that endorses a variety of methods (Sayer, 2000). Science is a human activity occurring in social contexts (Sayer, 2000). New knowledge is a social outcome that extends and transforms existing knowledge, which means that knowledge is never certain, absolute or definitive. Knowledge can always be replaced or extended with new knowledge (Sayer, 2000).

Critical realism aims to understand and explain the underlying mechanisms that cause the events that may be observed (Easton 2010). It distinguishes between two dimensions. The first

dimension is the distinction between what we can experience and describe, and the hidden mechanisms behind them. The second is that reality is assumed to consist of hierarchically ordered levels (e.g. real, actual, and empirical) where a lower level creates the condition for, but does not determine, the higher level. The distinction between the levels lies not in the entities, but in the generative mechanisms that operate at each level. These levels and their causes form an open, interactive world of events and contingent tendencies, which, according to critical realism, constitute the proper object of scientific investigation. In this sense, critical realism claims that mechanisms are contextually dependent on other mechanisms. Thus, a mechanism may produce an outcome in one context, and another in a different context, because in each layer of mechanism something qualitatively new emerges. This contingent causality is inherent in all open system, and warns us that we can use mechanisms to explain phenomena, but not to predict them. For example, when HEIs and industry interact, it may lead to new innovations (be it products, services or processes), or it can lead to new ways of collaboration. It can also lead to new institutional logic about how the world exists and works. The necessary context might be that academic staff and employees are willing to learn and share knowledge, and that a regional knowledge base and competence are sufficiently related so that knowledge can be easily transferred from one actor to another.

Mechanisms are described as “the ways of acting of (structured) things” that possess the causal power, which when triggered or realised, act as a generative mechanism to determine the actual phenomenon of the world (Easton, 2010; Sayer, 2000). Easton (2010:122) suggests that the best “way of regarding mechanisms is that they are ways in which structured entities (internally related objects or practices) by means of their powers and liabilities act and cause particular events”. Critical realism separates the transitive and intransitive dimensions of reality (Bhaskar, 1998). The intransitive dimension is the subject of scientific knowledge: the causal forces and

the generative mechanisms that exist whether we have knowledge of them or not. The transitive dimension is our beliefs about what exists. Theories are part of the transitive dimension. They are flawed - they can always be surpassed by new theories. As an example, Figure 3 describes the relationship between the real, the actual, and the empirical within a regional innovation system approach. A regional economy has a certain structure and causal power, which in this study are the regional industry knowledge base, firm routines, and knowledge base, which give the system its capacities (through mechanisms such as knowledge diffusion, social networking, labour mobility, and entrepreneurship) to behave in a particular way and be affected by certain kinds of changes (conditional mechanisms such as national innovation policies, the role of HEIs in regional economic development, and market or technology changes). The actual refers to what happens if and when those powers are activated, what they do, and what eventuates when they do (effects) in terms of path dependency and regional branching. The phenomenon and events in the actual domain, therefore, are always a complex result of the combined effect of many mechanisms and conditions, regardless of whether they are experienced by us or not. The empirical is defined as the domain of experience and observations with respect to either the real or the actual, however, it is not contingent on whether the researcher knows the real or the actual, that is, path dependency in terms of path extension, path renewal, or new path creation.

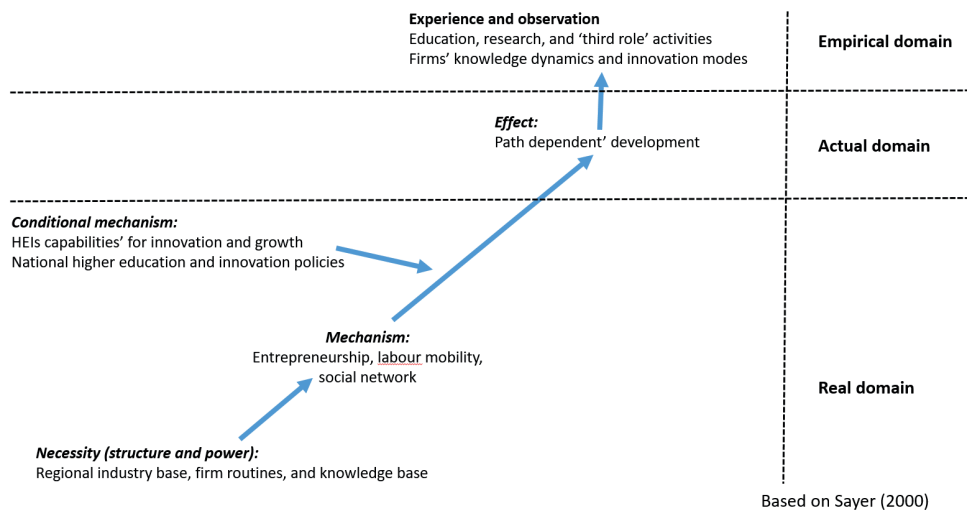


Figure 3. Relationship between the real, the actual, and the empirical in the thesis

A crucial implication of the critical realism ontology is recognition of the possibility that powers may exist unexercised, as what has happened or is known to have happened does not exhaust what could happen or could have happened. According to the critical realist approach, causation is not understood using the model of regular successions of events (Easton, 2010). According to Sayer (2000, p. 14), what causes something to happen has nothing to do with the number of times the researcher has observed it happening. The explanation depends instead on identifying the causal mechanisms and how they work, and discovering whether they have been activated, and under what conditions. Regional innovation systems or organisations such as HEIs, are not ‘closed systems’; they are open systems in which the same causal power can produce different outcomes according to the geo-historical context, regional knowledge dynamics, organisational capabilities, path dependency, or spatial-temporal relationships to other entities. It follows from critical realism that mechanisms and structures in the real domain are assumed be stratified. They are hierarchical structured where higher levels presuppose lower levels of reality. Social

reality would be placed at the top of such a hierarchy as it assumes a physical world. Furthermore, the combination of mechanisms on lower levels creates mechanisms on higher levels that have unique causal potentials not achievable by the mechanisms on the lower levels. As an example, the theory of regional innovation system might explain economic development through interaction between actors within a boundary of a region, but says nothing about when such interaction will take place, how actors will learn and share knowledge, or the extent to which the regional innovation system will create economic development.

The research implications of the above discussion on research design and methods will be presented in the next section.

3.2 Research design and methods

Depending on the ontological position of the researcher, different research designs and research methods are selected to address proposed research questions. The methods that are used as part of the research design are more specific and may be defined as techniques for data collection and analysis. Sayer (2000) and Yeung (1997) argue that the selection of the research design should be determined by the selected research topic, the context, the purposes, and the circumstances of the research, rather than from the methodological or philosophical divide, which often involves the appraisal of the qualitative-quantitative distinction in research (Guba & Lincoln, 1994; Maxwell, 2005; Tashakkori & Teddlie, 2010). It is evident that critical realism does not commit to a single type of research but rather endorses an extensive variety of research methods that are chosen according to the type of project and the aims of the study, which in this dissertation research involve identifying mechanisms that create change or cause events to happen within the boundary of a region.

Sayer (2000) differentiated between intensive and extensive research designs. An intensive research design emphasises how a process works in a particular case and asks questions about what produces changes and how the actors react to the changes. The focus is not necessarily on representative or regulatory events but on certain objects or events. The typical method is to study individual agents in their causal context using a theoretically informed case study that applies qualitative analysis, ethnography, and mixed methods. An extensive research approach emphasises regularities, common patterns, and the representativeness of the phenomenon studied based on representative generalisations. Typical methods include large-scale surveys of the population or representative samples in which the data is collected using quantitative methods, such as formal questionnaires, standardised interviews, and statistical analysis. The method used in this dissertation is an intensive theoretical informed case study using a mixed-method approach, designed to obtain a deep understanding of the processes, context, and causal mechanisms of complex situations (Miles & Huberman, 1994). According to Easton (2010), the term ‘case study’ does not have unified definitions or consensus in the literature, it is best understood as an ideal design type. The selection of case(s) is a critical step in order to obtain theoretical sampling with the objective of selecting cases that are particularly relevant and suitable for generating theoretical insights (Eisenhardt, 1989). Accordingly, I decided to conduct an intensive case study based on the ‘VRI-Vestfold’ and the ‘Different modes of innovation’ projects which both provided me with ample opportunities for sampling primary data within the boundary of the project and to undertake data analysis within a larger research community. Conducting case studies within larger research studies (e.g. VRI and ‘Different modes’) has been found useful in terms of giving rich data and a longer anticipated research horizon (Maxwell 2005). Being part of a larger research community gave me the opportunity to test and validate my assumptions, analysis, findings, and theory development. The two research projects mentioned are theoretically informed studies. The VRI-Vestfold project is

based on the regional innovation system approach discourse (Asheim & Gertler, 2005; Cooke, Heidenreich, & Braczyk, 2004). The “*Different modes of innovation and challenges for stimulating university–industry cooperation*” project builds on theoretical contributions from evolutionary economic geography that emphasise theories of related variety (Boschma & Iammarino, 2009), and forms of knowledge (Jensen, et al., 2007) as starting point for exploration of the foundation for regional development.

The mixed-method or triangulation research design typically combines the use of qualitative and quantitative data in a single case study or series of studies (Creswell & Plano Clark, 2007; Yin, 1981). Its central premise is that the combined use of quantitative and qualitative approaches (triangulation) provides a better understanding of research problems than either approach alone. The strength of the approach is, of course, that, by using qualitative and quantitative methods, a broader picture of the result will be achieved, encompassing a multidisciplinary view of a problem. There is great variability between mixed method designs. In this thesis, I have followed the variance of the procedure called explorative design for embedded data (Creswell & Plano Clark, 2007). It is commonly used when the purpose is to develop a taxonomy or classification system, or develop an emergent theory using embedded quantitative and qualitative data at the design phase where the intention is to make interpretation from both types of data (Creswell & Plano Clark, 2007). In particular, the paper ‘Globalization, modes of innovation and regional knowledge diffusion infrastructure’, applies a mixed-method approach by combining statistical information obtained through quantitative survey questionnaires and in-depth interviews with selected informants that created a greater understanding of the role played by the university in knowledge complexities and globalisation. Paper 4, ‘University change and regional economic development: A state-of-the-science review, prospective commentary, and guiding framework. What do we know about universities’

contribution to regional economic development?', uses an explorative design for embedded data by combining a systematic literature review of an extensive amount of literature with an intensive selection process aimed to build a state of the art of sound knowledge base. Paper 1, 'Entrepreneurship and path dependency in regional development', and Paper 3, 'Building entrepreneurial discovery process capabilities from university–industry interaction. Challenges and opportunity', apply a weak interventionist approach by questioning and holding dialogues with the selected informants and the research teams involved in the two research projects (VRI and 'Different modes of innovation'). The purpose was to provide a detailed, in-depth description in order to make to lead to theoretical contribution about the research phenomenon by using in-depth studies, interviews, notes, and document analysis in combination with literature studies.

Data collection was performed sequentially in phases in this dissertation, starting by collecting qualitative data (text) and analysing data that informed quantitative data collection (survey in Paper 2 and literature review in Paper 4). Priority was given to the qualitative data, where most time and effort was spent in collection and analyses. Qualitative and quantitative data were connected during the phases of research in Papers 2 and 4. Papers 1 and 3 are mostly based on qualitative data, which inspired the analysis in Paper 4 that applied quantitative and qualitative data collection. The rationale for this approach is that qualitative data and its subsequent analysis provides an in-depth understanding of the participant views, mechanisms at work and the causes of events.

This cover essay outlines the interpretation of the entire analysis (presented in the four research papers). The dissertation cover essay presents findings from the four papers. These papers are

not developed in a chronological way by first doing a literature review identifying research gaps which then become research questions to be answered by following research papers. As depicted in Table 1. and Figure 1, Papers 1, 2 and 3 need to be read in terms of being ‘standalones’ which provide theoretical and empirical insight for Paper 4. Paper 4 is a critical analysis of how the existing literature has studied HEI industry interaction within a regional economic development approach. By reading critically, Paper 4 makes it possible to identify gaps or missing issues in the existing research literature using an intransitive approach (Sayer, 2000). I find this structure appropriate in accordance with a critical realism approach where the first three papers act as a contribution to the transitive dimension of our knowledge of the world, and where Paper 4 contributes to intransitive knowledge (Bhaskar, 1998). The advantages of starting with the use of theory driven case study research (Papers 1, 2 and 3) is more obvious when Paper 4 is read critically in contrast to findings (theoretical and empirical findings) from Papers 1, 2 and 3. The critical approach to existing literature made me more aware of missing issues or gaps in the literature discussions. For example, the large amount of literature does not properly handle the micro-behaviour of firms and their complex knowledge search as a key mechanism for regional development.

3.3 Research implications for data collection and analysis

The empirical data for this thesis was collected as part of the ‘VRI Vestfold research and development project’ (2006-2010) and the ‘Different modes of innovation research project’ (2009-2011). I was personally responsible for collecting and analysing data on all four papers. However, the first author in paper 2, Herstad, conducted the quantitative empirical analysis and had the lead role in drafting and revising the paper. In total, 44 interviews were held between 2006 and 2014 in three rounds (2006, 2010 and 2014). Twenty-one of these interviews represented company managers or project managers, and 23 interviews were with academic

staff, project managers and the top management of the university college (deans and provosts). The informants, both academic and company CEOs, were selected based on their experience with HEI-industry interaction. The interviews took place at the informant's workplaces. The interviews lasted for about one to one and half hours, dependent on how much the informants talked. The thesis also analysed a large number of reports, documents, notes, websites, e-mail correspondence, informal conversations and observations. As a member of the VRI Vestfold research group, I also participated in project meetings and workshops. In total, there was data from 35 project meetings, 18 steering community meetings, and 4 workshops. In addition to this qualitative data, a survey analysis was applied in Paper 1 with 29 respondents representing local companies. In Paper 4, 178 articles were analysed using quantitative and qualitative analysis method. All interviews were conducted under an agreement of confidentiality, and the interviewee names were omitted from the papers. In order to ensure the reliability of the data, all interviewees received interview transcript as a quality check, which often lead to further comments and a deepening of the topic.

By working in the intersection between Vestfold University College and the regional industry I had access to a rich and unique set of data. Some of this data cannot be decomposed into a singular unit of data. Instead this data emerged through a back and forwards process between the intransitive and transitive dimension of knowledge (Bhaskar. 1998). In accordance with a critical realist approach (e.g. epistemology pluralism), I have applied abductive reasoning during the research process by observing events in the empirical domain which were further investigated by the theoretical informed studies of the VRI-Vestfold and 'Different modes of innovation' projects. It is important to note, however that abduction does not move directly from empirical observations to theoretical inferences, but relies on theories as mediators for deriving explanations. The analytical process can be divided into four main phases; the

description or appreciation of the research situations, hypothesis of mechanisms at work, elimination of alternative explanation, and a phase of action where research findings are satisfactory for an “intended audience” with background knowledge and expert (Figure 4.). The phase of description and appreciation of the research situation guided my focus on the identification of the events and phenomena to be studied. This observation of events became the focus for a reductive analysis of data, which involved the phase of hypothesis about the relationship between University College and regional industry. As an example, during the research process an observation was made which challenged the existing RIS theory of intentional collaboration between regional actors, which called for alternative explanation. Several informants expressed reluctance to collaborate with the university college while at the same time they also appreciated the university college’s efforts to collaborate with them. This type of duality in reasoning became the object of further reflection. Cycles of reflection between academic literature, data, and propositions, with an effort to achieve analytical stability, directed my research in three theoretical discourses, which became analytical coding templates during the research process; regional path dependency, firm behaviour of knowledge search, and HEI roles in regional development. The phase of action is further explained in the section of threats to validity.

Applying abductive reasoning also provides many challenges. One of the challenges is to create concept clarity and a homogenous research context. For concept clarity, I have bounded the research from the Vestfold University College and its systematic interaction (repeating interaction over a long time period) with the regional industry. In particular the regional innovation system that the university college is a part of, which is characterised as a “organisationally thick and specialised RIS”, includes industrial clusters such as the Electronic Coast Network (EC-Network). The EC-Network was a natural starting point and a boundary

object, as this industry cluster has a long history in the region (established in the early years of the 1980s) with companies located in the regions since the second world war. A new industry network, identified through the VRI-project, was also included in the analysis. This new network of engineering companies (later established as the Engineering Industry Network) represented large companies operating within oil and gas (Paper 2). Including this new industry network made it possible to cross-check hypothesis, findings and theory development.

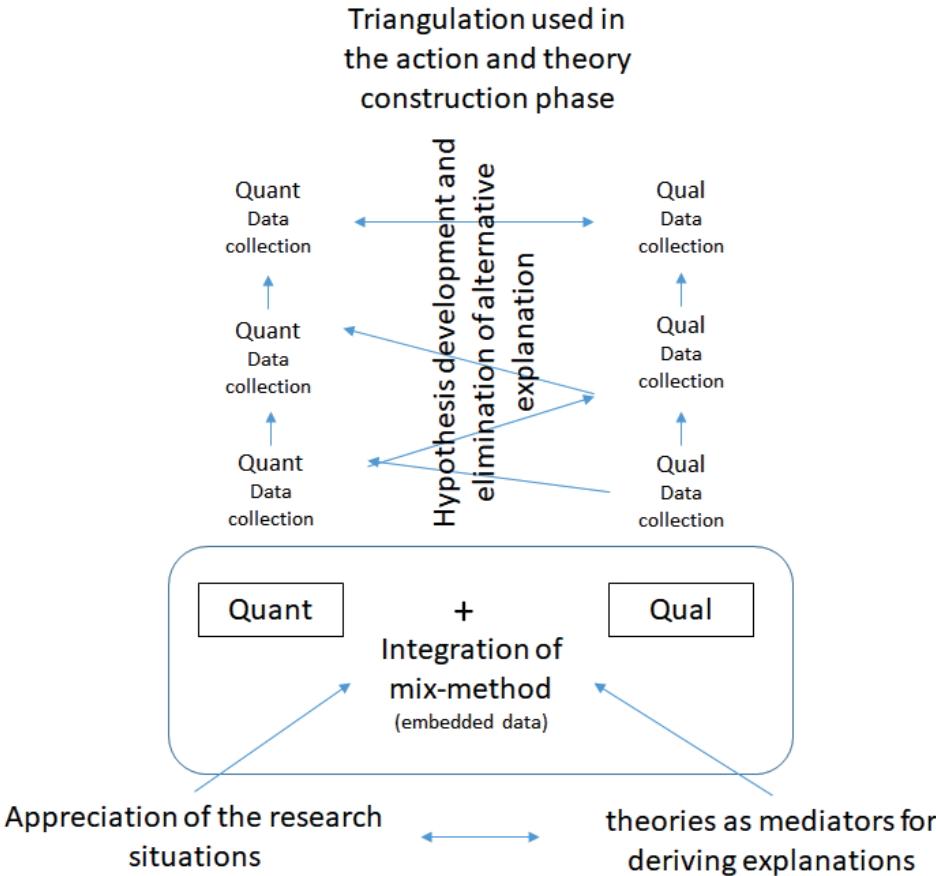


Figure 4 Description of the thesis mix-method design process

The data sources used in this dissertation provide rich details of various facets of HEI interaction with industry within the boundary of a region. In order to handle the rich amount of data it was necessary to codify information into more structured formats. Each of the presented papers includes a coding template which purpose was to capture relevant variables. It was essential to follow the development of the University College interaction with its surrounding industry network (in particular the EC-Network and Engineering Industry Network) and check variables included in the literature (such as path dependency, innovation and forms of knowledge, and HEI roles in regional development) with other structured sources (such as reports, notes, correspondence that describe events) in order to cross-check data reliability. The rich amount of qualitative data was analysed using the analytical software tool of QSR NVIVO in order to organise data by coding procedures (Sorensen, 2008). As an example, Paper 4 (the review article) used a systematic literature review (SLR) process that identified four key categories and thirteen subthemes. In addition to the analytical software tool, semi-structured interview guides were used to operationalise theoretical concepts as basis for coding templates. In Paper 1, the questions addressed issues such as the firms' history, core competences and skills, use of knowledge, search for new knowledge both internal and external to the region, their means of organising innovation and learning processes, use of external actors and resources, and entrepreneurial activities. The analysis included various reports and statistical sources to complement and cross-check the information obtained from the interviews and observations. These issues were further investigated using coding templates, into which information obtained from the interviews (citations) was grouped. In Paper 3, a purposeful sampling procedure was used to collect and organise data, where it was compared across informants over time. The informants from the university college, which all had some previous experience collaborating with the industry, were interviewed in two rounds (2007 and 2014). The semi-structured questionnaire focused on issues such as their experience with regional

development, industry interaction and the effect such interaction has on the university college different functions (e.g. teaching, research and third role mission). The information was cross-checked with reports, statistics and other formal sources such as governmental policies and relevant research studies focusing on the subject. This process resulted in an evolving and increasingly focused sample, until the analysis reached theoretical saturation. In Paper 2, based on a qualitative semi-structured survey, a set of indicators was developed and tested using a quantitative survey in order to describe the competence of companies when upgrading mechanisms by means of DUI and STI modes of innovation. The surveys identified DUI informal competence in upgrading mechanisms such as the importance of daily work, teamwork, and customer and supplier interaction, independently of innovation collaboration. The STI indicator included formal mechanisms such as internal R&D and interaction with universities and research institutes. The indicators (DUI and STI) were grouped into a measurement scale ranging from 4 (not used/relevant) to 1 (highly important) which was further investigated through reliability scores, descriptive statistics and reliability checks (Cronbach's alpha). Using the input variable and analysis we found that the companies were grouped into distinct competence upgrading mechanisms, such as STI and DUI companies, in addition to a group of companies which score highly on both indicators. These findings were further cross-checked and discussed as regards the qualitative survey findings from the firms.

As argued above, this thesis research approach applies a critical realist ontology to understand how the layers of mechanisms affect events and changes over time. Applying a realist approach made it possible to identify mechanisms by taking a critical position on the existing literature and what goes on at the regional level that create changes, however, I have also encountered challenges associated with practical problems concerning the objectivism of the interpretation of data. In particular in Paper 3, I combined a more interventionist and action-oriented approach

(Greenwood and Levin, 1998) by being a reflective and active member in some of the projects that involved interaction between Vestfold University College and regional business life. I recruited participants to network teams, participated in discussions at project meetings and initiated network activities. I had also previously worked as a community business manager at Horten Municipality (2000-2004), which gave me access to company managers and other regional actors. I think that combining a critical realist philosophy with an interventionist action-oriented approach definitely helped me to understand the interplay between layers of structures, mechanisms and events. Consequently, the large amount of data collected also offered several challenges concerning threats to the validity of my research, which I will discuss in the next chapter.

3.4 Threats to validity

Meeting threats to validity and reliability is seen as part of the research design and our aim is to answer the question of why we should believe the results and findings in a study such this (Maxwell, 2005). From the discussion above, it should be apparent that critical realism does not commit to a single type of research but rather endorses a variety of quantitative and qualitative research methods. This methodological pluralism is grounded in the ontological and epistemological assumptions of critical realism (Danermark, Ekström, Jakobsen, & Karlsson, 2002). There are several different interpretations of the term ‘validity’ in qualitative and quantitative research, which have created many different interpretations (Tashakkori & Teddlie, 2010). In order to avoid any confusion due to the variability between the connotations of the use of the term, I have followed the definition developed by Venkatesh, Brown, and Bala (2013: 35) for inference quality: inference quality in mix-method is defined as “a researcher’s construction of the relationships among people, events, and variables as well as his or her construction of respondents’ perceptions, behaviour, and feelings and how these relate to each

other in coherent and systematic manner". In other words, it includes various types of validities that are related to interpretation and conclusions from the use of methods designed to identify underlying causal mechanisms and not necessary "reflect" or "correspond" to reality. A validity discussion of concept, theories and claims is about whether these claims "work" in the regional environment and their relationship to a reality independent of our constructions of them which not only include supporting evidence but also alternative descriptions, explanations, or interpretations of the phenomenon about which the claim is made. From my point of view this means that validity is about the variance or diversity of relationships between the claim, and the phenomena that the claim is about. The aim of this chapter is to clarify the threat to the validity of the research process and what action I have taken to meet these threats.

The strategies that Maxwell (2005) suggests for meeting the threats to validity consists of eight items: intensive, long term involvement, "rich" data, respondent validation, intervention, search for discrepant evidence and negative cases, triangulation, quasistatistics and comparison. I will discuss these items in the following sections.

This study is an intensive case study in which I have had a long-term involvement in the context of this research. The main object of the methodological approach from a critical realism position is to regard the research process as a creative process that connects intervention and research in a back and forward process that goes through different phases of activities (Bhaskar, 1998). The acknowledgement of situatedness plays a key role and serves as an important resource that encourages the researcher to regard all data as situated in a point of view. The intention is to help the researcher to consider gaps in the corpus of data that needs to be collected in order for them to be systematic. It also involves considering extant theoretical schemes and how these

can help to shape the existing description of the phenomena. The initial starting point for this research study was the researcher's acknowledgement of that 'something' was changing'. Why changes happened and what causal mechanisms are at work in such complex and dynamic contexts (interaction at the regional level) demanded an explorative research process where I as a researcher needed to regard all data as important. I have spent a considerable amount of time in the interaction activities between the university colleges, the industry business life and regional actors in many years. The construction of my knowledge about that 'something that is going on' began as small hunches or sensemaking processes when I was working as business municipality advisor. I observed and even initiated talks and activities aimed to bring the industry and the university college into closer collaboration. This is not to say that I had a well-worked-out set of hypotheses to be tested, and I had no data-gathering instruments purposely designed to test relevant hypotheses. This pre-state of the study gave me access to informants from the object of study (organisations and their interaction) and legitimacy to do the study within the complex and dynamic environment of new and old organisations. I have been on both sides of the table (as publically employed and engaged within some of the interaction projects, and as a researcher) the latter of which, I believe, gave me legitimacy for doing this research study. This gave access to rich data, and to different kinds of data, that could help to develop premature theory (Maxwell, 2005).

I made several observations of different settings, participated in conversations and meetings, collected data through interviews and surveys, and undertook document analysis theory exploration, which ultimately provided me with rich data. This data and my findings have been presented to the informants during the study, and this means that I entered a respondent-validation-like situation. The nature of the response from the informants has been described in the three papers (Paper 1, 2 and 3), however, time limits do not permit a direct incorporation

into the dissertation cover essay, but this can be done in the future and will increase the validity of the findings.

Intervention was used in this study in terms of involving participants in reflecting and learning from previous and ongoing activities with the objectives to increase and strengthen interaction between HEI and industry. In particular the research design of the VRI-project was based on an action-oriented approach where industry and HEI, through joint collaboration, initiated and implemented several tools which aimed to increase HEI industry interaction and knowledge flow between the actors. It is a mild form of intervention where reflection and learning were key tools for improvement and where there was also access to discrepant evidence and negative cases during the study, as a source of reporting contradictory findings. As described, by using a mixed method triangulation of data I have reduced the risk of systematic bias due to a specific method which also leads to comparison (Maxwell, 2012; Venkatesh et al., 2013).

Comparison was undertaken by studying several entities of interaction between HEI and industry, which provided rich data. Since the study takes place under condition of radical changes (organisational changes and economic down and up turns) within a dynamic and complex environment, it was natural for the informants to compare the situation now to the situation before, which is a comparison that has become important in this study.

During the study, I continuously searched for data that could possibly contradict the preliminary findings, and discussed the same findings with my key informants and research fellows. We all have our biases and I have tried to be conscious of them and reflect on them along the way. The researcher's role in research is pronounced and visible, and therefore the bias and the conduct

of the researcher are of importance to the whole research process, and to the outcome. The advice of Miles and Huberman (1994) regarding this issue is to ensure openness about biases and the researcher's possible influence on the study by describing processes in detail, and for the researcher to be aware of these challenges. I have provided a detailed description of the procedures in this study and I have included reflection on my own role as a researcher and how this has influenced the context in different situations. I have confronted my perceptions and interpretations in order to make sense of the data by following standard and accepted procedures for data analysis and by presenting research findings in international conferences (Eisenhardt 1989, Levin 2012).

3.5 Science ethics

Science ethics is the ethical regulation of scientific work and the use of scientific results. Every stage of the research process may involve ethical consideration. Following an intensive critical realism approach using qualitative and quantitative data may lead to a situation in which the rights and welfare of the participants can be questioned. Participants involved in social research projects have the right to self-determination, privacy, and dignity, and social researchers have the right to conduct research to acquire knowledge. These rights may conflict with each other, and there is no right or wrong answer. This dilemma can be solved by following some specific research procedures, which should be considered by the researcher when conducting social science studies.

- Any researcher must weigh the potential benefit of the research study to decide whether it is ethically justified given the potential costs and risks.
- The researcher must inform the participants about their right to decide whether or not participate.

- The researcher must give the informants reasonable information about the existence, intentions, and consequences of the research.
- Informed consent must be given about the intentions of the observation and interviews and the way in which the information will be used.
- In general, research should preserve the anonymity of its informants.

I tried to follow these basic research principles and routines while carrying out my research. The participants involved in this research study are competent and highly educated people, so it is reasonable to assume that they are capable of judging the information given and making up their own minds. When conducting interviews or participating in meetings or other forms of workshops, the participants were informed about the role of the researchers, the issue under examination, and their right to determine their participation. As far as the researcher knows, there were no conflicts of interest and no informants asked to be removed from the study. The research study has been registered and followed the procedures set out by the Norwegian Register for Scientific Studies at the Notification Archive 'Personvernombudet for forskning' (www.nsd.uib.no).

3.6 Summary and limitations

In this chapter I have given account of how this dissertation study was conducted, including some of my reflections and doubts along the way. I ended up with an intensive research design based on a mix-method approach in order to embrace a complex context. The real challenge and excitement in the study of university industry interaction and regional development is the meeting with the research site itself and the people in it. In this research process, the understanding of rich data or data overload, by being active as a researcher over a long time

period, and “drowning in data” became more than a theoretical concept. In the next chapter I will turn to the empirical context itself.

4 Summary of findings from research papers

This thesis has explored the contribution of HEIs to innovation and growth in response to the dissertation's overall research question: *How do higher education institutions enhance and strengthen regional capabilities for innovation?* Table 3 recapitulates the research question, theory, research gaps, and research contribution developed in Chapters 1 and 2. This chapter outlines the research questions, theoretical framework, methods, and key contribution of each paper to the overall dissertation research question. This chapter is organised in four parts. First, I will summarise the key findings and theoretical contributions from the research questions. Four specific research questions were developed through four research papers, which will be presented. All papers are stand-alone contributions, written in a format suitable for publication in peer-review journals. The discussion will focus on the connections and interaction between the papers' research questions, how they together contribute to the dissertation's overall research question, and the theoretical implications emerging from the papers.

Research question	Paper	Level of analysis	Literature/theory	Gaps	Contribution
1. How can regional science and knowledge institutions interact with and influence the evolutionary processes at play in the economy?	Entrepreneurship and path dependency in regional development. Paper 1	System level, RIS construct	Evolutionary economic geography, path dependency, regional branching, related variety	EEG studies have analysed policy interventions and the role of science systems in path dependent evolutionary processes to a lesser extent	<ul style="list-style-type: none"> • Path development can be initiated by purposeful policy interventions, external investment and renewing the role of HEI functions • Three types of path processes were identified: extension, renewal and creation. • HEIs roles can be hampered by lack of proximities, weak firm absorptive capacity, functional, political, and regional cognitive lock-ins
	Globalization, modes of innovation, and regional knowledge diffusion infrastructure. Paper 2	Firm knowledge dynamics	Regional innovation system, knowledge bases, innovation modes, untraded interdependencies, knowledge diffusion infrastructure	The conceptualisation of RIS construction has placed globalisation and firm knowledge complexities at the core of firm-HEI interaction analyses to a lesser extent	<ul style="list-style-type: none"> • Firms are transcending RISs and utilising a variety of knowledge sources and innovation modes that decouple them from the regional knowledge infrastructure • Knowledge originating in different industries is rarely identified and explored systematically on a large scale by industry itself, which suggests the importance of local knowledge spill over and regional branching mechanisms • HEIs play a third-party actor that can operate independently of individual firm or sectors, yet adapt teaching and research to collective potentials and demands

<p>2. What types of mechanisms transform university capabilities for innovation and growth?</p>	<p>Building entrepreneurial discovery process from University-industry interaction. Challenges and opportunity. Paper 3</p>	<p>Higher education institutions and system level</p>	<p>Regional innovation systems, university change, innovation policy, knowledge bases, related variety, and untraded interdependencies</p>	<p>Firm knowledge dynamic impacting HEI organisational capabilities for innovation and regional growth have been explored to a lesser extent in the HEI and RIS literature</p>	<ul style="list-style-type: none"> • HEI need to respond to new contradictory policy schemes and firms' novel ways of searching for knowledge by inventing third-mission activities, developing new networking work forms, and entrepreneurial capacities • EDP mobilise industry resources and university industry interaction that transform the regional innovation system setup • New policy schemes create challenges concerning different cultural embedded beliefs and norms and operational objectives
<p>3. How has prior research addressed the question of HEI contributions to regional economic development and what do we know from this research?</p>	<p>What do we know about universities' contribution to regional economic development? A conceptual framework. Paper 4</p>	<p>Literature review</p>	<p>University change, regional innovation systems, research policy, knowledge diffusion infrastructure</p>	<p>The literature is characterised by shortcomings, weak definitions, and imperfect measurement tools</p>	<ul style="list-style-type: none"> • A conceptual methodological framework capturing the main topics found in the literature review • Synthesis of the field's state of knowledge into four key topics with thirteen sub-topics • The literature does not propose a well-developed understanding of regional development and the role of HEIs contribution for innovation and regional development

Table 3. Theory gaps addressed and contribution of the research papers

4.1 *Research Question 1. How can regional science and knowledge institutions interact with and influence evolutionary process at play in the economy?*

Paper 1 “Entrepreneurship and path dependency in regional development” and Paper 2 “Globalisation, modes of innovation, regional knowledge diffusion infrastructure”.

Introduction and research questions

Papers 1 and 2 contribute to our understanding of how regional science and knowledge institutions, such as HEIs, interact with and influence evolutionary processes at play in the economy by analysing path dependency in regional industry development and a firm’s knowledge complexities. Paper 1 is an empirical analysis of path dependent processes and branching mechanisms of industrial development within a specialised high-tech industry cluster of Horten/Tønsberg, located near Norway’s capital, Oslo. The research question addresses a gap in the contemporary EEG literature concerning the extent to which regional branching mechanisms are related to different path dependent processes of path extension, renewal, or path creation. The paper also explores how evolutionary processes first begin, and the role of the science system, such as HEIs, in different path dependent processes (Boschma & Martin, 2010; Frenken et al., 2007). Paper 2 provides a deeper understanding of firm level behaviour by analysing how firms increasingly transcend the boundaries of the regional innovation system in their search for technology and complementary capabilities. The paper discusses how science and educational institutions can respond to cluster-based policies and the challenges of knowledge base complexities and globalisation when firms become decoupled from localised knowledge collaboration.

Theoretical framework

The theoretical foundations of the papers are based on two main theoretical streams of research. The first paper applies the concept of path dependency from evolutionary economic geography to analyse path dependent processes. The second paper applies the concept of different modes of innovation (STI and DUI) and forms of knowledge (Jensen et al., 2007) to explain competence-upgrading activities, which transcend the boundaries of a regional innovation system. The theory of path dependency assumes that path dependence is a continuous and endogenous change process whereby the inherited local knowledge base of an industry, through branching, can push technology, industry or the regional economy along one path rather than another (Martin and Sunley 2010). Regional branching takes place when the regional industry structure and knowledge base diversify into new industry through a place-specific knowledge transfer mechanism that connects new industries to existing industries; such mechanisms can include entrepreneurship, labour mobility and social networking (Boschma and Frenken 2011a). The second paper applies different modes of innovation and forms of knowledge (Jensen, 2007) to understand why firms are forced to draw on the wide range of resources and knowledge which is embedded in global innovation networks, and that makes companies more vulnerable to fluctuation and adapting to structural changes (Trippel et al. 2009). By applying path dependency and different modes of innovation in a Norwegian region (Horten/Tønsberg), the paper discusses how science and education institutions can respond to the challenges of knowledge base complexities, globalisation and firm needs for competence upgrading.

Methods

The industrial development of the Horten/Tønsberg area is the empirical context of Paper 1 and 2. Paper 1 applied a longitudinal case study of regional industry path dependent processes. Such

longitudinal case-based research studies are rare at present, as the majority of existing studies are mostly based on the quantitative analyses of aggregated portfolio data (quantitative data). The primary data was interviews with 13 company managers representing three types of companies; technology companies, consultancies, and star-ups. The interviews were conducted between 2006 – 2010 and in 2011. Qualitative semi-structured interviews were used, in which the theoretical concepts were operationalised through research questions. The data analysis employed various reports and statistical sources to complement and crosscheck the information from the interviews. The analysis followed an iterative process where data from informant centric data, reports and statistical sources informed the evolution of the path dependent process of Horten/Tønsberg. Paper 2 applied a mixed-method approach by combining qualitative and quantitative data. The empirical analysis was based on interviews with manager directors and R&D executives in 11 firms, conducted in two rounds. The first explorative round involved three of the largest industrial actors of the electronic cluster, and focused on topics from competence upgrading and organisational specific innovation processes. Based on these interviews, a survey questionnaire was developed and sent to the 42-member firms of the electronic coast and engineering coast network. The survey included topics such as key innovation activities (R&D investment), information sources, collaboration partners, and competence upgrading mechanisms. Competence upgrading of DUI was specified by informal indicators such as daily work, teamwork, and customer and supplier interaction, independently of innovation collaboration. The indicator for the STI mode was based on formal activities such as internal R&D and interaction with HEIs and the science system. This information was used to group firms according to the dominant “mode of innovation” of knowledge development. The response rate of the survey was 67%; 28 of 42 respondents answered the survey. In addition to the industry informants, 12 interviews were conducted with personnel at Vestfold University College, and there were numerous informal conversations, and the use of strategic documents

from the late 1990s until 2011. The Horten/Vestfold case was compared with nine additional cases as part of the larger research project Different modes of innovation which included analyses of Oslo and Lister regions.

Key findings and contribution

Three main characteristics of path development were identified in the Horten/Tønsberg region: path creation, path extension and path renewal or diversification. Each of the specific path dependent processes contained a specific set of branching mechanisms and novel of HEI contributions to innovation and regional growth.

Firstly, the findings show that regional path dependent processes can be initiated by political events or decision-making, which over time transforms the regional economy in a certain direction. As an example, the study shows how political events, such as the establishment of a new naval ship yard, the NDRE, and industry policies, sparked the growth of a distinct regional industry knowledge base (engineering-based workforce, industries combining STI and DUI mode of innovation), supported by an institutional setup. Different path processes (e.g. path creation, extension and renewal or diversification), emerged in light of several macroeconomic shocks that challenged and transformed the regional innovation system capacities for path growth.

Secondly, the findings show how branching mechanisms (labour mobility, entrepreneurship, and social networks) and firms search for novel knowledge works during shock and path growth. In particular, labour mobility was found to be an important mechanism for regional branching during the period of path creation and expansion by attracting talented people to work

in or move to the region, bringing new competence with them. The second mechanism identified was entrepreneurship. The region experienced the rapid growth of new companies through spin-offs and start-ups (1960s to 1980s) based on ideas from science systems external to the region, which moved the frontier of the industry into related but new market areas. The emergence of entrepreneurship seems to be closely related to the domains of opportunity found in newly emerging global markets that hold the power to diversify the regional industry structure into a variety of related technology areas. The relationship with external knowledge providers, such as national research universities and institutions, is explained by the educational backgrounds of entrepreneurs, and their prior experience, and existing networks (Thune, 2007), which local firms have maintained at the expense of local university college-industry cooperation.

The third finding of the study identifies how the composition of the regional industry structure and regional branching mechanisms works during different path development, which challenges the innovation and path growth contribution capabilities of the local university college. As identified in path creation processes during the formative years after establishment of the shipyard and Norwegian Defence and Research Establishment, and the industrial booms in the 1960s, the role of the university college was mostly linked to the main functions of offering vocational education and a skilled work force. The entrance of cheap electronic equipment manufacturers from low-cost countries in the 1980s sent a shock into the regional industry production system (Balconi & Centuori, 2004). This type of shock produced a negative lock-in situation in which companies invested less locally, entrepreneurial activities fell, and companies invested more in in-house R&D. The study shows how the regional innovation system suffered from a system failure whereby interaction and knowledge transfer within the regional innovation system were hampered by the increased specialisation of the industry

structure and firms embedded in the global value chain. The regional governance structure, the government, firms, and the university college responded to these challenges by developing additional regional branching mechanisms with the aim of mobilising industry and creating new path growth based on renewal of the university college educational programs and research quality.

Fourthly, the study shows how the role of the university college's main function of teaching and research supports the path dependent process from path upgrading to path renewal/diversification, where new knowledge became accessible to the regional industry. The modernisation of the university college's main functions by building research-excellence did not exert any immediate and direct effects on the path development of the region, however. An explanation for the lack of a result is seen as company reluctance to collaborate with a vocational college with low-quality teaching and out-dated research, and the weak entrepreneurial role of University College. Another explanation was found to be related to firm routines or novel ways of searching for knowledge and their absorptive capacity to utilise localised collective learning and knowledge sharing. These high-tech companies draw on a wide range of technologies and knowledge bases, as they are integrated into complex and advanced global networks that make it less likely for high-tech companies to collaborate with a 'local' university college with low or weak educational and research performance. Another finding was that existing R&D-intensive firms seemed to perform well by introducing novel products and services to the global market, while the specialised production system experienced increasing cognitive distance between companies to such an extent that firm absorptive capacity to utilise localised knowledge was hampered. Local knowledge dynamics were still found to be important for firm innovativeness, however, owing to a unique regional diffusion infrastructure.

Finally, from the point of view of the academic staff, these companies and their search patterns for knowledge brought access to an international advanced research community which they would not otherwise be able to access. Furthermore, the collaboration between companies and the university college was not about access to advanced technology and research facilities as such. Instead, companies emphasised education and the public role of building a regional environment for cooperation and knowledge sharing as important. The importance of education (bachelor and master levels) and the public role of diffusing knowledge across industrial knowledge bases became very clear when the opinions of companies were sought concerning the efforts of University College to build research excellence within microelectronic technology (MEMS). In particular, some companies were sceptical about the college's research excellence ambitions, arguing that this type of competence upgrading does not support their innovation mode. Those who seemed to benefit most from the research excellence ambition was the academic staff, who could finally select collaborative partners and academically interesting projects. The findings triggered further investigation into the other possible role played by the University College of Vestfold in regional development, which is not captured by the different modes of innovation and path dependency concept.

Relevance to overall dissertation

The theoretical implication of these findings is that the micro-behaviour of economic agents (high-tech companies working globally) seems to hamper the liabilities of regional branching mechanisms to cause the positive lock-in of path dependent processes (path creation or path renewal). However, the study also identifies the 'social network' of the local environment and the role of HEIs in strengthening the region's 'untraded interdependencies' (Storper, 1993), and transforming the institutional setup by acting as a public space for ongoing local conversations about knowledge needs and by supporting existing businesses to search for opportunities in new

domains (path renewal or diversification). In particular, the modernisation of the university college's teaching and research function was made possible by strengthening the region's 'untraded interdependencies' to such an extent that companies invested time and resources in building a new scientific teaching programme (micro- and nanotechnology). The study answers Research Question 1 by determining how the micro-behaviour of economic agents (firm searches for knowledge embedded in the global innovation network) affects regional evolutionary processes under different types of path dependent processes (path creation and path stagnation) and the role of HEIs. It also directs attention to our limited understanding of how globalisation influences a company's novel ways of searching for localised knowledge and the impact on the local knowledge diffusion infrastructure, involving the role of HEIs.

This underlines the importance of regional capabilities concerning the accumulation and diffusion infrastructure, such as HEIs, which operate independently of the local inter-firm collaboration at the level of the region. Another finding was that the contemporary regional innovation system approach does not propose a well-developed understanding of regional growth dynamics following increased globalisation and the effect of globalisation on firms' knowledge-searching routines within the local context. The study thus reveals that there is a current need for more knowledge about how these types of change mechanisms, following path dependency and firm knowledge searches, influence HEI abilities for innovation and regional growth. This study also answers Research Question 1 by suggesting a broader role for HEIs as a regional hub or accumulator of knowledge for information sharing, personal network formation, and knowledge diffusion, which creates system changes and affects industrial development and regional path growth. The role of HEIs and their mode of response to firm knowledge dynamics are further explored in Research Question 3, Paper 3.

4.2 *Research Question 2. What types of mechanisms transform university capabilities for innovation and growth?*

Paper 3 “Building entrepreneurial discovery process from university – industry interaction. Challenges and opportunities”.

Introduction and research question

The role of universities and the complexities of knowledge dissemination are thoroughly discussed and examined within the RIS framework. To a lesser extent, the role of HEIs in regional development is discussed within an evolutionary economic geography approach that emphasises the abilities of HEIs to unfold multiple regional path dependent trajectories through entrepreneurial discovery processes. The study in Paper 3 contributes with new knowledge about mechanisms that transform HEIs by analysing changes in regional business life and the entrance of new policy schemes which challenge the response of HEI abilities to new regional development needs.

Theoretical framework

The paper applies the regional innovation systems (RISs) framework (Isaksen and Trippel, 2016) and theories of path dependency to analyse the entrepreneurial discovery process of university-industry interaction in Vestfold. Tödting and Trippel (2005) are critical of RIS policies, and claim that they lack specific understanding of the strength and weaknesses of regions in terms of their industries, knowledge institutions, innovation potential and problems. The critique is interpreted as a call for better and more nuanced policy models that take into consideration the regional history and industry path dependency. Regions vary not only in terms of their technological and industry competence or infrastructure setup, but also in terms of institutional

setup (Garud, Hardy, & Maguire, 2007) and their potential evolutionary trajectory. The literature on entrepreneurial discovery process (Foray, 2015) assumes that new paths start as individual entrepreneurs examine technologies and market opportunities to identify future potentials and create new knowledge which can be spilled over to the other economic agents, and as a result create some form of industrial change, however, these system changes call for an entrepreneurial system level actor who is able to mobilise resources, competence, and power to create new system changes or transform existing systems (Isaksen et al., 2018). Universities are expected to have such capabilities, precisely because of their evolving role in society and their engagement in third mission activities, but these capabilities need to be aligned with regional growth dynamics (e.g. regional strength and weakness, and path dependent industry trajectory).

Methods

The study analysed Vestfold University College's adaptation to regional industrial development needs and new policy reforms, from 1994 to 2014, by conducting a longitude intensive case study (Sayer, 2000, Weick 1995). The single intensive case study approach (Sayer 2000) is widely accepted as a valid research design for this type of study, where the purpose is to provide in-depth insights into underlying processes and mechanisms that have not been properly discussed in existing theory, thereby contributing to theory development (Eisenhardt, 1989). The case study is based on 23 key interviews with the Provost, Dean, Department Manager and academic staff at Vestfold University College between the years 2008 to 2014. Interview selection was based on their experience with HEI-industry interaction. The interviews were held at the informant's workplace and lasted for one to one and half hours, depending on the information being given by the informants. The interviews focused on the kind of experiences they had with regard to regional development issues concerning the regional role and effect on

the university college. All interviews were conducted personally (face-to-face) and lasted from one and half hour. Interviewees received transcripts and analyses as a quality check, which led to further comments. All interviews were conducted confidentially; the interviewees' names were withheld by mutual agreement. The case study used qualitative semi-structured interviews focusing on the abovementioned themes, which were fundamental for manual coding and the use of software analytical tools. In addition to interviews, the analysis employed various reports, documents, statistical sources, and observations of project meetings to complement and cross-check the information obtained from the interviews in order to increase the data's validity (Maxwell, 2012). Purposeful sampling was an important part of the coding technique employed, where data was repeatedly compared across informants over time. This process resulted in an evolving and increasingly focused sample until the analysis reached theoretical saturation.

Key findings and contribution

Three main types of change mechanisms were identified; demand-driven innovation policies and the novel ways that firms search for knowledge which imposes transformation in HEIs; the entrepreneurial discovery process which presupposes the existence of a regional entrepreneurial system level actor, such as an HEI, to renew the regional framework condition for path growth; and different culturally embedded beliefs and norms on the value of knowledge and the role of HEI.

The paper concludes that by responding to new and conflicting policy schemes and adapting to companies' novel ways of searching for knowledge in the global-local context, the university college has developed abilities to diffuse related knowledge into the wider industry community and gradually change the institutional setup of the regional industry community. The university college has developed a strategic vision, reformed and reinvented in its educational and research program, invented in new collaborative work forms, in addition to embedded third-mission

activities within its organisational structure and culture. By building entrepreneurial discovery process competence, the university college can meet with partners who were previously out of their radius of research and innovation activities. Despite the overall positive experience and opportunities of EDP capability building, the university college encountered several challenges in their efforts to take on the role of an entrepreneurial system level actor. These challenges partly reflect the shifting circumstances following the entrance of new contradictory policy schemes, different institutions in the meaning of culturally embedded understanding, and the challenges of a lack of experience and routines following entrepreneurial discovery process. These difficulties suggest the need for universities to build relevant and legal administrative capacities, and they also call for greater reflection on formative processes and how regions diversify and grow (e.g. path dependent regional development) which calls for more experimentation in new collaborative work forms. The study also shows that society has a general expectation of continuous transformation in the higher educational system through modernising organisational structures, building entrepreneurial capacities, and using resources more efficiently. While these difficulties suggest the need for universities to build relevant and legal administrative capacities, they also call for greater reflection on formative processes and how regions diversify and grow (e.g. path dependent regional development), which calls for more experimentation by entrepreneurial system level actors, such as HEIs.

Relevance to overall dissertation

The findings from this study suggest that it is critical to further improve theory building for regional development and university change, which can improve innovation and higher education policies, which take into consideration the path-specific processes of innovation system dynamics (Gunasekara, 2006, Uyarra, 2010b). It also shows that universities are still facing several challenges to fulfilling the broader objectives of RIS policies, and the expectation of third-mission activities. The paper concludes by claiming that, while the future is challenging

for universities, which face a more dynamic policy environment than the organisational culture and administrative capacities of university, universities are showing both resilience and leadership in taking up the challenges arising from becoming regional entrepreneurial system level actors (e.g. RIS3 approach) (Vallance, 2016). These challenges mirror dynamic, heterogeneous and regional path dependent processes, which reflect the effect of the strategic nature of the entrepreneurial discovery process. While these difficulties suggest the need for universities to build relevant and legal administrative capacities and educational programs, they also call for greater reflection on the formative processes of how regions diversify and grow (e.g. path dependent regional development).

4.3 *Research Question 3.* How has prior research addressed the question of HEI contributions to regional economic development and what do we know from this research?

Paper 4. What do we know about university contributions to regional economic development?
A conceptual framework.

Introduction and research question

There has been a considerable and rapid growth of research studies examining the different roles of HEIs in regional development, which have expanded our understanding of the different roles that HEIs play in regional development and growth. The growth of research studies and policy tools have created a plethora of different research approaches, methods and definitions, which makes it hard to draw conclusions for policy and management purposes. The study answers Research Question 4 through a thorough and critical examination of the literature between 1990 and 2016.

Methods

A search for relevant literature was completed using the Web of Science citation indexing service. The literature review consisted of a total of 178 articles which was further investigated using systematic literature process (SLR) (Pittaway & Cope, 2007) consisting of five stages. Four main topics were identified and thirteen sub-themes. Based on these results, an integrated framework of university and regional economic development was developed.

Key findings and contribution

The findings of the literature review were that the research field has taken a huge step forward in nuancing the mechanisms at work in HEI contributions to innovation and regional development, creating a context-sensitive understanding and broader policy implications than the early success stories from places such as Silicon Valley, Route 66, MIT, and Boston. The study shows how the literature can be organised into four main topics and thirteen sub-topics which address different aspects of the HEI role in regional development. However, as the exponential growth of new articles emerges and the progress of new knowledge is achieved, the research field is characterised by fragmentation, vague definitions, disparate approaches, unclear measurements for policy design, and a lack of sound theoretical grounds of core concepts.

Relevance to overall dissertation

The thesis contributes with new knowledge about the complexities and nuances that follow different types of roles and categories of HEIs in regional economic development. The study reports that there is a current need for more research studies that offer a better understanding of the development of the broader role of HEIs and the way in which HEIs influence innovation system development and firm innovation performance. There is also a gap in previous studies,

as they did not seek to theorise the process of dynamic change in HEIs in response to the micro-behaviour of endogenous company development and their search for novel knowledge in the external environment within which HEIs are embedded.

5 Discussion, conclusion and implication

This dissertation has explored the different roles of HEI contributions to innovation and growth, responding to the dissertation's overall research question: *How do higher education institutions enhance and strengthen regional capabilities for innovation?* An outline of the thesis research questions, research gaps, theory, and contributions are presented in Table 3. Figure 5 recapitulates the conceptual framework developed in Chapter 2, the theoretical gaps and focus of the results of the thesis. The conceptual arguments from this dissertation is that; HEI capabilities for innovation depend on the manner of interaction, response and correction given to the on-going path processes by mobilising industry resources in joint efforts to create new work forms for teaching, and combining teaching and research in new ways linked to third mission activities. Through four research papers, this thesis demonstrates that HEIs can strengthen regional capabilities for innovation in institutionally thick and specialised regions in four ideal ways (Table 4). Each of these ideal ways calls for different types of contributions based on the distinct path characteristic of the regional innovation system, firm innovation behaviour, the distinct regional entrepreneurial discovery process, the entrepreneurial system level role, and the specific challenges and opportunities following regional RIS policies interpretation.

This chapter is organised in three parts. First, I will summarise and discuss the key findings and theoretical contributions from the research papers. Four research papers have been developed which addressed the dissertation's research question. The discussion will focus on the connections and interaction between the papers, how they together contribute to the dissertation's research question and the theoretical implication emerging from the papers. The contribution of HEIs to regional innovation will be discussed first, followed by methodological

aspects and limitations of the study; then the practical application of the thesis will be presented before the dissertation ends with a brief suggestion for further work.

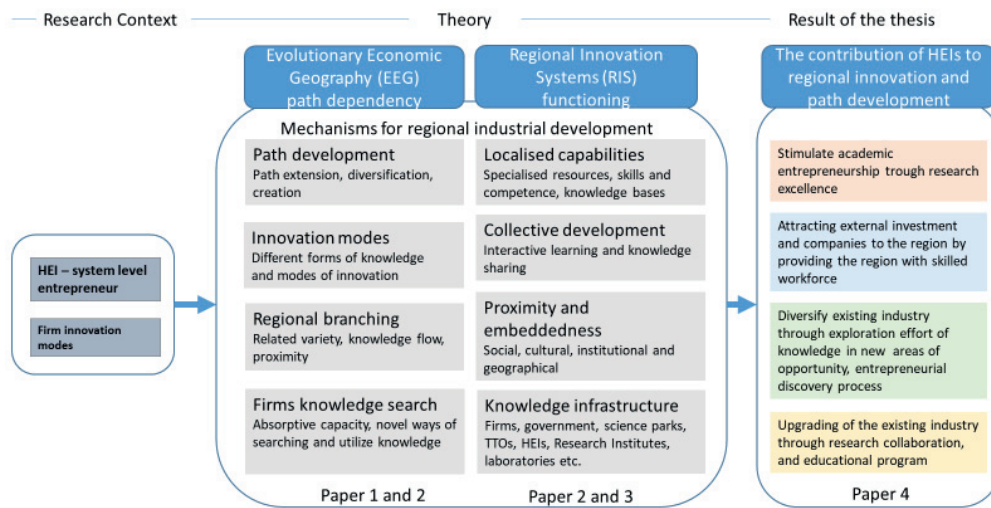


Figure 5. The dissertation's overall conceptual framework, context, theory and result

Path characteristic of the region	HEI contributions to innovation and regional development	Firm behaviour	The entrepreneurial discovery process	The system level entrepreneur (such as HEIs)	Policy implication and challenges
Creation	Stimulate academic entrepreneurship through spin-off Build high quality research	Endogenous development process using scientific methods and analytical knowledge combined with use of different modes of innovation	Identify individual entrepreneurs as sources for path creation Bridge related knowledge bases between industry and HEI	Radical in form by reorienting the innovation system framework by building knowledge infrastructure aimed to support academic knowledge flow	Narrow technology innovation RIS policies aiming to strengthen research excellence
Diversification	Attract external investment and new firms to the region Diversify the industry structure into new areas of opportunity	Searching for the right “place” to invest or relocate. Endogenous and novel search for knowledge in global knowledge networks Utilising knowledge in a global-local context-complex	Connect external knowledge connections to the region industry base Mobilise localised resources, identify opportunities and disperse related knowledge into the regional industry	Entrepreneurial experimentation of third-mission activities that mobilise industry resources, competence, and power to transform the framework conditions and institutional setup	Broad RIS policies combined with a Smart Specialisation approach Nuanced RIS policies supported by a Smart Specialisation approach aiming to identify regional possibilities
Extension	Upgrade industry through educated skilled work force	Incremental innovation based on upgrading existing knowledge base	Mobilise a bottom-up process by involving regional actors to create system changes	Strengthen third-mission activities and inflow of knowledge aimed to expand the institutional setup	Broad RIS policies aiming to mobilise local resources

Table 4. The dissertation's overall summary of key findings.

5.1 Research contributions, key findings and theoretical development

This chapter outlines the research contribution, key findings and contribution to theoretical development of the overall dissertation's research question: *How do higher education institutions enhance and strengthen regional capabilities for innovation?* The theoretical premise of this thesis proposes that HEI contributions to innovation and regional development take place in four ideal ways (Figure 2), with each calling for stronger awareness of the entrepreneurial discovery process and the system level entrepreneur role of HEIs in regional development. The entrepreneurial discovery process in this dissertation is an experimental role where University College, through its educational, research and third-mission activities (networking), responds to and mobilises companies to become more involved with localised knowledge spillover that ensures regional growth in four ideal ways; academic entrepreneurship, attracting external investment, diversifying the industry, and upgrading existing industry.

This chapter is organised in four parts. First, I will present the four ideal HEI contributions to path growth and the overall findings. Then the methodology and limitations will be discussed. The third section will present practical implications of the findings from the dissertation's overall question. Finally, there will be a discussion of future research needs.

Stimulated academic entrepreneurship

The first type of contribution, academic spin-off and new venture formation, is related to the more demanding process following path creation, which emphasises that HEIs contribute by commercialising knowledge for academic spin-offs and new venture formation (Calcagnini et al., 2016). Papers 2 and 4 show how through spin-off and new venture formation academic entrepreneurship is not necessarily in close proximity to the parent university. Papers 1 and 2 show that regional industrial strongholds characterised by institutionally thick and specialised

industries (Isaksen & Trippel, 2016) might over time enter into a situation described as path extension due to a lack of regional diffusion mechanisms and weak system level entrepreneurs who can change the framework conditions, or the ‘wider’ settings that affect industrial development. Building regional research excellence to meet industry needs for academic knowledge, resulted in less extensive industry cooperation, new firm formation, and knowledge diffused into the wider industry community. This result, supported by findings from Research Paper 3, suggests that any real effects from narrow RIS policy intervention, focusing on narrow academic entrepreneurship (research excellence) has a more symbolic than substantive effect on path creation, innovation and regional growth (Trippel, Sinozic, & Smith, 2015). The theoretical implication of these contributions is that policy studies should consider academic spin-off as an overall national strategy rather than a narrow RIS approach that aims to strengthen regional path growth.

Attract external investment and companies to the region

The second type of contribution made by HEIs is to attract external investment and new companies to situate in the region, which stimulates path creation or path diversification. As shown in Research Papers 1, 2 and 3 the region attracted external investment and new company formation based on the strength of the existing industry knowledge base and access to a skilled work force (Herstad & Sandven, 2017). The dissertation’s theoretical premise for this type of contribution presupposes that HEIs offer high quality education and research, and benefit from being part of a wider knowledge network from which knowledge can be disseminated into the regional industry base. As shown by Research Paper 2, external investment in local companies gave academic staff access to knowledge actors that they could not access previously, which strengthened their academic activities but not necessarily the regional knowledge spill over or social networking (Neffke et al., 2011).

Diversify existing industry

The third type of HEI contribution to innovation and regional growth is to diversify existing industry into new areas of opportunities through regional branching (Boschma & Frenken, 2011). Several findings in Research Papers 1, 2, and 3 are examples of how the university college contributes to the path renewal and diversification of the regional industry structure by strengthening its networking capabilities (Neffke et al., 2011) and educational programs (Nilsson, 2006). Research Papers 1, 2 and 3 contribute with knowledge about how HEIs contribute by invest in its educational programs, increased research quality and experimenting with new interactive learning and network-based knowledge sharing that take different innovation modes (STI and DUI) and forms of knowledge into consideration (Jensen et al. 2007). By developing new network-based work forms such as knowledge brokering, think-tanks, workshops and dialogue conferences, the participants developed competence and knowledge to diffuse different forms of knowledge and ideas into the wider industry structure and by so doing created possibilities for system change and new path growth. The papers show how Vestfold University College contributes to a rigorous assessment of the region's knowledge assets, capabilities, and competencies; including those embedded in departments in the University College, and its teaching and research functions (Nilsson 2006), by disseminating knowledge in new areas of opportunity, which cannot be handled alone by a single actor, such as a firm (Papers 1 and 2) (Kogut and Zander, 1996). Within this type of regional diversification, HEIs can act as a system level entrepreneur (Isaksen et al., 2018, Foray, 2015) by enhancing entrepreneurial discovery processes that bridge disconnected industrial sectors and disperse knowledge into related industry sectors through new forms of interactive learning and knowledge sharing (labour mobility and social networking). The dissertation's theoretical premise is that path renewal or diversification is initiated by firm level entrepreneurs (economic agents), who introduce new activities into a region at the same time as the innovation

system is further developed or restructured by system level entrepreneurs, such as HEIs, or other support organisations (Isaksen et al. 2018). System level entrepreneurs mobilise resources, and competences, and have the power to create new institutions or transform existing institutions. The theoretical implication of these contributions is that policies should, to a greater degree, include the role of system level entrepreneurs such as HEIs, abilities to disperse ideas and knowledge from entrepreneurial firms into new regional economic activities and create institutional system changes.

Upgrading the existing industry

The final HEI contribution is to support the upgrade of the existing industry knowledge base, which is in line with path extension (Isaksen & Trippel, 2016). A path extension is related to a situation where the regional industry is more or less characterised by incremental innovation in existing industries along prevailing technology paths. HEIs can upgrade the existing industry through research collaboration (social networking) and by upgrading educational programs (Nilsson, 2006). When regional path development is characterised as path extension, we can expect that HEIs will contribute with problem-solving competence (Jensen et al. 2007), engaging in contract research and consultancy, and developing industry relevant degrees, which is in accordance with the third-mission activities of HEIs and the tacit flow of knowledge. For the case of Vestfold, characterised as an institutionally thick and specialised region of advanced technology companies, papers 1, 2 and 3 contribute understanding about upgrading the industry through educating a skilled work force and by providing industry with problem-solving knowledge (DUI-modes of innovation) through formal and informal networking and research cooperation.

Overall, this dissertation first proposes that HEIs can enhance and strengthen regional capabilities for innovation within four ideal ways (Table 4), all of which address different aspect

of HEI functions and roles. Further, the analysis shows that HEIs can contribute to innovation and path growth by: (a) ensuring that localised symbolic knowledge and synthetic knowledge bases are enriched by analytical knowledge through their teaching and research functions and third-mission activities, (b) preparing students and companies to work with and understand the underlying premises for different forms of knowledge (symbolic, synthetic and analytic) through cross-sectoral problems based work forms (Jensen et al. 2007, Nilsson, 2006), and (c) finally, supporting internationalisation and the capture of spill over from global network collaboration (firm and academic staff) by ensuring that knowledge is dispersed throughout the local economy. In particular the study shows how new educational programs (at the master's level, based on industry needs) mobilised industry to cooperate more closely with the university college and thereby transformed its abilities to interact with and support regional industry with new knowledge. Secondly, the thesis shows that new entrepreneurial network-based work forms (Paper 1, 2, and 3) increased informal activities and knowledge sharing between company workers and the academic staff. Based on these findings, it is reasonable to assume that embedding the entrepreneurial discovery process as a regionally institutionalised innovation system framework will increase localised knowledge diffusion dynamics, and people will increase knowledge sharing and learning by being involved with HEIs- industry interaction, which is the key ability in building regional capabilities for innovation. This thesis advances our knowledge of the role HEIs play in the development of new industries and path development in organisationally thick and diversified regions (Isaksen and Trippel, 2016). These complex patterns of growth, combined with a firm's complex and novel ways of searching for knowledge and innovation modes, long development cycles, and shifting policy schemes, indicate that analysing HEI contributions to innovation and regional development is sensitive to the timing of the enquiry. At any given point, there will be a range of mechanisms of uncertain outcomes and path dependent processes which all of a sudden can achieve growth

and performance events that significantly shift the total impact of HEI contributions to regional growth. The theoretical implication emerging from the dissertation is that RIS policies, university change and regional innovation studies should to a greater degree consider the potential of education and research as regional branching mechanisms within a more experimental and entrepreneurial framework which might supplement existing narrow RIS policies and Smart Specialisation strategies.

The focused attention and introduction of innovation policy tools and higher education reforms has also created new challenges for HEIs (Morgan, 2004, Uyarra, 2008). Three types of challenges were identified in this dissertation. These are related to challenges concerning conflicting policy schemes (Paper 2 and 3) which enhance the pursuit of research excellence based on the STI-mode of innovation within some narrow technological fields, which the diversified regional industry (which is dominated by combined innovation modes) is capable of utilising to a lesser extent due to their weak absorptive capacity (Cohen & Levinthal, 1990). Thirdly, there is a cognitive in-locking of the innovation system framework which might narrow the scope of potential path creation or diversification. The thesis analysis suggests that transformation of RIS is not uniform or constant, but characterised as discontinuous (regions experience different growth paths at work at same time) and erratic (firm innovation modes) which calls for a more nuanced understanding of the entrepreneurial discovery processes and the role of HEIs as entrepreneurial system level actors in regional development (Foray, 2015).

Concerning the identified limitations of the RIS approach and the EEG literature, this thesis, by applying a critical realism approach, offers a deeper understanding and explanation of structural changes (the regional industry structure and knowledge base,) and those processes in which the

structure is itself continually being transformed by the micro-behaviour of agents, which, under specific conditions results in events, that is, path development (Figure 3). According to critical realism ontology (the world exists independent of our knowledge), such a formal explanation will not normally be possible due to the complexity of real-world behaviour. A critical realist approach provides a logical framework to guide researchers to gain a better understanding of the complexities of the objects, structures, mechanisms (causal powers and liabilities), and events that the contemporary RIS approach neglects in its focus on system components, connections, and boundaries as an explanatory mechanism for change.

5.2 Methodological aspects and limitations

According to the description of the research design in Chapter 2, the research presented in this thesis is best defined as intensive research supported by mixed methods based on a world view related to critical realism.

The selection of a medium-sized specialised industrial region, Horten/Tønsberg, and the University College of Vestfold was important methodologically. An intensive research design provides many opportunities to study the different roles of HEI contributions to innovation and regional growth from a variety of angles, which is a strength of the selected design. By using one specific case in a longitudinal study, it is possible to examine different mechanisms under concrete conditions in which unexercised power works (Figure 2). This gives the thesis a depth that is difficult to achieve by following several cases or by conducting cross-based studies within an extensive research design.

The weakness of an intensive research design based on one case is naturally the validity of the generalisation of the results. In particular, it is hard to replicate the mechanisms at work in regional economic development, as regional innovation systems are open, context sensitive, and different in nature. This means that repeating studies to reduce uncertainties in the outcome or to identify the correlation between causal powers and effects is in practice impossible, compared to an objective experimental design (Figure 2). However, regional economic development as a subject is a multidimensional concept that involves different actors, events, and social and cultural qualities that unfold over time and space. The role of HEIs in regional economic development is therefore a multidimensional and complex phenomenon involving multiple actors, knowledge transfer mechanisms, change mechanisms, path dependency, soft institutional structures, and different aggregated levels of analysis (global, national, and regional). Understanding the complex nature of the problem is therefore difficult, and a case-based design, as selected in this thesis, is therefore a preferable choice. Mixed methods are therefore used as the necessary research approach to understand the complex nature of the problem.

The research uses research methods typical of constructive and objective epistemology. This is preferable, since using a variety of methods also allows the case to be discussed from different angles using conceptually different methodologies, as promoted in mixed-method research (Creswell & Plano Clark, 2007). Combining methods such as interviews and surveys enriches the case compared to following a single disciplinary approach. At the same time, working with mixed methods requires detailed knowledge of several research disciplines. It is difficult to develop a detailed understanding of all the aspects of the study phenomenon. There is therefore a risk that the research may be superficial and inadequate. This thesis deals with that risk by

actively collaborating and presenting methods, models, and findings at research conferences to allow scientific feedback on each studied topic to promote the subjective research objective.

5.3 Practical applications for policy and HEIs

Research into why some companies and regions are more innovative and competitive than others has contributed to a new understanding of the role that knowledge plays in innovation. In the 1970s, Bell (1976) claimed that the codification of knowledge and the new relationship with science drove post-industrial society to embrace technology. Bell asserted that academic science and research are enablers of new industry growth and that the role of research-intensive universities is to transfer knowledge to industry for commercial purposes. This linear mode of thinking, or the technology push policy, was replaced in the 1990s by an innovation system perspective that emphasised interactive learning and knowledge sharing as the most important process of knowledge creation (e.g. broad interpretation of RIS). The shift of perspective represented a very different approach to innovation and knowledge production, by including a broader set of actors, the importance of untraded interdependency (institutions of norms, values, and cultures), and place-specific factors (proximity, path dependency, and relatedness). The RIS approach informs policies makers about developing targeted innovation policies that aim to strengthen the abilities of organisations (firms) and regional actors (such as HEIs) to contribute to innovation and regional path changes. However, the RIS approach lacks a better understanding of how singular companies (entrepreneurial firm) routinise the search and selection processes of knowledge, which in turn influences the region's path dependent processes. The lack of connections and knowledge about RIS approaches and the firm level may hamper the effect that innovation policy might have on regional path development and the contributory role of system level entrepreneurs, such as HEIs, in innovation and regional growth.

HEIs should carefully consider the consequences of their role in regional development and the effects they are assumed to have on path dependent processes. As the papers show, firms are searching for knowledge in a global-local context that continuously transforms the regional path dependent processes and the region knowledge base. This type of search process might thus hamper the regional knowledge diffusion process into the wider regional industry, which calls for system level actors to further explore and diffuse related knowledge into the region industry structure. There is conflict of interest embedded in the different RIS policies, however, narrow versus broad RIS policies that address the different capacities and contributions from HEIs (research excellence and broad development role) that needs to be handled. It would be useful for HEIs, firms and other support organisations to define the specific challenges concerning the RIS characteristics (institutionally thick/thin), and the path dependent (path creation, diversification or extension) process at play in the region with adequate strategies.

The results of the research papers provide a sceptical perspective on narrow RIS policies that does not include the regional specific path dependent processes which challenge HEI abilities for innovation and regional growth, such as the entrepreneurial discovery process. This implies that HEIs are not organisationally designed to take on the entrepreneurial system level role without making continuous changes to their organisational structure, culture and work forms. To do that, HEIs need to develop a greater understanding of the path dependent processes at play in regional development, which can be done by mobilising industry and other actors through a joint entrepreneurial discovery process.

5.4 Further work

This thesis has investigated the ability of HEIs for innovation and regional economic growth using an intensive research design within the worldview of critical realism. As for all research using an intensive research design, some of the findings are generally applicable, whereas others are more specifically related. It is therefore important for other researchers to continue this kind of research and evaluate the findings and proposed methodology in a broader setting.

It is necessary to acknowledge that no single method or 'one-size-fits-all' model of regional economic growth will be sufficient for all universities and regions. Even though the dominant view of regional innovation systems is challenged in this thesis, regional innovation systems are a powerful tool for designing a regional knowledge infrastructure aimed at diversifying regions into future regional economic development. More research is still needed to understand the mechanisms, and in particular the roles and missions of universities, that drive regional diversification processes and policy effects on new policy frameworks, such as the smart specialisation policy framework, research excellence, and RIS approaches.

6 References

- Arthur, W. B. (1994). *Increasing returns and path dependence in the economy*. Ann Arbor, MI: University of Michigan Press.
- Asheim, B. T. (1996). Industrial districts as 'learning regions': A condition for prosperity. *European Planning Studies*, 4(4), 379–400. doi:10.1080/09654319608720354
- Asheim, I., Boschma, R., Cooke, P., Lindholm Dahlstrand, Å., Brzica, D., Lareda, P., & Piccaluga, A. (2006). *Constructing regional advantage. Principles, Perspectives, Policies*.
- Asheim, B. T. (2007). Industrial districts as 'learning regions': A condition for prosperity. In R. Rutten & F. Boekema (Eds.), *The learning region: Foundations, state of the art, future* (pp. 71–101). Cheltenham, UK: Edward Elgar.
- Asheim, B. T., & Gertler, M. S. (2005). The geography of innovation. Regional innovation system. In J. Fagerberg, D. C. Mowery, R. R. Nelson, B. T. Asheim, K. Bruland, & S. Grodal (Eds.), *The Oxford handbook of innovation* (pp. 291–317). Oxford: Oxford University Press.
- Asheim, B. T., & Isaksen, A. (1996). Location, agglomeration and innovation: Towards regional innovation systems in Norway. *European Planning Studies*, 5(3), 31.
- Asheim, B. T., Boschma, R., & Cooke, P. (2011). 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
- Archer, Margaret S. (1998). *Critical realism: Essential readings*. London: Routledge.
- Audretsch, D. B., Leyden, D. P., & Link, A. N. (2013). Regional appropriation of university-based knowledge and technology for economic development. *Economic Development Quarterly*, 27(1), 56–61. doi:10.1177/0891242412472536
- Balconi, M., & Centuori, A. (2004). On the creation and distribution of knowledge in microelectronics. Retrieved from www.oecd.org/edu/educationeconomyandsociety/32126062.pdf
- Baltzopoulos, A., & Brostrom, A. (2013). Attractors of entrepreneurial activity: Universities, regions and alumni entrepreneurs. *Regional Studies*, 47(6), 934–949. doi:10.1080/00343404.2011.602335
- Barra, C., & Zotti, R. (2017). Investigating the human capital development–growth nexus: Does the efficiency of universities matter? *International Regional Science Review*, 40(6), 638–678. doi:10.1177/0160017615626215
- 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
- Beaudry, C., & Schiffauerova, A. (2009). Who's right, Marshall or Jacobs? The localization versus urbanization debate. *Research Policy*, 38(2), 318–337.
- Bell, D. (1976). *The coming of post-industrial society: A venture in social forecasting*. New York: Basic Books.
- Berger, Peter L., and Thomas Luckmann. (1967). *The social construction of reality a treatise in the sociology of knowledge*. Anchor Books ed. Garden City, N. Y.: Doubleday.
- Bhaskar, R. (1998). Philosophy and scientific realism. In M. S. Archer, R. Bhaskar, A. Collier, T. Lawson, & A. Norrie (Eds.), *Critical Realism: Essential readings* (pp. 16–47). London: Routledge.
- Bleiklie, I., & Kogan, M. (2007). Organization and governance of universities. *Higher Education Policy*, 20(4), 477–493.
- Boschma, R. (2005). Proximity and innovation: A critical assessment. *Regional Studies*, 39(1), 61–74. doi:10.1080/0034340052000320887

- Boschma, R. (2014). Constructing regional advantage and smart specialisation: Comparison of two European policy concepts. *Scienze Regionali*, 1, 51–68. doi:10.3280
- Boschma, R., & Frenken, K. (2011). Technological relatedness and regional branching. In H. Bathelt, M. P. Feldman, & D. F. Kogler (Eds.), *Beyond territory: Dynamic geographies of knowledge creation, diffusion, and innovation*.
- Boschma, R., & 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., & Martin, R. (2010). *The handbook of evolutionary economic geography*. Cheltenham: Edward Elgar.
- Boschma, R., Neffke, F., & Henning, M. (2010). *How do regions diversify over time? Industry relatedness and the development of new growth paths in regions*. Paper presented at the DRUID Summer Conference 2010, London, Imperial College London Business School.
- Brekke, T. (2015). Entrepreneurship and path dependency in regional development. *Entrepreneurship & Regional Development*, 1–17. doi:10.1080/08985626.2015.1030457
- Calcagnini, G., Favaretto, I., Giombini, G., Perugini, F., & Rombaldoni, R. (2016). The role of universities in the location of innovative start-ups. *Journal of Technology Transfer*, 41(4), 670–693. doi:10.1007/s10961-015-9396-9
- Charles, D. (2006). Universities as key knowledge infrastructures in regional innovation systems. *Innovation: The European Journal of Social Science Research*, 19(1), 117–130. doi:10.1080/13511610600608013
- Chatterton, P., & Goddard, J. B. (2000). The response of higher education institutions to regional needs. *European Journal of Education: Research, Development and Policies*, 35(4), 475–496.
- Clark, B. R. (1998). *Creating entrepreneurial universities: Organizational pathways of transformation*. New York: Pergamon.
- Coenen, L., Asheim, B., Bugge, M. M., & Herstad, S. J. (2016). Advancing regional innovation systems: What does evolutionary economic geography bring to the policy table? *Environment and Planning C: Government and Policy*, 0263774X16646583. doi:10.1177/0263774X16646583
- Cohen, M. W., & Levinthal, A. D. (1990). Absorptive capacity: A new perspective in learning and innovation. *Administrative Science Quarterly*, 35(1), 128–152.
- Cooke, P., Heidenreich, M., & Braczyk, H.-J. (2004). *Regional innovation systems the role of governance in a globalized world* (2nd ed.). London: Routledge.
- Cooke, P., Heidenreich, M., & Braczyk, H.-J. (1998). *Regional innovation systems: The role of governance in a globalized world*. London: Routledge.
- Creswell, J. W., & Plano Clark, V. L. (2007). *Designing and conducting mixed methods research*. Thousand Oaks, CA: Sage.
- Danermark, B., Ekström, M., Jakobsen, L., & Karlsson, J. C. (2002). *Explaining society: An Introduction to critical realism in the social sciences*. Routledge.
- Denzin, N. K., & Lincoln, Y. S. (2005). *The Sage handbook of qualitative research* (3rd ed.). Thousand Oaks, Calif.: Sage.
- Doloreux, D., & Parto, S. (2005). Regional innovation systems: Current discourse and unresolved issues. *Technology in Society*, 27(2), 133–153.
- Drucker, J. (2016). Reconsidering the regional economic development impacts of higher education institutions in the United States. *Regional Studies*, 50(7), 1185–1202. doi:10.1080/00343404.2014.986083

- Drucker, J., & Goldstein, H. (2007). Assessing the regional economic development impacts of universities: A review of current approaches. *International Regional Science Review*, 30(1), 20–46. doi:10.1177/0160017606296731
- Easton, G. (2010). Critical realism in case study research. *Industrial Marketing Management*, 39(1), 118–128. doi:10.1016/j.indmarman.2008.06.004
- Edquist, C. (2005). Systems of innovation. Perspectives and challenges. In J. Fagerberg, D. C. Mowery, R. R. Nelson, B. T. Asheim, K. Bruland, & S. Grodal (Eds.), *The Oxford handbook of innovation*. Oxford: Oxford University Press.
- Eriksson, R., & Lindgren, U. (2009). Localized mobility clusters: Impacts of labour market externalities on firm performance. *Journal of Economic Geography*, 9(1), 33–53. doi:10.1093/jeg/lbn025
- Eisenhardt, Kathleen M. (1989). Building theories from case study research. (Special Forum on Theory Building). *Academy of Management Review* 14 (4):532.
- Fagerberg, J., David, M. C., & Verspagen, B. (2009). *Innovation, path dependency, and policy: The Norwegian case*. New York: Oxford University Press.
- Florida, R. (1999). The role of the university: Leveraging talent, not technology. Retrieved from <http://www.issues.org/15.4/florida.htm>
- Foray, D. (2015). *Smart specialisation: Opportunities and Challenges for Regional Innovation Policy*. London; Routledge Taylor & Francis Group.
- Foss, L., & Gibson, D. V. (2015). *The entrepreneurial university: Context and institutional change* (Vol. 37). London: Routledge.
- Frenken, K., Van Oort, F., & Verburg, T. (2007). Related variety, unrelated variety and regional economic growth. *Regional Studies*, 41(5), 685–697.
- Garud, R., Hardy, C., & Maguire, S. (2007). Institutional entrepreneurship as embedded agency: An introduction to the special issue. *Organization Studies*, 28(7), 957-969. doi:10.1177/0170840607078958
- Gausdal, A. (2008). *Network reflection: A road to regional learning, trust and innovation* (no. 14-2008). Bodø: HHB.
- 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
- Gibb, A., Haskins, G., & Robertson, I. (2013). Leading the entrepreneurial university: Meeting the entrepreneurial development needs of higher education institutions. In A. Altmann & B. Ebersberger (Eds.), *Universities in change: Managing higher education institutions in the age of globalization* (pp. 9–45). New York, NY: Springer New York.
- Goddard, J. B., & Chatterton, P. (2003). The responses of university to regional needs. In F. Boekema & R. Rutten (Eds.), *Economic geography of higher education: Knowledge, infrastructure and learning regions*. London: Routledge.
- Grabher, G. (1993). The weakness of strong ties: the lock-in of regional development in the Ruhr area. In G. Grabher (Ed.), *The Embedded Firm: On the Socio-Economics of Industrial Networks*. London, United Kingdom: Routledge.
- Granovetter, M. S. (1973). The strength of weak ties. *American Journal of Sociology*, 78(6), 20.
- Greenwood, Davydd J., and Morten Levin. 1998. *Introduction to action research: Social research for social change*. Thousand Oaks, Calif.: Sage Publications
- Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. In N. K. D. Y. S. Lincoln (Ed.), *Handbook of qualitative research* (pp. 105-117). London: Sage.
- Gulbrandsen, M., & Slipersæter, S. (2007). The third mission and the entrepreneurial university model. In C. Daraio & A. Bonaccorsi (Eds.), *Universities and strategic*

- knowledge creation: Specialization and performance in Europe* (pp. XV, 492 s.).
Cheltenham: Edward Elgar.
- Gunasekara, C. (2006). Universities and associative regional governance: Australian evidence in non-core metropolitan regions. *Regional Studies*, 40(7), 727–741.
doi:10.1080/00343400600959355
- Hedström, P., & Ylikoski, P. (2010). Causal mechanisms in the social sciences. *Annual Review of Sociology*, 36(1), 49–67. doi:10.1146/annurev.soc.012809.102632
- Herstad, S. J. (2018). Beyond 'related variety': How inflows of skills shape innovativeness in different industries. *European Planning Studies*, 26(2), 396–420.
doi:10.1080/09654313.2017.1392490
- Herstad, S. J., and T. Brekke. 2012. "Globalization, Modes of Innovation and Regional Knowledge Diffusion Infrastructures." *European Planning Studies* 20 (10):1603-1625.
doi: 10.1080/09654313.2012.713334.
- Herstad, S. J., & Sandven, T. (2017). *Towards regional innovation systems in Norway? An explorative empirical analysis*. Nordic Institute for Studies in Innovation, Research and Education NIFU/Nordisk institutt for studier av innovasjon, forskning og utdanning NIFU.
- Herstad, S. J., Sandven, T., & Ebersberger, B. (2015). Recruitment, knowledge integration and modes of innovation. *Research Policy*, 44(1), 138–153.
doi:10.1016/j.respol.2014.06.007
- Isaksen, A., & Karlsen, J. (2010). Different modes of innovation and the challenge of connecting universities and industry: Case studies of two regional industries in Norway. *European Planning Studies*, 18(12), 1993–2008.
doi:10.1080/09654313.2010.516523
- Isaksen, A., & Trippel, M. (2014). *Regional industrial path development in different regional innovation systems: A conceptual analysis*. Papers in Innovation Studies 2014/17, Lund University, CIRCLE – Center for Innovation, Research and Competences in the Learning Economy.
- Isaksen, Arne. 2014. Industrial development in thin regions: trapped in path extension? *Journal of Economic Geography*. 15(3), 585-600, doi: 10.1093/jeg/lbu026.
- Isaksen, Arne, Nina Kyllingstad, Jan Ole Rypestøl, and Ann Camilla Schulze-Krogh. 2018. Differentiated regional entrepreneurial discovery processes. A conceptual discussion and empirical illustration from three emergent clusters. *European Planning Studies*:1-16. doi: 10.1080/09654313.2018.1530143.
- Jacobs, J. (1969). *The economy of cities*. Random House. New York
- Jensen, M. B., Johnson, B., Lorenz, E., & Lundvall, B. Å. (2007). Forms of knowledge and modes of innovation. *Research Policy*, 36(5), 680–693.
- Kogut, B., & Zander, U. (1996). What firms do? Coordination, identity, and learning. *Organization Science*, 7(5), 502–518. doi:10.1287/orsc.7.5.502
- Larsen, I. M., & Kyvik, S. (2006). *Tolv år etter høyskolereformen en statusrapport om FOU i statlige høyskoler*. Oslo: NIFU STEP.
- Laursen, K., & Salter, A. (2004). Searching high and low: What types of firms use universities as a source of innovation? *Research Policy*, 33(8), 1201–1215.
- Lester, R. K., & Sotarauta, M. (2007). Universities, innovation, and the competitiveness of local economies: An overview. *Innovation, universities, and the competitiveness of regions*, 214(2007), 9.
- Levin, M. (2007). Knowledge and technology transfer: Can universities promote regional development? In A. Harding, A. Scott, S. Laske, & C. Burtscher (Eds.), *Bright satanic mills*. Aldershot: Ashgate.
- Levin, Morten. 2012. Academic integrity in action research. *Action Research* 10 (2):133-149.
doi: 10.1177/1476750312445034

- Lundvall, B.-Å. (1992). *National systems of innovation: Towards a theory of innovation and interactive learning*. London: Pinter Publishers.
- Marshall, A. (1919). *Industry and trade: A study of industrial technique and business organization, and of their influence on the conditions of various classes and nations*. London: Macmillan.
- Martin, R. O. N. (2012). (Re)placing path dependence: A response to the debate. *International Journal of Urban and Regional Research*, 36(1), 179–192. doi:10.1111/j.1468-2427.2011.01091.x
- Martin, R., & Simmie, J. (2008). Path dependence and local innovation systems in city-regions. *Innovation: Management, Policy & Practice*, 10(2–3), 183–196. doi:10.5172/impp.453.10.2-3.183
- Martin, R., & Sunley, P. (2006). Path dependence and regional economic evolution. *Journal of Economic Geography*, 6(4), 395–437. doi:10.1093/jeg/10.4.395
- Martin, R., & Sunley, P. (2010). The place of path dependence in an evolutionary perspective on the economic landscape. In R. Boschma & R. Martin (Eds.), *The handbook of evolutionary economic geography* (pp. 62–93). Cheltenham, UK: Edward Elgar Publishing.
- Maxwell, J. A. (2005). *Qualitative research design an interactive approach* (2nd ed.). Thousand Oaks, Calif.: Sage Publications.
- Maxwell, J. A. (2012). *A realist approach for qualitative research*. Los Angeles: SAGE.
- McCann, P., & Ortega-Argilés, R. (2015). Smart specialization, regional growth and applications to European Union cohesion policy. *Regional Studies*, 49(8), 1291–1302. doi:10.1080/00343404.2013.799769
- Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd ed. ed.). Thousand Oaks, Calif: Sage.
- Morgan, K. (2004). The exaggerated death of geography: Learning, proximity and territorial innovation systems. *Journal of Economic Geography*, 4(1), 3–21. doi:10.1093/jeg/4.1.3
- Mowery, D., & Sampat, B. N. (2005). Universities in national innovation systems. In J. Fagerberg, D. Mowery, & R. R. Nelson (Eds.), *The Oxford handbook of innovation* (p. 22). Oxford: Oxford University Press.
- Nauwelaers, C., & Wintjes, R. (2002). Innovating SMEs and regions: The need for policy intelligence and interactive policies. *Technology Analysis & Strategic Management*, 14(2), 201–215. doi:10.1080/09537320220133866
- Neffke, F., Henning, M., & Boschma, R. (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*. Cambridge, MA: Belknap Press.
- Nilsson, J.-E. (2006). *The role of universities in regional innovation systems: A Nordic perspective*. [Frederiksberg]: Copenhagen Business School Press.
- Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science*, 5(1), 14–37. doi:10.1287/orsc.5.1.14
- Nooteboom, B. (2000). Learning by interaction: Absorptive capacity, cognitive distance and governance. *Journal of Management and Governance*, 4(1), 69–92. doi:10.1023/a:1009941416749
- OECD. (2017). *OECD reviews of innovation policy: Norway 2017*. Paris,: OECD Publishing.
- Piore, M. J., & Sabel, C. F. (1984). *The second industrial divide: Possibilities for prosperity*. New York: Basic Books.

- Pittaway, Luke, and Jason Cope. 2007. Entrepreneurship Education: A Systematic Review of the Evidence. *International Small Business Journal* 25 (5):479-510. doi: 10.1177/0266242607080656.
- Polanyi, M. (1966). *The tacit dimension* (1st ed.). Garden City, NY: Doubleday.
- Sayer, R. A. (2000). *Realism and social science*. London: Sage.
- Slaughter, S., & Leslie, L., L. (1997). *Academic capitalism: Politics, policies, and the entrepreneurial university*. Baltimore: Johns Hopkins University Press.
- Sorensen, A. 2008. Use of QSR NVivo 7 qualitative analysis software for mixed methods research. In *Journal of Mix Methods Research*. 2(1), 106-108. <https://doi.org/10.1177/1558689807309082>
- Sporn, B. (1999). *Adaptive university structures: An analysis of adaptation to socioeconomic environments of US and European universities*. London; Philadelphia: J. Kingsley Publishers.
- Steffensen, M., Rogers, E. M., & Speakman, K. (2000). Spin-offs from research centers at a research university. *Journal of Business Venturing*, 15(1), 93–111. doi:10.1016/s0883-9026(98)00006-8
- Storper, M. (1993). Regional ‘worlds’ of production: Learning and innovation in the technology district of France, Italy and the USA. In R. Rutten & F. Boekema (Eds.), *The learning region. Foundations, state of the art, future*. Cheltenham, UK: Edward Elgar.
- Storper, M. (2011). Why do regions develop and change? The challenge for geography and economics. *Journal of Economic Geography*, 11(2), 333–346. doi:10.1093/jeg/lbq033
- Tashakkori, A., & Teddlie, C. (2010). *SAGE handbook of mixed methods in social & behavioral research* (2nd ed. ed.). Thousand Oaks, Calif: SAGE.
- Thune, T. (2007). University industry collaboration: The network embeddedness approach. *Science and Public Policy*, 34, 158–168.
- Tripl, M., Sinozic, T., & Smith, H. L. (2015). The role of universities in regional development: Conceptual models and policy institutions in the UK, Sweden and Austria. *European Planning Studies*, 1–19. doi:10.1080/09654313.2015.1052782
- Tödtling, F., & Tripl, M. (2005). One size fits all? Towards a differentiated regional innovation policy approach. *Research Policy*, 34(8), 1203–1219. doi:<http://dx.doi.org/10.1016/j.respol.2005.01.018>
- Tödtling, Franz, and Michaela Tripl. 2013. Transformation of regional innovation systems: From old legacies to new development paths. In *Re-framing regional development: evolution, innovation and transition*,. London: Routledge, 62, 297,
- Uyarra, E. (2008). *The impact of universities on regional innovation. A critique and policy implication*. (No. 564). Manchester Business School Working Paper.
- Uyarra, E. (2010a). Conceptualizing the regional roles of universities, implications and contradictions. *European Planning Studies*, 18(8), 1227–1246. doi:10.1080/09654311003791275
- Uyarra, E. (2010b). What is evolutionary about ‘regional systems of innovation’? Implications for regional policy. *Journal of Evolutionary Economics*, 20(1), 115–137. doi:10.1007/s00191-009-0135-y
- Vallance, P. (2016). Universities, public research, and evolutionary economic geography. *Economic Geography*, 92(4), 1–23. doi:10.1080/00130095.2016.1146076
- Van de Ven, A. H. (2007). *Engaged scholarship*. Oxford: Oxford University Press.
- Venkatesh, V., Brown, S. A., & Bala, H. (2013). Bridging the qualitative-quantitative divide: Guidelines for conducting mixed methods research in information systems. *MIS Quarterly*, 37(1), 21-54. doi:10.25300/MISQ/2013/37.1.02

- Verspagen, B., & Schoenmakers, W. (2004). The spatial dimension of patenting by multinational firms in Europe. *Journal of Economic Geography*, 4(1), 23–42.
doi:10.1093/jeg/4.1.23
- Weick, K. E. (1976). Educational organizations as loosely coupled systems. *Administrative Science Quarterly*, 21, 1–19.
- Weick, Karl E. (1995). *Sensemaking in organizations, Foundations for organizational science*. Thousand Oaks, Calif.: Sage.
- Yeung, H. (1997). Critical realism and realist research in human geography: A method or a philosophy in search of a method? *Progress in Human Geography*, 21, 51–74.
- Yin, R. K. (1981). The case study as a serious research strategy. *Knowledge: Creation, Diffusion, Utilization*, 3(Sept. 1981), 97–114.
- Yin, R. K. (2003). *Case study research design and methods* (3rd ed.). Thousand Oaks, CA: Sage.

PART 2:
RESEARCH PAPERS

PAPER 1:

Entrepreneurship and path development in regional development

p. 101

PAPER 2

Globalization, modes of innovation, and regional knowledge diffusion infrastructure

p. 129

PAPER 3

Building entrepreneurial discovery process from university–industry interaction. Challenges
and opportunity

p. 167

PAPER 4

What do we know about the university contribution to regional economic development? A
conceptual framework

p. 195

RESEARCH PAPER 1

Entrepreneurship and path development in regional development

Thomas Brekke

PUBLICATION

Brekke, T. (2015). Entrepreneurship and path dependency in regional development.

Entrepreneurship & Regional Development, 1–17.

Is not included due to copyright
available at <https://doi.org/10.1080/08985626.2015.1030457>

RESEARCH PAPER 2

Globalization, modes of innovation, and regional knowledge diffusion infrastructure

Sverre Herstad

Thomas Brekke

PUBLICATION

Herstad, S. J., and T. Brekke. 2012. "Globalization, Modes of Innovation and Regional Knowledge Diffusion Infrastructures." *European Planning Studies* 20 (10):1603-1625.
doi: 10.1080/09654313.2012.713334.

Is not included due to copyright
available at <https://doi.org/10.1080/09654313.2012.713334>

RESEARCH PAPER 3

Building entrepreneurial discovery process from university–industry interaction.

Challenges and opportunity

Thomas Brekke

TO BE REVISED FOR PUBLICATION

Industry and Higher Educational

Building entrepreneurial discovery process from university – industry interaction. Challenges and opportunities.

Abstract

This study provides new insight into the entrepreneurial system level role of university following a regional entrepreneurial discovery process. In the last decades universities have been called into action to provide regions with innovation capabilities. The latest European policy Strategies for Smart Specialisation (RIS3) calls university into action to identify new areas of opportunity based on the existing knowledge base of a region. The analysis focuses on the region of Vestfold, which holds an institutional thick and specialized industry within electronic and microelectronic companies supported by a university college. The author examines in depth, the entrepreneurial discovery process of the long involvement of the university college in constructing a regional innovation system. The university college and the region industry have developed joint regional innovation capacities based on an entrepreneurial discovery approach. The entrepreneurial discovery process entails a rigorous assessment of the region's knowledge base and experimentation of new work forms that mobilize industry interaction with university education, research and third-mission activities. The article highlights challenges and opportunities following innovation policies and companies' novel ways of searching for knowledge. The article concludes with some policy implications.

Keywords:

Entrepreneurial development, regional development, Smart Specialization Strategies, university change

Introduction

The involvement of universities in regional development has in the last decades gained increasing prominence in the academic literature (Goddard et al., 2013; Vallance, 2016) and in national, regional and European Union (EU) policies. This increased role has been highlighted in the agenda for European Commission (EC) and has been promoted by the Organization for Economic Cooperation and Development (OECD) (Marinelli and Elena-Perez, 2017). The concept of Research and Innovation Strategies for Smart Specialization (RIS3), a key element of the new EC cohesion policy framework (2014-2020), reinforced the early policy framework

based on innovation systems approach, recognizing university as key actors in regional development (Asheim et al., 2011; Kempton et al., 2013). Smart Specialization strategies aim to foster national/regional competitive advantages through the bottom-up identification of the knowledge intensive areas for potential growth and development (McCann and Ortega-Argilés, 2015). The identification processes are related to the role of certain class of players and the science and educational link to industry. Identification occurs through entrepreneurial discovery made by an individual entrepreneur, a firm, a researcher, and so on, which spill over the entrepreneurial knowledge to more economic actors, and as a result form some industrial and structural changes that can stimulate new growth path (Foray, 2014; Isaksen et al., 2018). It follows from this point that the entrepreneurial discovery process (EDP) involves more actors than those who identify and establish new firms or innovate in existing firms. It also includes actors, such as universities or other organizations or individuals, that can change or diffuse new practices into the wider industry community by changing the framework conditions and mobilizing resources, competence and power to create new institutions or transform existing institutions and regional knowledge bases (Isaksen et al., 2018).

Although concerning the ability for universities to identify new opportunities and change the regional development framework (Trippel et al., 2015), it is difficult to understand whether and how such potential can be tapped (Kempton et al., 2013) and how universities can develop such capabilities (Uyarra, 2010) that transform regional institutions and create path growth. This article contributes to this debate by exploring a university's capabilities for innovation and regional path growth by using a longitudinal case study of the region of Vestfold, Norway.

The region of Vestfold consist of a regional innovation system characterized as an institutionally thick and specialized region within advanced high-tech companies of electronic and microelectronic companies supported by a local University College. The regional

innovation system evolved in the 1960s as part of a national strategy to build a research-based industry within emerging technologies. The regional industry experienced rapid growth and diversified its industry structure until increased global competition in the late 1980s slowed down regional path growth. As a response to these challenges, the industry and the local university college supported by local authorities started to build regional innovation capabilities by transforming the old university college and experimenting on new work forms aimed to diffuse new innovation practice into the wider industry community.

The case of Vestfold is particularly interesting: the region has continuously strengthened its regional innovation system capabilities with strong participation from the private sector, local authorities and the University College. The university college is a result of a political reform which brought together numerous small higher education institutions in Norway in fewer larger units. The intention was to build more robust and stronger higher educational institutions who could behave more entrepreneurially, in the sense of being more engaged regionally, nationally and globally (Kwiek and Maassen, 2012). By looking at the regional innovation system of Vestfold, we can thus explore the path-dependent process of building regional capabilities by using regional entrepreneurial discovery process.

In order to gain insights into this issue, the paper is organized as follows: the next section discusses changes in regional innovation systems approaches in light of last decades' policy frameworks, focusing on the debate about university roles, the third section describes industry path-dependent processes, paying particular attention to the contribution to changes of the university's main functions and the entrepreneurial discovery process, the fourth section describes the context and method used in the study, the fifth section presents empirical analysis of the university college and regional development, the sixth section discusses the findings from the empirical analysis, and finally the last section concludes and provides policy recommendations.

Policy frameworks and regional development

The concept of Smart Specialisation Strategies (RIS3) has developed from the academic critic of the Regional Innovation System (RIS) framework. The critic led by Tödtling and Trippel (2005) claimed that RIS policies which focus on high-tech, knowledge based or creative industries; building up of research excellence; attraction of global companies; and stimulation of spin-offs' (Goddard et al., 2013), lack specific understanding of strengths and weaknesses of regions in terms of their industries, knowledge institutions, innovation potential and problems. The debate calls for better and more nuanced policy models which takes into consideration the different regional economic path challenges and institutional problems in regions. According to the RIS literature content, there are three types of RISs as follows: Organizational thick and diversified RISs, organizational thick and specialized RISs, and organizational thin RISs. Organizational thin RISs have only few knowledge and support organizations, and weak developed network-based cooperation. This RISs are often found in peripheral region. Inflow of new knowledge through external links or attracting knowledge organizations are assumed to be important for innovation and regional development. Organizational thick and diversified RIS is often found in large core and advanced technology regions. They are characterized by a relatively large number of different firms, a heterogeneous industrial structure and a number of knowledge and support organizations. Regions that hosts strong cluster in one or few industries only, and knowledge and support organization are mostly tailored to support their narrow industrial base. This type of RIS poorly supports entrepreneurship and more possibilities for lock-in of existing industrial strongholds (Isaksen et al., 2018). However, with the emergence of more differentiated RISs models, the regional innovation policies in the last decade is marked by a narrow technology-oriented policy interpretation, based on a narrow definition of RIS, in which most policies are focused on

individual firms in the form of R&D subsidies, rather than selecting policy instruments in relation to the actual problems identified in the regional innovation systems (Tripl et al., 2015).

In addition to regional innovation policies, several nations introduced policy reforms with objectives to reform the educational system, such as the Bologna process in EU and the Norwegian new act of Universities in 1995 (Kwiek and Maassen, 2012). In Norway, these reforms were designed to create more effective and robust units which could behave more entrepreneurially by being more involved with regional development. Educational reforms were also supported by national industry policies that emphasized demand-driven innovation policies which challenged universities to redefine their roles and functions in accordance to industry need for knowledge support and regional development needs (Wicken, 2009a).

The entrepreneurial discovery process

The smart specialisation concept evolved as a response to the critic of RIS and oversimplified innovation policies in the European context. This concept builds on and contains many elements that were already evident in the innovation system literature, the entrepreneurship and growth literature (McCann and Ortega-Argilés, 2015). The innovation system's way of thinking underpinned the smart specialisation strategy by explicitly acknowledging that for reasons of history and path dependency, regions vary not only in terms of their technological and industrial competence, but also in terms of institutional setup (cultural embedded beliefs and norms) (Garud et al., 2007) and their potential evolutionary trajectory. Consequently, a smart specialisation strategy entails the regional specific setting capability to mobilize industry, government and higher education institutions through a bottom-up learning and exploration process aimed to identify areas for future specialism that build on a region's assets (Kempton et al., 2013). This implies that smart specialisation concept requires localized action attuned to the specific needs and available resources of regions. However, before we go deeper into the

EDP following the RIS3 strategy, there is the need to unpack the innovation system concept by exploring how regions change and diversify.

Evidence from evolutionary economic geography researchers show that regions are more likely to branch into industries that are technologically related to the pre-existing industries through path dependency and place-specific knowledge transfer mechanism that connects the new industry to existing industries (Boschma and Frenken, 2011). In this context, path dependency is used to explain how the inherited local knowledge base of an industry, influenced by past history, diversification processes, policy making and purposive behaviour, push technology, industry or the regional economy along one path rather than another (Martin and Sunley, 2010).

New growth path begins by entrepreneurial discovery made by individual entrepreneurs who scan technologies and market opportunities, to identify future potential, create new knowledge which can spill over to more economic actors, and as a result create some form for industrial and structural change that can stimulate new growth path which allows the system to reorient and renew itself (Isaksen et al., 2018; Foray, 2014). The EDP is seen from a broad perspective by including a range of actors such as individual actors (including entrepreneurs, regional leader), organization (such as universities and firms), support organizations, and the wider social and economic structures surrounding entrepreneurship and innovation in a region. Besides the individual entrepreneur discovery search process, the result of a successful EDP is assumed to create innovation and system changes that affect industrial development within a specific region and industry (Isaksen et al., 2018). These changes calls for a system level entrepreneur, individuals, organizations or group of actors who are able to mobilize resources, competence, and power to create new system changes or transform existing systems.

Universities are regarded as one of the actors to build system level entrepreneur capabilities, precisely because of their evolving role in society and their engagement in third-

mission activities. The third-mission stream refers to three main activities: (a) innovation, technology and knowledge transfer, (b) continuing education and lifelong learning, and (c) broader engagement in regional development. Despite the increasing engagement of universities in the society (Pinheiro and Stensaker, 2014), and their increasingly recognized regional development role, building EDP capabilities and the entrepreneurial system level role is not a simple process. This is partly because such role requires important organizational and governance changes, including new administrative and management competences, and as such put significant strains on the organization (Bonaccorsi et al., 2010). It is also because of changing policy schemes, as there has been a degree of ambiguity of goals of university role in regional development (Foss and Gibson, 2015). The third challenges concern capacities inherited in the regional knowledge industry structure and potential for new growth path to emerge. This multifaceted difficulties in implementing the system level entrepreneurial role in light of last decade's policy schemes are critical to understanding the role of universities in entrepreneurial discovery process.

Context and Method

The study analysed the adaptation of Vestfold University College to regional industrial development needs and new policy reforms from 1994 to 2014, by conducting a longitude intrinsic case study based on principles of ethnography (Weick, 1995; Berger and Luckmann, 1967). The single intrinsic case study approach (Sayer, 2000) is widely accepted as a valid research design for this type of study, where the purpose is to provide in-depth insights into underlying processes and mechanisms that have not been properly discussed in existing theory, thereby contributing to theory development (Eisenhardt, 1989). The case study is based on 23 key interviews with the provost, dean, department manager and academic staff at Vestfold University College between 2007 and 2014. The informants were selected based on their

experience with university – industry interaction. The interviews were gathered at the informant's workplace. The interviews lasted for one to one and half hours, depending on the amount of information the informants had. The interviews focused on what kind of experiences they had with regards to regional development issues concerning the regional role and effect on the University College. All interviews were conducted personally (face-to-face) and lasted for one hour. Interviewees received transcripts and analyses as a quality check, which led to further comments. All interviews were conducted in confidentiality; the interviewees' names were withheld by mutual agreement. The case study used qualitative semi-structured interviews which made was fundamental for manual coding and use of software analytical tools. In addition to interviews, the analysis employed various reports, documents, statistical sources, and observation of project meetings to complement and cross-check the information obtained from the interviews in order to increase the validity and reliability of data (Yin, 1981). Purposeful sampling was an important part of the coding technique employed, where data were repeatedly compared across informants over time. This process resulted in an evolving and increasingly focused sample until the analysis reached theoretical saturation (Gioia et al., 2013). Concerning reliability, the author has been working at the university college since 2006. Much of the information obtained through interviews, observation and actions taken was cross-checked with public information, internal notes and conference presentations.

The University College is located 100 kilometres southwest of the capital city Oslo, Norway. In 2013, Vestfold University College was organized into four faculties: Faculty of Health Science, Faculty of Humanities and Education, Faculty of Technology and Maritime Sciences, and Faculty of Social Science. The University College offered several Bachelor's (20) and Master's (8) degrees and a Ph.D. programme in Nano- and Micro-electronics. The region is a medium-sized region with a population of about 250,000. The region has a long history of being an important port for ferries, shipbuilding and maritime activities. Today, the

region's business life consists of two main industrial branches: the first consists of diverse companies within wholesale business, trade, logistics and transport, food and forestry; the second comprises advanced electronics and ICT companies that evolved in the 1960s as part of a national strategy to build a research-based industry within emerging technologies. These companies serve the international market for defence, maritime, offshore and electronics products, health and medical equipment, and communication software (Brekke, 2015; Isaksen, 2003). The cluster of companies is mainly within a 40 kilometre circle around the University College. Such spatial proximity of firms represents an innovation power, explained as knowledge spill overs between related companies and higher educational institutions (Gausdal, 2008).

Empirical Analysis of Vestfold University College and Regional Development

Capability building of the Higher Educational System of Norway

Rapid industrial growth and tax income channelled to the higher educational system in the 1970s resulted in the growth of 98 public University Colleges. Most of these institutions provided regions with vocational teaching and basic training. In the late 1980s, these University Colleges were regarded as weak rural institutions unable to provide regions and companies with research and problem-solving capacities (Bleiklie and Kogan, 2007; Larsen and Kyvik, 2006).

In 1994, a new national higher educational policy reform followed by a new Act in 1995 reduced the number of public University Colleges. The objective of the reform was to create more effective organizations through scale economics, a better division of functions and tasks between large national universities (Kwiek and Maassen, 2012; Kyvik, 2002). The reform also emphasized the need to create stronger and more robust University Colleges that behaved entrepreneurially, in the sense of being more involved regionally, nationally and globally

(Kyvik, 2002). The educational reform was also supported by a new national industry policy that emphasized more demand-driven innovation than the dominating technology push approach (Wicken, 2009a). Within this new demand-driven policy context, universities were challenged to redefine their teaching and research mission in accordance with existing industry need for knowledge support and regional development demands. The national innovation and research policy was further strengthened in the 2000s by the introduction of a National Centre of Excellence (CoE) scheme. CoE is based on project funding, where selection is done through open calls and international peer review processes. The main objective is to promote high scientific quality, ground-breaking research and international competitiveness. The idea is that CoE should enable universities to build strong research communities, securing additional funds and attracting highly qualified scholars and partners, and to increase their international visibility through citation scores in highly ranked journals (Langfeldt et al., 2015).

In 2005, the new Act from 1995 was revised, granting universities and colleges with adequate research capacity greater autonomy. The degree and credit system was changed in order to meet new European credit transfer standards. A new financial model comprising basic funding, a piece rate payment for education candidates, and a strategic and result-based budget appropriate for research and CoE was introduced (Nilsson, 2006; Stensaker and Benner, 2013).

Industry path changes and the need for entrepreneurial discovery process

The current industrial structure of the region can be traced back to the aftermath of the Second World War. Due to the location of a national defence research institute, a specialized workforce and the agglomeration of electronics manufacturing industries, an advanced semiconductor manufacturing industry emerged in the region in the 1960s (Brekke, 2015; Wicken, 2009b). The rapid growth of the semiconductor industry, which was driven by global demand for user electronics, was supported by a national technology push policy logic, similar to other Western

countries' technology-driven industrialization (Gulbrandsen and Nedrum, 2009). In the 1970s and 1980s, the regional semiconductor and electronics industry became a specialized production system within micro- and macro-electronics production that served a variety of markets such as defence systems, maritime equipment, offshore technologies, electronics products, communication software, and health and medical equipment. The industrial growth in the 1960s and 1970s was based on strong ties with national research universities that provided the regional industry with scientific knowledge (Brekke, 2015; Isaksen, 2003). The results of academic research are especially important for firms in the so-called science-based industries, as these firms invest relatively heavily in R&D and collaborate intensively with academia (Ponds et al., 2010). The local University College played only a minor role in the production system by providing the industry with mostly vocational teaching programmes.

The first glimpse of EDP occurred in 1994. In 1994, the Norwegian government decided to include smaller vocational colleges as part of a regional knowledge infrastructure through a new research and development programme, RUSH. The aim of the programme was to build regional technology transfer capacities by empowering regional vocational university colleges to better organize and structure their regional relationships and enhance the commercialization of knowledge. The programme had two main objectives: 1) to increase regional knowledge flow by selling colleges' competence at market price and 2) to offer research equipment for hire. Regionally, the Departments of Engineering, Maritime Education and Social Sciences were selected as target departments due to their assumed scientific relevance for the regional business life. However, several challenges were identified. The college had weak teaching and research quality, and it lacked significant senior research capacity that could support the regional industry with scientific knowledge in related but different markets. The college lacked entrepreneurial competence and organizational routines, which consequently made it difficult to convince companies to 'buy knowledge' from the college and build REP competence.

Further possibilities for build-up of regional EDP competence happened in 1997, when the RUSH programme was replaced by a new programme. The new programme, NODE, was designed to build regional R&D competence based on regional competitive advantages and the division of work between university and vocational university colleges. Such an academic beacon was assumed to take a leading national role in cooperation with similar educational and professional environments and other institutions, thus pushing up the quality of higher education as a whole. In 1998, Vestfold University College was appointed by the government to host a maritime node function due to the long industrial trajectory of the region. According to the university dean, the node function was mostly used as a rhetorical argument to accomplish the university college's vision of becoming the region's knowledge centre and, secondly, to position itself within the new order of the national higher educational system. The global economic downturn and the entrance of cheap labour from east Europe and Asia in the 1980s impacted regional knowledge collaboration in the sense that local shipyards and maritime companies were forced either to close down their business or to search for low cost manufacturers in other countries. Thus, despite the high ambition of the programme, the internationally-oriented maritime industry remained reluctant to collaborate with the university college due to the poor research and teaching quality of the college, and lack of capabilities to diffuse related knowledge to the wider regional industry.

During the late 1980s and 1990s, the global market for microelectronics and electronics equipment changed significantly due to stiff global competition and increased R&D costs, arising from the increased miniaturization and complexities of components that were very difficult for single firms to manage alone (Balconi and Centuori, 2004). The global microelectronics and electronics industry responded to these challenges by establishing manufacturing or assembly facilities in multiple low cost regions of the world. Developing industrial alliances, joint venture projects and strong cooperation with leading global research

universities became the innovation modes of global manufacturers (Ham et al., 1998). The new ways of producing knowledge affected local companies in several ways. Local companies invested more abroad than within the region. Several companies became foreign-owned or they became part of larger national corporations. The growth of new companies declined, and local manufacturing was challenged by low cost production. In order to meet these challenges, local microelectronics and electronics manufacturers asked for greater regional responsiveness to the turbulent market environment and novel ways for companies to search for knowledge (Brekke, 2015; Uhlin and Johansen, 2001).

In order to turn the tide for the local industry, several steps were taken. In 1997, the university college participated in the Regional Innovation Programme (REGINN). Unlike the RUSH and the NODE programmes, REGINN was designed to support promising international competitive and advanced industrial clusters based on specific industrial knowledge needs within a RIS approach (Asheim et al., 2011). The REGINN project identified several system failures of the RIS components (Coenen, et al., 2016). There was low interaction between the exploration (University College) and the exploitation (companies) parts of the system, and the regional innovation system lacked system level entrepreneur who could change the region institutional setup and framework for systematic interaction and diversification of the regional industry base. According to the microelectronics and electronics companies, the college's teaching programme was outdated and the research was of poor quality and not in line with an innovation mode where companies search for advanced knowledge in global knowledge network (Herstad and Brekke, 2012; Teece and Pisano, 1994). There were also bottlenecks concerning systematic interaction and knowledge transfer between what seemed to be technology related industries. Overall, the long-term ongoing diversification process of the regional industry into different market areas seemed to create a greater cognitive distance

between companies, which hampered the diffusion processes of regional knowledge, and lack of regional EDP capabilities (Boschma, 2010; Nooteboom, 2000).

The college responded to these challenges by inviting the industry to define the future domain of opportunity (Foray, 2014) within a specific selected scientific area. Micro-electromechanical systems (MEMS) were chosen as a future technology platform. The MEMS technology platform was selected due to its general purpose technology (GPT), which is applicable and increasingly relevant across most segments of advanced electronics. MEMS packaging research was organized as contract research within the boundaries of the newly established Institute of Micro Systems Technology (IMST). The regional industry provided IMST with a clean laboratory, production equipment, research cooperation and knowledge expertise. A tenant professor was recruited from the industry, along with key personnel. Incentives were also given to academic staff at the college to finish their Ph.D. degrees or qualify as professors. Partly based on external funding through contract research and the recruitment of skilled staff, the university college managed to build the new institute (IMST) and finance a Bachelor's, Master's and Ph.D. programme within a short period of time (2003–2009). In 2013, the institute had 30 employees and hosted 25 Ph.Ds and six professors.

Selection of the MEMS scientific field was not without internal or external tension. Internally, it entailed channelling attention and financial resources towards one specific scientific area at the expense of other well-established areas. In practice, this meant a substantial reorganization of the engineering department and the downsizing of former academic strongholds. Secondly, the specific innovation mode of the industry emphasized contract research and face-to-face communication where scientific analytical knowledge was put into context before being transformed into commercial innovation, which indicate that the use of scientific knowledge requires a fundamental understanding of the research principles and trust based personal relationships as the main work forms, which differed from the college's

vocational teaching culture. Externally, several companies experience financial crises after a while due to global recession, which forced them to reduce their project obligations. Other electronics manufacturing companies claimed that the MEMS technology research was too scientifically focused and it was only a very small part of their core knowledge portfolio. Some company managers even claimed that the college had its own interest in building a research environment that could compete nationally and internationally and did not necessarily serve local needs for knowledge. A researcher expressed the distance between the companies' needs and the university college's ambition in this way:

“Local companies are too small and they do not have the necessary research competences to utilize such advanced and expensive knowledge production in the long run. To become a world leader within MEMS packaging, we need conduct advanced research and publish in international journals with the best companies and research institutions in the world”.

This citation illustrates that capacity building of general purpose technology (GPT) within the confines of the university college does not necessarily lead to an expanded regional knowledge base that local companies can harvest from. It illustrates that different development mechanisms exist in academia and business life, where the academic standard is often measured by citations and publication in highly ranked journals, while companies need to continually innovate in order to respond to market pressures. It also illustrates that new technologies do not develop fully in a single place, but in a wider geographical configuration of interlinked territorial and network-based work forms which companies and universities need to be a part of (Bathelt et al., 2004). The complexity of GPT such as MEMS is often associated with a long development cycle before the technology is used or has the expected regional agglomeration effect on the new economic structure, which might make it hard for local manufacturing

companies to be involved. Even though several local companies did not benefit directly from the MEMS packaging research, new modes of innovation made it possible for the university college to upgrade its research and teaching quality and to position itself as an acknowledged scientific institution nationally and internationally.

Enhancing the entrepreneurial system level role

In 2005 and 2007, supported by two new research programmes—the Regional Research and Development programme (VRI) and the Norwegian Centres of Expertise programme (NCE)—the region further improved the knowledge infrastructure by identifying new sectors of the regional economy to be involved in research-based collaboration, and strengthening the university college’s capability to interact with the industry. Four new industrial clusters of the regional economy were identified: the markets of water treatment, oil and gas industry, food manufacturing and creative industry. Due to the lack of a corresponding profile with the college (Caniels and van den Bosch, 2011), food manufacturing and the creative industry were excluded as independent cluster initiatives. However, the role of the college became controversial, with some company managers claiming that the university college and its focus on research and publication was not necessarily in the interest of individual companies: “there is high attention from the college to focus on research and, through that, publication in international journals, but that is not in our interest as we seldom benefit directly from such collaboration”; ‘We need more attention to tailor-made courses or teaching programmes where we can recruit engineers.’ The criticism needs to be seen in the light of these companies’ innovation mode and their need for applied engineering science. Companies within water treatment and the oil and gas industries are mostly based on engineering science, organized in in-house R&D departments. Innovation is characterized by recombining existing knowledge into new solutions based on customers’ and suppliers’ feedback, and the oil and gas industry revenue stream is based on

charge per hour. This type of innovation mode is characterized as the 'doing, using and interaction' mode of innovation, where engineering design practice involves engineers learning what works without a particularly sophisticated understanding of why (Jensen et al., 2007). A science, technology and innovation mode (STI) is mostly applied when new prototypes are to be tested, which is done at research institutions or universities located outside the region.

In 2010, the university college, on behalf of national maritime interest groups, developed a new Master's in Technology and Commercial Maritime Management. However, according to oil & gas and maritime companies, the competence profile of the Master's did not correspond with the competence and innovation mode of the regional industry. This challenge was partly solved by involving companies in the construction of the educational profile of the Master's programme and through student-industry projects. Internally at the college, there was a significant gap in meeting the national standard of significant qualified academics to run a maritime educational Master's programme. According to the dean of the maritime department, contract research was used to attract additional funding to be used to upgrade staff formal competence, invest in equipment and employ full-time professors. Another dilemma concerns the lack of entrepreneurial routines of the university college to collaborate with its external environment. Through use of network-based learning forms such as industry mobilization, knowledge brokering and think-tank experimentation, firm became more familiar with interacting with the university college. As an example, construction of the water treatment cluster and new technology solutions for water treatments were done using network-based knowledge brokering, workshops and think-tank experimentation that involved competence from different companies, universities and research institutions (Svare and Gausdal, 2015). The evolution of the university college through industry interaction can be interpreted as an entrepreneurial system level role responding to more nuanced RIS innovation policy that

enhanced the EDP capabilities of the regional knowledge system to unfold new development trajectories and path growth (Vallance, 2016).

Discussion, challenges and opportunities concerning EDP capability

Changes in RIS policies and higher educational reforms represent decades of ongoing debate concerning the structure, objectives and capabilities of Norwegian universities. The national intention was, and still is, to build more robust institutions that are able to mobilize regional resources for identification of new opportunities. In particular three types of interrelated challenges are identified in the case of Vestfold. These are related to:

- Challenges concerning contradictory policy schemes;
- Challenges concerning different culture and operational objectives;
- Challenges concerning weak entrepreneurial routines and capacities within university

As for the first point, the university college has responded to contradictory policy reforms by redefining its roles and strategies in regional industry development processes and by upgrading teaching and research quality, in addition to introducing third-mission activities. However, as reported by the university college and the industry, the contradictory policies have revealed the existence of friction between companies and the university college capabilities to serve the industry with adequate knowledge. It was not easy for a small vocational university college to receive recognition as local knowledge provider as they lacked industry cooperation experiences, administrative routines, and significant teaching and research quality. One of the difficulties encountered by the university college was the dilemma of building research capacities related to a diversified industry structure, commercialize knowledge and to build regional technology transfer capacities. In this respect, some of the difficulties encountered by the university were to identify regional industry strongholds when companies were reluctant to collaborate with the university and at the same time taking a regional and national position

within a specific industry niche. As reported by the university college, these policies were mostly used as rhetoric arguments to fulfil the vision of the university college. Such friction of reluctances following contradictory policies is a very important finding of this study, as they reveal the inherited complexities of implementing new innovation policies that foster system changes to reorient the regional industry structure, one in which all actors need to adjust their role to new ways of producing knowledge. These challenges were solved by introducing bottom-up process through industry mobilization and involvement. The aim was to modernize the university college by renewing educational programs, increase research quality, and identify regional strongholds by using an EDP which mobilized regional actors.

Concerning the second pullet point, different culture between university and industry, the mutual reluctance between industry and academia illustrate the differences in culturally embedded understanding of the role of the university college in the society and new forms of knowledge production. As a response to the new policies, the university college upgraded the academic staff formal competence, Ph.D. and professor qualifications, which did not necessarily benefit industry needs. The broader majority of companies reported that the upgrading of academic competence was not related to their core business area innovation mode. Another difficulties concern the regional industry search for knowledge and their innovation modes. Larger technology-intensive firms investing heavily in R&D capacity tap knowledge from the global knowledge chain rather than rely on localized research collaboration. As an example, the high ambition of the MEMS technology research agenda pushed the university college to become more internationally visible through publication, which in turn pushed the college further away from the companies' shorter term commercial goals and knowledge need. On the other hand, becoming part of a global knowledge chain within MEMS technology research gave the academic staff an opportunity to collaborate with highly ranked academics, which in turn made them more attractive as research partners for microelectronics companies

but not necessary for the wider industry community. The MEMS/IMST story illustrates how universities are exposed to strong interest conflict between being regionally oriented and global research ambition, which might not necessarily coincide with regional EDP due to companies' modes of innovation and different institutional setup.

The last pullet point, challenges concerning weak internal organizational routines and entrepreneurial practice. As illustrated, these types of vocational university colleges were not designed to provide regions with basic teaching and educational programs. Most of these universities colleges lacked experiences to collaborate with a demanding industry, they also lacked administrative practice and competence to serve such forms for EDP development processes. However, a very important finding from this study is how long-term engagement in EDP practice strengthened a university college capability to support regional advanced companies and the wider industry community with innovation competence. The case illustrate the challenges of build-up of a regional entrepreneurial discovery process in the mind of the university college, companies' innovation mode and their novel ways of searching for knowledge in addition to their short-term commercial focus which drives regional economic path growth. On the other hand, universities operate on a longer time scale and hold a significant surplus of resources which can be used to unfold multiple evolutionary trajectories and enhance the overall responsiveness of the regional innovation system capability to react to market pressures e.g. the entrepreneurial system level role. This case shows that mobilization of industry cooperation mobilized resources (human, physical infrastructure, knowledge and funding) help the university college to renew and modernize their educational programmes and research quality, in addition to experiment with new interactive work forms. These types of work forms became internalized and embedded in the university college's organizational capacities to support regional EDP. The entrepreneurial discovery process which seems to be in the heart of the university college has strengthened the regional system ability to identify

new areas of opportunities based on existing knowledge base and diffuse knowledge into new economic activity, such as the water treatment case.

Conclusion and policy recommendation

The purpose of this paper was to identify challenges and opportunities experienced by Vestfold University College in building entrepreneurial discovery process capabilities by responding to new policy schemes and companies' novel ways of searching for knowledge. The University College and the region of Vestfold seemed appropriate for this type of analysis because of its long term engagement in developing regional innovation system with strong participation from the region industry.

The Vestfold University College appears, in their experimental work form, to be a valuable entrepreneurial system level actor for engaging relevant industries and actors in a continuous long term EDP. While this article cannot constitute a complete evaluation of the EDP process or the entrepreneurial system level role of universities, it never less indicates that small university colleges offer an appropriate development platform for mobilizing industry engagement and collaboration between regional actors. By continuous response to new and conflicting policy schemes and adapting to companies novel ways of searching for knowledge in the global-local context, the university college have developed capabilities to diffuse related knowledge into the wider industry community and gradually change the institutional setup of the regional industry community. The university college have developed a strategic vision, reformed and reinvent in its educational and research program, invented in new collaborative work forms, in addition to embedded third-mission activities within its organizational structure and culture. By building EDP competence and mobilizing industry resources (human, funding, infrastructure) the university college meet with partners previously out of their radius for research and innovation activities. Notably, the EDP process and the entrepreneurial system

level role is intended to be sustainable over time, allowing the actors in the regional innovation system to continuously build new interactive learning and knowledge sharing capabilities which will attract new and related knowledge to diffuse into the regional industry community. Many of these results can be generalized for the benefit for of other periphery regions in Europe which holds an institutionally thin or diversified region supported by a smaller university or university college with few resources; first the paper confirms that building regional EDP capability is a long-term engagement process of many regional actors addressing the importance of mobilizing industry resources and collaboration with the science and educational system, second, it confirms the importance of building responsiveness to shifting policy reforms and companies novel ways of searching for knowledge, third, it confirms the importance to build internal capacities to handle third-mission activities through reforming teaching and research activities, developing new entrepreneurial practice and routines, and continuous experiment in new collaborative interactive learning and knowledge sharing activities.

Despite the overall positive experience and opportunities of EDP capability building, the university college faced several challenges in their effort to take the role as an entrepreneurial system level actor. These challenges partly reflect the shifting circumstances following the entrance of new contradictory policy schemes, different institutions in the meaning of culturally embedded understanding, and challenges of lack of experience and routines following entrepreneurial discovery process. These challenges mirror the dynamic, heterogeneous and path dependent processes of regional development which reflect the strategic nature of the EDP. While these difficulties point to the need for universities to build relevant and legal administrative capacities, they also call for greater reflection on the formative processes and how regions diversify and grow (e.g. path dependent regional development) which calls for more experimentation in new collaborative work forms. A policy implication following this study findings suggest that it is critical to further improve and nuance regional

innovation and higher education policies so that EDP processes can strengthen the entrepreneurial system level role of universities in peripheral and core areas. Last but not least, the findings from the study show that universities are still facing several challenges concerning fulfilling the broader objectives of third-mission activities, despite greater awareness of the possibilities ingrained in EDP.

To conclude, while the future is challenging for universities which face policy environment more dynamically than the organizational culture and administrative capacities of university, universities are showing both resilience and leadership abilities in taking up the challenges from becoming regional entrepreneurial system level actor (e.g. RIS3 approach).

Disclosure statement

No potential conflict of interest was reported to the author.

Funding

This work was supported by the Research Council of Norway

References

- Asheim BT, Boschma R and Cooke P (2011) Constructing Regional Advantage: Platform Policies Based on Related Variety and Differentiated Knowledge Bases. *Regional Studies* 45: 893-904.
- Balconi M and Centuori A (2004) *On the creation and distribution of knowledge in microelectronics*. Available at: www.oecd.org/edu/educationeconomyandsociety/32126062.pdf.
- Bathelt H, Malmberg A and Maskell P (2004) Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. *Progress in Human Geography* 28: 31-56.
- Berger PL and Luckmann T (1967) *The social construction of reality a treatise in the sociology of knowledge*, Garden City, N. Y.: Doubleday.
- Bleiklie I and Kogan M (2007) Organization and Governance of Universities. *High Education Policy* 20: 477-493.
- Bonaccorsi A, Daraio C and Geuna A (2010) Universities in the New Knowledge Landscape: Tensions, Challenges, Change-An Introduction. *Minerva* 48: 1-4.
- Boschma R. (2010) The spatial evolution of innovation networks: a proximity perspective. In: Boschma R and Martin R (eds) *The Handbook of Evolutionary Economic Geography*. Edward Elgar, 120-139.
- Boschma R and Frenken K. (2011) Technological relatedness and regional branching. In: Bathelt H, Feldman MP and Kogler DF (eds) *Beyond Territory: Dynamic Geographies of Knowledge Creation, Diffusion, and Innovation*. Routledge.
- Brekke T. (2015) Entrepreneurship and path dependency in regional development. *Entrepreneurship & Regional Development*: 1-17.
- Caniels MCJ and van den Bosch H. (2011) The role of Higher Education Institutions in building regional innovation systems. *Papers in Regional Science* 90: 271-U377.
- Eisenhardt KM. (1989) Building theories from case study research. (Special Forum on Theory Building). *Academy of Management Review* 14: 532.
- Foray D. (2014) *Smart Specialisation : Opportunities and Challenges for Regional Innovation Policy*, Hoboken: Taylor and Francis.
- Foss L and Gibson DV. (2015) *The Entrepreneurial university : context and institutional change*, London: Routledge.
- Garud R, Hardy C and Maguire S. (2007) Institutional Entrepreneurship as Embedded Agency: An Introduction to the Special Issue. *Organization Studies* 28: 957-969.
- Gausdal A. (2008) Network reflection: a road to regional learning, trust and innovation. Bodø: HHB, XIII, 266 s.
- Gioia DA, Corley KG and Hamilton AL. (2013) Seeking Qualitative Rigor in Inductive Research: Notes on the Gioia Methodology. *Organizational Research Methods* 16: 15-31.
- Goddard JB, Kempton L and Vallance P. (2013) Universities and Smart Specialisation: challenges, tensions and opportunities for the innovation strategies of european regions. *Ekonomiaz: Revista vasca de economía*: 82-101.
- Gulbrandsen M and Nedrum L. (2009) Public Sector Research and Industrial Innovation in Norway: A Historical Perspective. In: Fagerberg J, Mowery D and Verspagen B (eds) *Innovation, Path Dependency and policy. The Norwegian Case*. New York: Oxford University Press, 61-88.
- Ham RM, Linden G and Appleyard MM. (1998) The evolving role of semiconductor consortia in the United States and Japan. *California Management Review* 41: 137.

- Herstad SJ and Brekke T. (2012) Globalization, Modes of Innovation and Regional Knowledge Diffusion Infrastructures. *European Planning Studies* 20: 1603-1625.
- Isaksen A. (2003) Learning, globalization, and the electronic cluster in horten: discussing the local buzz-global pipeline argument. In: Asheim BT, Coenen L and Svensson-Henning M (eds) *Nordic SMEs and Regional Innovation Systems-Final Report*. Oslo: Nordic Innovation Centre.
- Isaksen A, Kyllingstad N, Rypestøl JO, et al. (2018) Differentiated regional entrepreneurial discovery processes. A conceptual discussion and empirical illustration from three emergent clusters. *European Planning Studies*: 1-16.
- Jensen MB, Johnson B, Lorenz E, et al. (2007) Forms of knowledge and modes of innovation. *Research Policy* 36: 680-693.
- Kempton L, Goddard JB, Edwards J, et al. (2013) Universities and Smart Specialisation. In: Commission E (ed) *JRC Scientific and Policy Reports*. Spain: Institute for Prospective Technological Studies
- Kwiek M and Maassen P. (2012) *National Higher Education Reforms in a European Context: Comparative Reflections on Poland and Norway Higher Education Research and Policy 2*: Germany: Peter Lang Ag.
- Kyvik S. (2002) The Merger of Non-University Colleges in Norway. *Higher Education* 44: 53-72.
- Langfeldt L, Benner M, Sivertsen G, et al. (2015) Excellence and growth dynamics: A comparative study of the Matthew effect. *Science and Public Policy* 42: 661-675.
- Larsen IM and Kyvik S. (2006) *Tolv år etter høskolereformen en statusrapport om FOU i statlige høskoler*, Oslo: NIFU STEP.
- Marinelli E and Elena-Perez S. (2017) Catalan universities and the entrepreneurial discovery process: Challenges and opportunities emerging from the RIS3CAT Communities. *Industry and Higher Education* 31: 360-372.
- Martin R and Sunley P. (2010) The place of path dependence in an evolutionary perspective on the economic landscape. In: Boschma R and Martin R (eds) *The Handbook of Evolutionary Economic Geography*. Celtenham UK: Edward Elgar Publishing 62-93.
- McCann P and Ortega-Argilés R. (2015) Smart Specialization, Regional Growth and Applications to European Union Cohesion Policy. *Regional Studies* 49: 1291-1302.
- Nilsson J-E. (2006) *The Role of universities in regional innovation systems a Nordic perspective*, [Frederiksberg]: Copenhagen Business School Press.
- Nooteboom B. (2000) Learning by Interaction: Absorptive Capacity, Cognitive Distance and Governance. *Journal of Management and Governance* 4: 69-92.
- Pinheiro R and Stensaker B. (2014) Designing the Entrepreneurial University: The Interpretation of a Global Idea. *Public Organization Review* 14: 497-516.
- Ponds R, Oort Fv and Frenken K. (2010) Innovation, spillovers and university industry collaboration: an extended knowledge production function approach. *Journal of Economic Geography* 10: 231-255.
- Sayer RA. (2000) *Realism and social science*, London: Sage.
- Stensaker B and Benner M. (2013) Doomed to be Entrepreneurial: Institutional Transformation or Institutional Lock-Ins of 'New' Universities? *Minerva* 51: 399-416.
- Svare H and Gausdal AH. (2015) Strengthening regional innovation through network-based innovation brokering. *Entrepreneurship & Regional Development* 27: 619-643.
- Teece D and Pisano G. (1994) The Dynamic Capabilities of Firms: an Introduction. *Industrial and Corporate Change* 3: 537-556.
- Trippel M, Sinozic T and Smith HL. (2015) The Role of Universities in Regional Development: Conceptual Models and Policy Institutions in the UK, Sweden and Austria. *European Planning Studies*: 1-19.

- Tödtling F and Trippel M. (2005) One size fits all?: Towards a differentiated regional innovation policy approach. *Research Policy* 34: 1203-1219.
- Uhlin Å and Johansen R. (2001) Innovation and the post-academic condition. The case of Vestfold University College and the "Electronic Coast" project. *2nd Research Conference on University and Society Co-operation*. Halmstad University Sweden.
- Uyarra E. (2010) Conceptualizing the Regional Roles of Universities, Implications and Contradictions. *European Planning Studies* 18: 1227-1246.
- Vallance P. (2016) Universities, Public Research, and Evolutionary Economic Geography. *Economic Geography* 92: 1-23.
- Weick KE. (1995) *Sensemaking in organizations*, Thousand Oaks, Calif.: Sage.
- Wicken O. (2009a) The layers of National Innovation Systems: The Historical Evolution of a National Innovation System in Norway. In: Fagerberg J, Mowery D and Verspagen B (eds) *Innovation, path Dependency, and policy. The Norwegian Case*. New York: Oxford University Press, 33-60.
- Wicken O. (2009b) Policies for Path Creation: The Rise and Fall of Norway's Research-Driven Strategy for Industrialization. In: Fagerberg J, Mowery D and Verspagen B (eds) *Innovation, path Dependency, and policy. The Norwegian Case*. New York: Oxford University Press, 89-115.
- Yin RK. (1981) The Case Study as a Serious Research Strategy. *Knowledge: Creation, Diffusion, Utilization* 3: 97-114.

RESEARCH PAPER 4

What do we know about the university contributions to regional economic development?

A conceptual framework

Thomas Brekke

TO BE REVISED FOR PUBLICATION

International Regional Science Review



What do we know about the university contributions to regional economic development?

A conceptual framework

Abstract

There is a rapidly growing number of scientific studies analysing the role of university and higher educational institutions in regional economic development. In this study, the author reviews the rapidly growing body of research streaming out of the geography of innovation and knowledge with particular attention to the period from 1994 to 2019. The author discusses several seminal contributions on the role of universities in regional economic development and then applies a systematic literature review to review the extant research of 193 articles. This literature review on the relation between universities and regional economic development offers a conceptual framework by identifying four key topics in the literature: organizational capacity, intermediaries, knowledge dynamics and policy.

Keywords: university change, regional development, entrepreneurship, literature review, research policy

Introduction

What do we know about universities and higher educational institutions (HEIs) in relation to regional economic development? In recent decades, universities and HEIs have been addressed as key actors for industrial renewal and regional economic growth, due to their assumed effect on spatial knowledge production, innovation and societal changes (Benneworth and Hospers 2007, OECD 2014). Yet, the role of universities in economic and social development is a

complex, multilevel and emergent phenomenon that spans over time and that requires a skilful leadership and policy approach in order to maximize the benefits of localized university–industry interaction (Drucker and Goldstein 2007). Considerable knowledge has been built up over the last few decades of research at four levels of analysis: the organizational impact and functions of universities; intermediary functions; the multilevel approaches focusing on the knowledge dynamic of firm behaviour; and policies for regional development and innovation. Despite this breadth of research, knowledge is still fragmented and the research field lacks integrative multi-analysis as Peer and Penker (2016) argue in their review. Inspired by the growing amount of policy documents and regional innovation studies that emphasize the role of universities, a literature search on the term “University/Higher Education and regional economic development” was conducted on Web of Science on 18 November 2016, which identified 158 articles. A new search was conducted on 28 February 2019 based on the same search string, which created 35 new articles. The literature reviewed consists of a total of 193 articles, from which there were three distinct review articles that are relevant to the purposes of this study (Peer and Penker 2016, Drucker and Goldstein 2007, Caniels and van den Bosch 2011). Peer and Penker’s (2016) ambition is to build a sound knowledge basis based on an investigation of policy documents and literature on the role of HEIs in regional economic development. Caniels and van den Bosch (2011) take a narrower regional innovation system approach by asking the question, “In what ways can HEIs fuel interorganizational learning within the region?” The third approach, by Drucker and Goldstein (2007), analyses the evidence of four research studies in the literature by asking the question of whether and to what extent HEIs influence regional economic development outcomes. While all of these review articles focus on the relationship between universities/HEIs and the regional level, they all take different methodological approaches and use different definitions of core concepts. Only one of the reviewed articles is common to all three of the review articles. Based on the literature review,

it seems that the research field is characterized by a panoply of different research approaches, methods and definitions, which makes it hard to draw conclusions for policy and management purposes (Trippel, Sinozic, and Lawton Smith 2015). As an example, the constituency of what characterizes a university has different meanings in different countries, and the roles of universities in regional development have been measured and interpreted differently within the same research area (Trippel, Sinozic, and Lawton Smith 2015). The same is true of the concept of regions, which has been criticized as being a fuzzy analytical concept. Region as an analytical concept has been interpreted differently by researchers and policymakers in terms of regional characteristics, boundary drawing, change mechanisms, and policies (Asheim, Lawton Smith, and Oughton 2011). These issues will be further addressed in the discussion and conclusion section of the paper. The aim of the paper is to review the growing number of studies on university and regional development and offer a better understanding of core findings from the large amount of research studies carried out in this research area. Then the paper proposes a conceptual framework for future research studies.

This paper is organized as follows. In the next section the process of the literature review is described. Then a discussion on the interpretation of the words “university” and “region” is presented, followed by a methodological overview. Next, the review process is described, which ends with a presentation of the four main key topics with their 13 subthemes. Based on the four key topics a conceptual framework is discussed. At the end of the paper there is a discussion on the direction of future research and a conclusion.

Methodology

In this study, the review methodology began from a disciplinary stance by exploring the emerging phenomenon of university change and regional economic development based on the researcher’s prior experience of extensive reading in the literature. In order to avoid the pitfalls

of a narrative literature review, which can sometimes be vulnerable to criticism that the choice of articles was biased, arbitrary or limited in scope, a systematic literature review process (SLR) was used (Pittaway and Cope 2007, Bazeley 2007, Sorensen 2008). The SLRs emphasize basic principles of transparency, clarity, equality and accessibility, supported by the use of methods for assessing the quality of the empirical evidence via detailed search criteria within citation indexes from Web of Science (Pittaway and Cope 2007). The SLR process, in this study, is based on a five-stage procedure of formal and manual delimitation and expansion of the selected articles (Table 1) supported by the use of the software analytical tool QSR NVivo 11.

In the first stage, a formal search was performed on 16 November 2016 supported by a follow-up search on 28 February 2019 in Web of Science using the following search string ("University" OR "Higher Education") AND ("regional economic development" OR "regional innovation system?"). The terms “university” and “higher education” as the construct of the search string were used, because they were traditionally treated as interchangeable in the literature (Boucher, Conway, and Van Der Meer 2003, Chatterton and Goddard 2000, Clark 2004, Drucker 2016, Goddard and Chatterton 2000). “Regional economic development” and “regional innovation system” are selected as constituents of the search process as these terms have become popular research topics in the last few decades and they also emphasize the localized or regional role of universities/HEIs (Etzkowitz and Leydesdorff 1997, Cooke, Heidenreich, and Braczyk 1998). The selected time span was set from 1994 to 2018, as there were no journal publications identified by Web of Science before 1994. The total number of selected articles was 193. Non-English papers and papers in working progress were eliminated.

The second stage included a citation analysis through the use of Web of Science analytical tools, which is further described in the section on descriptive analysis.

Third, an intensive selection process of reading abstracts and keywords was used to reduce the number of papers, ending up with 178 articles. By focusing on the relationship

between university/higher education and regional development, only abstracts that directly positioned the selected papers' research findings and research questions in line with the literature review research question were selected for further analysis. Papers that referred in general terms to university or higher education without discussion of the particular relationship between university/higher education and regional economic development or the regional innovation system were discarded from the process.

Fourth, in order to gain an overview of frequently occurring words or concepts, frequent-words analysis was conducted as the starting point of a coding scheme with the use of QSR NVivo 11 analysis software. This technique identified the 20 most frequent words found in the literature (Table 1). The coding scheme identified keywords, themes and the relationships between keywords and themes, which called for more exploration and a basis for building categories and subthemes.

In the fifth stage, based on the coding scheme, a manual inductive review process (Strauss and Corbin 1990, Gioia, Corley, and Hamilton 2013) identified concepts (first-order concepts), themes (second-order themes) and key categories. The SLR process identified four key dimensions or categories and 13 sub-themes of the research topics, which became the subject of further manual text search analysis. The organizational principles of the manual text search analysis were study topic, hypothesis or questions, and contributions. The analysis revealed that several papers are boundary-spanning papers. A cluster analysis of coding similarities (QSR NVivo 11) shows that the articles are not coherent in terms of theme structure. In other words, studies that were similar in word usage did not necessarily deal with similar issues and vice versa. The first key category of articles is studies that take the university point of view by focusing on the organizational capacity for regional innovation and growth. The category includes subthemes such as organizational characteristics, university roles and models, and drivers of change. The second category of studies examines intermediary roles, functions

and activities. Issues such as Triple Helix/RIS, knowledge spillover, knowledge production function (KPN), spin-off, start-up, employment, and knowledge infrastructure are found in this subtheme of articles. The third category of articles examines industry knowledge dynamics such as firm R&D strategies, absorptive capacity studies, and region as locus for knowledge sources. The fourth and last key category of studies is policy studies that include subthemes of general policy studies, core and peripheral RIS studies, and broader RIS policy studies.

Stage	Description
1.	A formal search was conducted with the use of Web of Science using the following search string ("University" OR "Higher Education") AND ("regional economic development" OR "regional innovation system?"). Non-English papers were discarded from the review process, ending up with 193 papers.
2.	Descriptive citation analysis was conducted by using Web of Science citation analytical tools identifying the most popular journals, countries of origin, research areas, citation score and h-index 2.
3.	Relevant articles and abstracts were downloaded into bibliographic software (EndNote). The bibliographic software was used to abstract and manually identify keywords, discarding papers for which the paper research findings or research questions were not positioned within the literature review framework, ending up with 147 articles.
4.	The EndNote library was download into qualitative analysis software (QSR NVivo 11) where an exploratory content analysis and text search query were conducted by using word frequency analysis aimed at building a coding scheme where articles were classified by assigning attributes.
5.	A manual review process based on the coding scheme identified key themes and subthemes using a rigorous inductive method.

Table 1. Stages and procedures of the systematic literature review process

The terms “regions” and “university” used in the research studies

Regions are today seen as important bases for economic coordination and transfer of knowledge as regions represent spaces where people live and work, where business operates, wealth is produced, and services and products are consumed (Cooke, Heidenreich, and Braczyk 1998, Arbo and Benneworth 2007, Martin 2017). Although the term “regions” is often used to explain uneven spatial economic development and as a unit of target policy design, there exists

no unified definition or operational measurement of the concept. Some theorists merely presume the a priori existence of a cohesive geographic and economic entity known as a “region”, whereas others base theory on more explicit definitions found in some common approaches such as central place theory and location theory, the nodal or labour market approach, and the functional economic area approach (Dawkins 2003). The most widely used approach among theorists is the functional economic area approach, which is a variation of the central place theory and the labour market approach. The theory is based on the view that the dominance of a central node (place or city) over the surrounding periphery is attributed to the spatial dependence of workers adjacent to employment centres. The approach applies labour as the unit of measurement as labour mirrors how economic agents perceive their environment, the commuting distance, and the fact that labour markets also serve as a consumer market. The problem with this definition is that geography (region) is no longer the primary constraint on the boundary of social and economic organizations as advances in communication and transportation technologies have weakened many of the centripetal forces that tie the labour market and economic agents to a place. Secondly, political boundaries rarely correspond to functional economic areas, which reduces the causal relationship between a specific regional problem and the policy instrument design to solve the problem, and estimating the effect of policy tools on regional economic development. In the last few decades a strain of economic theories has contributed with a new understanding of what drives regional transformation processes. These theories (institutional, neo-Schumpeterian and evolutionary theory) emphasize the existence of a place-specific institutional, social and cultural set-up that creates unique regional competitive advantages, and sees change as endogenous and relational. These theories propose a shift of focus from defining region in terms of absolute and relative (i.e. functional and administrative) to focus on region as absolute, relative and relational where the term “region” is defined as a system of requiring interaction among a set of actors. The absolute,

relative and relational theories emphasize the local cultural embeddedness of economy and the spatialities of knowledge creation and transfer (Martin 2017). Consequently, regional spaces become more complex to define and they cannot be treated as a pre-given entity with clear boundaries as actors continuously shape and reshape social interaction. Cooke (2005) claims that a region is “a unit for geographical, functional, social or cultural reasons”, which emphasizes different forms of proximities (social, geographical, cultural, etc.), interaction, and institutional mechanisms such as norms, culture, trust, rules, and history. Consequently, the cultural and social dimension of space also includes a shift in searching for general and universal laws towards focusing on particularities, and the context-based dimension (Isaksen and Trippel, 2017). The shift towards the region as absolute, relative and relational has two research implications. There are a growing number of comparative surveys and case studies capturing the unique place-dependent regional knowledge spillover dynamism, and there is a research stream focusing on articulating generalities and particularities of specific regional development dynamics. The objectives of research on generalities and particularities are to measure R&D investment, innovation output, the degree of university involvement in university–industry collaboration and a region’s knowledge base (Leydesdorff and Fritsch 2006). However, the quality and reliability of national patent data and other sources used in large surveys, such as the European Union Community Innovation Survey (CIS) and the German Social Insurance Statistics, have been questioned due to a lack of unifying definitions, common sampling procedures and access to longitudinal data (Pinto, Fernandez-Esquinas, and Uyarra 2015). As an example, Strand and Leydesdorff (2013) conclude in their study of the Norwegian innovation system that a comparison with the Netherlands is of little value or relevance due to the various sizes of geographical units, and different population density, sampling procedures, and historical and geographical factors. Case studies based on qualitative methods with objectives to describe unique place-dependent regional knowledge spillover

dynamism are often used as an approach to identify how change mechanisms work under different regional contexts and circumstances. Such case studies are often criticized for lacking significant generalities, so they become storytelling without explanatory power to describe or identify significant mechanisms of regional change. However, case studies can provide a better and richer understanding of localized growth dynamics based on a bottom-up perspective that identifies particularities (Martin 2017). Bearing in mind that regions are often used as an analytical starting point or unit of analysis and policy design, there is a current need to further clarify the term “region”, what constitutes the boundary of a region, how regions change and grow, and what mechanisms influence regional knowledge dynamics in a long-term perspective (Benneworth and Hospers 2007). In particular, as Cooke (2005, 1129) notes, “... it may serve some purpose in reminding ‘regional’ scientists to make doubly clear their use of the term ‘regional’ is relational not containerized”. For the purpose of this review, a region will be defined as a spatially contiguous population of human beings and economic agents (organizations) that is bounded either by historical necessity or by choice to a particular geographic space. The dependence on location may arise from a shared attraction to local culture, labour force, natural resources, geographical and social proximity, and an institutional set-up that is unique and not easy to imitate.

As the regional discourse has shifted from a focus on structure and generalization to process and contextualized generalization, the role of the higher educational system and universities at the regional level has become an important topic in the regional development debate. The objectives of regional economic development studies are to better grasp the regional knowledge dynamism and capabilities for innovation in a significantly more open and more global knowledge system, where place-specific capabilities (proximity, spatial concentration, institutions) are seen as competitive advantages and drivers for path-dependent regional development processes (Asheim, Boschma, and Cooke 2011). In particular, the regional

innovation system approach emphasizes co-operation in innovation activity between firms and knowledge-creating and -diffusing organizations, such as universities. In general, universities are recognized as a key actor for creating and diffusing localized knowledge. However, the variety of university types has not been readily recognized by scholars or policymakers (Huggins, Johnston, and Stride 2012, Smith 2007). There are several types of typologies and indicators used in the literature to differentiate the variety of university types and their relationship with society. A classical approach is to differentiate between established, “prestigious”, and research-intensive universities and those with less established track records in terms of knowledge production, measured by patent data, research publication or licence agreement. Some studies indicate that prestigious large universities are more outward-looking and network-oriented than younger institutions. However, other studies claim that old prestigious institutions are more loosely coupled to societal needs and act more or less independently of the surrounding environment. Other studies differentiate between various university roles or models in terms of their regional engagement and third-mission activities. New typologies such as the entrepreneurial university, the engaged university, the Mode 2 university and the Triple Helix university have emerged in the last few decades. These university typologies are not clearly defined, they have weak theoretical support and they are often treated as a relatively homogeneous group of actors, which they are not (Uyarra 2010).

Based on the above, it is clear, then, that the terms “regions” and “universities” are not unproblematic entities and they are far from simple concepts to be used for research and policy purposes without careful interpretation. Regions, like any other spatial scale of the economic system, are formed by complex social, technological and economic processes that are shaped by an almost infinite range of forces. These forces create different forms of regional path-dependent process (path creation, diversification or extension) and influence the unique

composition of the regional knowledge infrastructure, which universities are a part of. A similar interpretation can be noted for the term “university”, which is treated differently in the literature in terms of universities’ roles in society, functions, outreach activities and their organizational capacities to interact with their surrounding environment. Based on the above elaboration, and for the sake of this study, the term “university” will be used as a broad term that includes all types of higher educational institutions that provide society with education and research capacities.

Research review

In this section, an overall descriptive analysis of selected articles is first presented, focusing on the issue of the relationship between universities and regional economic development. Then the articles are grouped into four main categories of origin of studies (i.e. organizing principles). The first category includes articles focusing on a hypothesis about the organizational capacities of universities, the second group of studies emphasizes a hypothesis about the role of intermediary structures and functions for localized knowledge spillover, the third category of studies focuses on a hypothesis regarding localized knowledge dynamics, and the fourth and final category of studies focuses on a hypothesis concerning policy design and measurements.

Descriptive analysis of studies

The initial search revealed 193 articles. In addition, references were used from previous review articles (Drucker and Goldstein 2007, Caniels and van den Bosch 2011, Peer and Penker 2016). The publication years spanned from 1994 to 2018. Non-English papers and papers not relevant to university or regional development were discarded, resulting in 193 articles. The articles came from 78 journals and 377 authors. In total, the articles were cited 4504 times, with an h-

index score of 30 (based on h-index calculation by Web of Science). The average number of citations per item is 23.34. The 10 most common research areas are business economics (118), public administration (62), environmental sciences ecology (56), geography (53), urban studies (29), engineering (20), education research (15), operation research management science (13), information science library science (7) and computer science (6). The most popular journals are (by number of articles) *European Planning Studies* (15), *Regional Studies* (15), *Economic Development Quarterly* (8), *Research Policy* (8), *Science and Public Policy* (7) *Journal of Technology Transfer* (6), *Technological Forecasting and Social Change* (5), *Entrepreneurship and Regional Development* (5) and *Technological Forecasting and Social Change* (5). Most of these articles are dominated by authors from Western countries (156 out of 193 articles). Fifty-five articles came from the USA, 29 from England, 18 from Italy, 17 from Sweden, 15 from China, 12 from the Netherlands, and nine from each of Norway, Canada and Spain. The average citation score and h-index from articles were as follows: the USA 33.82/16, the Netherlands 23.55/7, Sweden 24.87/9, England 12.54/10, Italy 10.5/6 and China 8.75/6. There has been an exponential growth in the number of articles published on universities or higher education institutions, especially in relation to regional economic contribution (Benneworth and Hospers 2007, Peer and Penker 2016). The growth of the research field shows that between 1994 and 2018 the number of published articles grew gradually from 1995 until 2012, with a significantly increased number of publications from 2013 to 2017 (Figure 1).

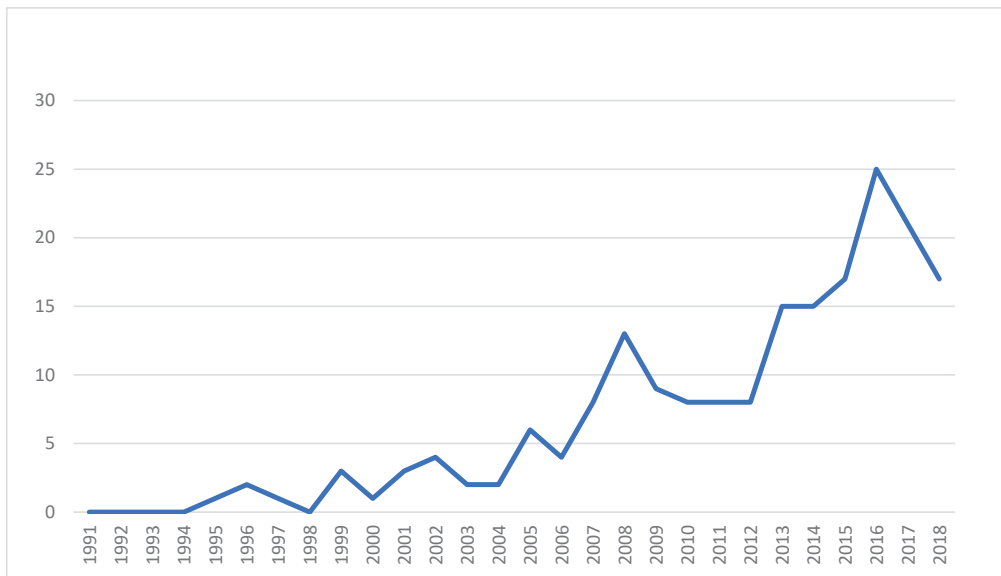


Figure 1. Publications per year from 1994 to 2018 (N=193).

The growth of studies discussing/dealing with university contributions to regional development reflects the significant rise in interest among scientific communities in the last decade. In light of the increasing interest in the role universities play for societal and innovation purposes, the growth of new articles will probably continue in the years to come.

Studies on universities' organizational capacities for regional innovation and growth

Studies on universities' internal capacities for innovation and growth (28 articles) include issues such as the role of the university in a knowledge-based society, and how universities organize themselves in boundary-spanning activities (Gumport and Sporn 1999, Gumport 2000, Harding 2007). Three streams of research are identified in this study category (Table 3). These are the organizational characteristics of universities, universities' roles and university change forces. Studies focus on the internal characteristics of universities as a mechanism that either promotes or hampers universities' role in regional economic development. The basic assumptions are that

organizational capacities are formed by the relationship between the internal organizational structure of the university and the corresponding profile of the economic structure of the region (Caniels and van den Bosch 2011). These studies emphasize that such a correspondence to the profile of the economic structure opens up the opportunity for the transfer of knowledge, interactive learning and resource mobility between universities and society. The hypothesis of similarities in competence and experience assumes that corresponding competence and knowledge make interactive learning possible, which is further strengthened when there is a strong academic ethos that is supportive of university–industry interaction (Lee 1996, Hayter 2015, Boucher, Conway, and Van Der Meer 2003). One possible reflection made from these analyses is that the degree of organizational similarities, competence and knowledge bases seems to impact on regional innovation capability in terms of universities' capacity to interact and disseminate knowledge to the regional business life. However, it is a more open question whether overly close similarities or correspondence of knowledge and competence might hamper a region's capability to diversify into new promising industries or companies' novel ways of searching for (un)related knowledge (Brekke 2015, Cowan and Zinovyeva 2013).

Another research theme is focusing on different types of university roles (Uyarra 2010). In particular, the role played by universities in different regional innovation system (RIS) approaches, and the regional and national context including policy institutions that underpin them, have become popular studies. The literature has gradually changed focus from seeing the university–industry relationship as ad hoc activities of independent actors towards an integrative and systemic perspective where universities become key actors within a more global, national and regional knowledge system. Trippel, Sinozic, and Lawton Smith (2015) classify different roles of universities in a narrow and a broad view. These views of roles are based on different types of activities, the policy implication that can be drawn, and the regional and national policy context. Uyarra (2010) identifies five key roles portrayed in the literature

in relation to university activity and the way policies tend to explicitly reflect one or a combination of several of these roles. These are: the knowledge factory, the relational or collaborative role, the commercial or entrepreneurial university, the node- or boundary-spanning role, and the development role. As Uyarra (2010), Youtie and Shapira (2008), and Tripl, Sinozic, and Lawton Smith (2015) point out, universities often reflect all these roles or different views to a lesser or greater extent, which raises a serious concern over the potentially unrealistic expectation of the university balancing a broad range of stakeholders' needs and new tasks against its traditional core mission without fundamental restructuring and reorientation of the university. One conclusion from these studies reveals that national policies, industrial trajectories, university characteristics, regional culture and norms may be key explanatory variables for different forms of university engagement and knowledge transfer mechanisms at work.

The last research theme focuses on what the mechanisms and forces are that drive university changes. There two main categories of studies within this research stream. The first group of studies takes a more critical stand to the transformative forces following greater interaction with industry, and also includes studies that emphasize the dilemma between academic freedom and the expected, and sometimes unrealistic, contribution of universities to regional development (Boucher, Conway, and Van Der Meer 2003, Etzkowitz 2013). The second group of literature sees universities' contribution to regional development as a way of transforming old and sometimes outdated academic institutions into modern knowledge machines that have the capacity to become powerhouses for economic development by transferring knowledge to society and educating highly skilled students (Chatterton and Goddard 2000). The forces that drive these changes are often explained as exogenous to the university, driven by an increasingly open and global knowledge production system where nation states seem to be in a less favourable position to handle these forces, as it is at the regional

level that people live their lives and do their work. Mass education, the decline of state funding and the emergence of user-driven research policies are also forces that have been mentioned in regard to university change. Other studies have emphasized that the changes are also driven by endogenous forces, occurring within the university, through the upgrading of academic staff, and access to funding schemes, which can further increase the research quality and output into new areas of opportunity (Bramwell and Wolfe 2008).

Category	Themes	Key findings of mechanisms	Authors
University/HEI capacities	Organizational characteristics	Organizational capacities are formed by the relationship between the internal organizational structure of the university and the corresponding profile of the economic structure of the region.	Lee (1996), Goldstein and Drucker (2006), Fischer and Varga (2002), Huggins, Johnston, and Stride (2012), Hayter (2015)
	University roles and models	New university roles and models emerge as a series of transitions whereby multiple stakeholders continually shape the university business model. Different roles or models of universities emphasize different national policy path dependence, spatial activities and mechanism for engagement.	Gunasekara (2006), Benneworth et al. (2009), Miller, McAdam, and McAdam (2014), Flores et al. (2009), Guerrero et al. (2016)
	Drivers of university change	Diminishing public funding, globalization and regionalization of knowledge system, upgrading of academic staff competence, universities are seen as powerhouses for economic development and dissemination of knowledge for economic change.	Benneworth (2007), Boucher, Conway, and Van Der Meer (2003), Chatterton and Goddard (2000), Charles, Kitagawa, and Uyarra (2014), Coenen and Moodysson (2009)

Table 2. Most cited studies of university capacity building and impact studies

Studies of intermediary roles, functions and activities

Ninety-three out of the 193 reviewed articles in the literature emphasize the intermediary roles, functions and activities of universities. These studies address topics such as the Triple Helix

governance role and regional innovation system discourse, knowledge transfer or spillover and the knowledge production function (KPF), output analysis, which includes spin-off and knowledge infrastructure solutions such as technology transfer offices (TTOs), and science parks (Table 4).

Studies applying the theoretical concepts of Triple Helix and RIS are often used to inform policymakers about how to construct regional development and innovation. The Triple Helix model and the regional innovation system (RIS) explain the evolution of institutionalized collaboration among academia, industry and public government (Etzkowitz and Leydesdorff 1997). The Triple Helix hypothesis assumes that close interaction among a university, industry and government disintegrates the boundary of actors in such a way that each actor's sphere integrates into a self-sustaining dynamic process that is capable of moving across technological trajectories and renewing itself into new promising areas of opportunity (Etzkowitz and Leydesdorff 1997, Coenen 2007, Arbo and Benneworth 2007). The Triple Helix model is seen as endogenous and dynamic as the actors react to each other's selection. Within an RIS perspective, universities are seen as agents that can play a broader systemic role in regional economic development by plugging gaps in the local RIS or facilitating cluster development, particularly in less favoured regions (Benneworth 2007, Isaksen and Trippl 2017, Benneworth, Pinheiro, and Karlsen 2017). Network and local knowledge sharing based on geographical and cognitive proximity among actors is seen as a selection mechanism for enhancing regional economic growth. However, as Benneworth (2007, 504) states, "proximity is subject to a U-curve in its regional value; too much proximity can produce lock-in, path dependence and weaken the overall regional value of the activity". Organizational boundaries are assumed to be a selection mechanism that either strengthens or hampers university–industry interaction by discouraging some knowledge crossovers while encouraging others (Etzkowitz 2012). The constellation or composite of selection mechanisms is found to be highly localized, which is

often supported by a bottom-up policy, “use and demand driven”, that promotes localized knowledge spillover through regional branching mechanisms such as academic entrepreneurship, mobility or social networking.

The literature analysing knowledge transfer and spillover suggests there is a wide range of mechanisms (spin-off, research collaboration, human capital, licences and patents) through which universities can potentially contribute directly and indirectly to regional economic development. Economists, in particular, have used the knowledge-production-function framework (KPF) to articulate generalities and particularities of specific regions, policy implication and new development trends (Goldstein and Renault 2004). The KPF framework, first introduced by Griliches (1979) and later modified by Jaffe, Trajtenberg, and Henderson (1993), has been widely applied in survey studies on different geographical scales and in different industrial sectors (Fukugawa 2016, Ponds, van Oort, and Frenken 2010). The KPF framework captures regional knowledge inputs, such as private and academic R&D expenditures, and the effect on regional innovation output in terms of patents, new products or firm formation particular to certain technological and scientific fields (Drucker and Goldstein 2007). Recent research studies have modified and extended the Griliches-Jaffa model, and by so doing include other variables that give a wide variety of results. Findings from these studies indicate that universities stimulate regional economic development in a wide range of areas and especially where the presence of a university is found to positively impact on regional economic growth and innovativeness (Goldstein and Renault 2004, Buesa, Heijjs, and Baumert 2010). Ponds, van Oort, and Frenken (2010) found in their studies that spillover mechanisms from research collaboration occur over longer distances, since geographical distance is less important in the establishment of collaborative research in science-based industries.

Studies focusing on universities’ effect on regional economy are divided into three study themes: university spin-off (USO) or spin-out effects, technology transfer offices and science

park analysis, and human capital and employment studies. The terms “spin-off” and “spin-out” are often used in the literature interchangeably, and sometimes different definitions are applied to the same term. “Spin-out” is often defined as a new entity formed by staff from a parent organization that is based around some form of asset that was developed while staff were employed by the university. A “spin-off”, on the other hand, is defined as a part of a business that is separated from the parent organization to operate as an independent organizational entity. University spin-offs are assumed to be important technology transfer mechanisms for generating and sustaining regional economic growth and competitiveness (Bathelt, Kogler, and Munro 2010). A university spin-off is typically viewed as a new venture that is based on commercializing academic research efforts formed by a faculty, staff or students (Miner et al. 2012). A university spin-off can impact on economic and employment growth through the formation of new ventures and is recognized as being more innovative than other new technology-based firms. Other research findings indicate that a university spin-off can act in an intermediary role by attracting other high-tech companies to enter the region or by providing ideas and incentives for industrial renewal and reorganization of established firms (Bathelt, Kogler, and Munro 2011). Thus, USOs are often viewed positively by policymakers, yet evidence indicates that very few USOs grow and many remain very small. Some studies emphasize the role of experienced researchers as the founders of new ventures. Other research studies find that university spin-offs are often localized close to their parent organization as they are more dependent on the spatial proximity following from network effects in the first phase of the venture’s life, while later in their life cycle the customer relationship becomes a stronger location coefficient (Huggins 2008). The literature does not provide a clear-cut definition of the actual spin-off phenomenon; instead the term “university spin-off” remains a vaguely defined concept. This vagueness has created confusion about the different types of spin-off and the impact on local economic development.

Technology transfer offices (TTOs) or knowledge technology offices (KTOs) and science parks emerged as an organizational phenomenon in the late 1980s and 1990s as a response to encourage scientists to commercialize their research results. TTOs and science parks as intermediary structures are designed to support the commercialization of academic knowledge through spin-out, and intellectual property rights (IPR) management (Looy, Debackere, and Andries 2003). Most of these institutions are localized in technology-dense areas or larger city areas, which makes them less favourable tools for revitalizing less favourable regions. At the national level, research supports the effect that TTOs/KTOs and science parks have on promoting research collaboration and acting as a knowledge link among technology-dominating regions within and between nations (Yun and Lee 2013). Niosi and Banik (2005) examine the evolution and performance of several biotechnology regional innovation systems in Canada, finding that the creation of technology transfer offices in research universities plays a significant role in the growth of new RIS. A study by Parker and Hine (2014) examines intermediary knowledge transfer programmes and the effect on organizational learning capabilities; findings indicate that knowledge intermediaries, such as universities, affect firms' organizational learning capabilities by impacting on firms' network relationship, internal and external communication channels and internal learning process, which in turn affect the ability to interpret and use knowledge within the firm.

The last group of studies in this subtheme examine the positive university effect on employment growth and human capital. Eriksson and Forslund (2014) find that the university effect on employment growth is greatest in regions with a high concentration of skills capable of applying the knowledge created in universities, which means that the regional composition of skills needs to match the knowledge produced by the university for a significant university knowledge spillover effect. Another study, by Fallah, Partridge, and Rickman (2014), finds that

universities play their primary role in creating human capital rather than knowledge spillovers for nearby technology firms.

Category	Themes	Key findings of mechanisms	Authors
Intermediary roles and boundary-spanning functions	RIS/Triple Helix development	Universities as key actors for knowledge spillover. Knowledge selection mechanisms are found to be related to organizational boundary permeability, market environment, technological trajectories, cultural and communicative competence.	Chen and Kenney (2007), Coenen (2007), Etzkowitz (2012), Leydesdorff and Deakin (2011), Leydesdorff and Fritsch (2006)
	Knowledge spillover and knowledge production function	The KPF framework captures a variety of different regional knowledge spillover mechanisms and their effect on regional innovation output in terms of patents or new products. Findings from these studies indicate that universities are generally seen as important factors influencing regional differences in innovation performance.	Acs, Anselin, and Varga (2002), Buesa, Heijs, and Baumert (2010), Cowan and Zinovyeva (2013), Fukugawa (2016), Li, Kong, and Peng (2007), Li (2009), Hayter (2015)
	Spin-off, start-up, employment, and economic impact	University contribution to regional economy through several knowledge transfer mechanisms such as spin-offs or spin-outs, start-ups and employment. Findings indicate that larger or metropolitan areas benefit mostly from these knowledge transfer mechanisms due to growth being greatest in regions with a high concentration of skills capable of applying knowledge created by university.	Bathelt, Kogler, and Munro (2010), Bramwell and Wolfe (2008), Brown and Mason (2014), Huggins (2008), Steffensen, Rogers, and Speakman (2000)
	Knowledge infrastructures such as TTOs, science parks and KIBS	Knowledge intermediaries affect firms' organizational learning capabilities by impacting on firms' network relationship, and internal learning processes.	Niosi and Banik (2005), Pinto, Fernandez-Esquinas, and Uyarra (2015), Shapiro, So, and Woo Park (2010), Yun and Lee (2013), Lee and Kim (2016)

Table 3. Most cited studies of intermediary structure, role and function

Studies of regional knowledge dynamics

The literature review conducted in this study can be categorized into three types of research themes for regional industrial knowledge dynamics (total of 29 articles in this category). The first group of studies examines firms' strategies for searching for innovation and knowledge resources from a territorial perspective. The second group of studies emphasizes firms' ability to utilize external knowledge sources and spillovers for innovation purposes, and the third group of articles examines different types of regions and firms' patterns in sourcing knowledge relevant for innovation.

Recent work on innovation suggests that the strategies employed by firms to innovate depend not only on their own internal R&D capacities and competences, but also on boundary-spanning activities for searching for innovation and knowledge resources and the quality of the innovation systems, networks and supply chains with which they are operating. In particular, the availability of external knowledge sources for innovation – such as universities, and public and private research institutes – has been seen as a significant enabler of innovation (Roper et al. 2010, Agrawal and Cockburn 2003). Belussi, Sammarra, and Sedita (2010) examine the life science industry located in the region of Emilia Romagna and its use of public research organizations (PROs), finding that the life science industry used universities and PROs located outside the region more than regional-located universities. Freel (2000) examines strategy in innovative manufacturing SMEs, finding that innovators are found to spend a significantly greater proportion of turnover on research and development and to have more links with universities and support organizations than non-innovators. Some newer studies are expanding our knowledge about the knowledge spillover mechanism by including analyses of human capital development such as education and training. Barra and Zotti (2017) find in their studies that human capital development through university contribution has a positive impact on domestic production and geographical proximity. Pinto, Fernandez-Esquinas, and Uyarra

(2015), studying universities and knowledge-intensive business services (KIBS) as sources of knowledge for firms in a peripheral region in Spain, find that the absorptive capacity remains a central dimension in the interaction between universities and the use of KIBS. The interpretation is based on an understanding that universities are used as a form of KIBS in the absence of real KIBS. Taken together, the findings from these in general support the assumption that companies strongly benefit from university interaction through the educational function of universities with the recruitment of a skilled workforce. However, findings indicate that companies do not solely rely on local research capacities, such as universities, as companies become more integrated in the global network of knowledge (Fischer and Varga 2002).

The second group of studies deals with firms' absorptive capacity and modifies the seminal work by Cohen and Levinthal (1990) on notions of firms' ability to utilize external knowledge sources and spillovers as a function of their own investment in R&D. Cooke (2005) expands the absorptive capacity assumptions to include a more dynamic view. His proposition emphasizes that dynamic capabilities stimulate knowledge transfer in a spiralling model of knowledge that is complementary and upgrading, and where it also engages innovation institutions such as universities, it pulls them up the knowledge spiral.

The third group of articles examines different types of regions and firms' patterns in sourcing knowledge relevant for innovation. The hypothesis claims that central or metropolitan regions, which are characterized as organizationally thick and diversified or specialized, offer better conditions for knowledge transfer and localized learning than organizationally thin regions (Isaksen and Trippel 2017). By analysing different modes of innovation (doing, using interactive and science and technology innovation), types of regions (RIS typologies, e.g. organizationally thick and diversified or specialized and organizationally thin) and types of knowledge linkages, Isaksen and Trippel (2017) claim that spatial patterns of learning and knowledge exchange vary substantially across different types of regions and industrial contexts.

Tödtling, Lengauer, and Höglinger (2011) examine a thick and thin RIS within ICT companies in Austria, finding strong support for ICT localized in a metropolitan region benefiting more from the dense knowledge networks and university–industry collaboration than companies located in less urbanized areas. Their findings support the hypothesis that the density, structure and size of the RIS, as well as the characteristics of the industrial sector in the regions, influence the nature and geography of knowledge sourcing and the use of knowledge transfer mechanisms.

Category	Themes	Key findings of mechanisms	Authors
Industry knowledge dynamics	Firms' R&D strategy for knowledge source	Companies, particularly within science and engineering, strongly benefit from close collaboration with a university and the presence of a university impacts the regional support environment for innovation.	Agrawal and Cockburn (2003), Freel (2000), Roper et al. (2010), Pinto, Fernandez-Esquinas, and Uyarra (2015), Barra and Zotti (2017)
	Firms' absorptive capacity	Firms' ability to utilize external knowledge sources and spillovers is a function of their own investment in R&D. Knowledge transfer in a spiralling model of knowledge upgrades the actors' collective absorptive capacities.	Agrawal and Cockburn (2003), Cooke (2005)
	The region or RIS as locus for knowledge sources	The density, structure and size of the RIS, as well as the characteristics of the industrial sector in the regions, influence the nature and geography of knowledge sourcing and the use of knowledge transfer mechanisms.	Leydesdorff and Fritsch (2006), Tödtling, Lengauer, and Höglinger (2011), Liefner and Zeng (2008), Isaksen and Trippel (2017)

Table 4. Most cited studies on industrial knowledge dynamics and firm behaviour

Studies of policy implication

A central thread running throughout the majority of the investigated articles on policy approaches (41 articles), which is more or less based on the normative concept of the Triple Helix and regional innovation system framework, is that universities are assumed to produce a

number of core benefits for regions. However, recent research studies (Smith and Bagchi-Sen 2012) have questioned these innovation policies by investigating national and regional innovation policy. One finding from these studies indicates that regional differences in terms of governmental support, composition and capabilities of the research and educational sectors, the industry-specific environment, the innovation performance and paths of regional economic development vary widely between nations. Cai and Liu (2015) examine the roles of universities in fostering knowledge-intensive clusters in the Chinese regional innovation system, finding that the Chinese practice of university engagement differs from Western practice from the perspective of the Triple Helix. The Chinese policy emphasizes a top-down approach by providing financial incentives, the development of science parks and setting up university towns, while bottom-up initiatives are supported by local or regional government through a trial-and-error approach. Brown (2016) studied entrepreneurial spillovers from universities in peripheral regions in Scotland, finding that university knowledge spillover has been greatly exaggerated due to the disconnection between universities and their surrounding local entrepreneurial and innovation ecosystem. Brown (2016) states that within the Scottish context it seems impossible to achieve the expected third-mission contribution by universities, despite the considerable resources directed at this aim, due to the lack of involvement and poor performance of other actors in the RIS. The policy issue stemming from the Triple Helix and regional innovation system addresses the dichotomy between a top-down and bottom-up innovation policy approach. As mentioned, several findings indicate that a top-down policy approach needs to be combined with local or regional engagement policies, which are more context based and experimental where local knowledge spillovers between academia and industry are at stake. Coenen and Moodysson (2009, 602) conclude in their study on putting constructed regional advantages into Swedish practice that there is no “one-size-fits-all” policy solution to innovation system failure and challenges. Instead, they argue, successful regional

innovation policy must be embedded in, and attuned to, the specific needs and available resources in a particular region, which includes the specific industrial characteristics, knowledge base, human and financial capital, and cultural norms and attitudes among firms and individual subjects to influence regional economic development.

Category	Themes	Key findings of mechanisms	Authors
Policy implication	Policy framework	Regional differences in terms of government support, composition and capabilities of the research and educational sector, and the industry-specific environment, the innovation performance and paths of regional development vary widely among nations and regions. Trust, culture, proximity, the regional knowledge base and type of policy approach are found to be of relevance when explaining different path-dependent processes.	Cai and Liu (2015), Chen and Kenney (2007), Lenger (2008), Sohn, Kim, and Lee (2009)
	Regional characteristic	Evidence indicates that universities play different roles in different types of regions and policy instruments.	Brown (2016), Sohn, Kim, and Lee (2009), Tödttling, Lengauer, and Höglinger (2011), Karlsen et al. (2017)
	Top-down and bottom-up, demand-driven or technology push policy instruments	The development of strong RIS, where the university contributes to regional economic development, is found to be a function of a top-down policy approach combined with, or attuned to, a technology push policy that is aligned with specific regional knowledge needs and dynamics.	Brown (2016), Coenen and Moodysson (2009)

Table 5. Most cited studies on policy implication

Towards an analytical framework of university and regional economic development

Since the early 1990s, the discussion on the concept of region has moved distinctly away from the pursuit of high-level generalizations, whether a positivistic location theory or historical-materialist Marxist kind, to an increasingly strong emphasis on the local context, and

contingent, relational and embedded processes of knowledge (Sunley 2008, Castells 1996). What has emerged from this discussion is a more pragmatic, relativistic and open-ended approach where region is seen as the product of multiple separate mechanisms including many processes, such as social life, that are highly localized and particularistic. Regions might be in different forms and shapes. The type of definition adopted can heavily influence the strength and weakness of specific aspects of regions, competitive advantages and path-dependent processes, and thus often makes it impossible to draw comparisons among them. One way to deal with the blurry concept of region is to differentiate between types of regions and their specific path characteristic (i.e. path extension, industry diversification or new path creation) (Isaksen and Tripp 2017). The shift of focus (i.e. proximities, spatial concentration, social and cultural factors) highlights the spatiality of the creation of new knowledge within “territorial places” where systematic localized interaction between private and public interest, and contextualized learning is seen as the main mechanisms to secure competitive advantages for regions. The hypothesis claims that the composition of regional actors produces pervasive and systemic effects that encourage firms within the region to develop specific forms of capital that is derived from social relations, norms, values and knowledge interaction with the community in order to reinforce regional innovation capability and competitiveness. Universities, as knowledge-producing and -diffusing institutions, are often seen as key actors in improving regional capabilities for localized interaction and contextualized learning, which in turn might change the regional characteristics and ongoing path processes. Some studies have identified that the characteristics of a region, organizationally thick versus thin regions, do play a role when it comes to the opportunities to disseminate knowledge into society.

Studies analysing the hypothesis of the corresponding profile between universities and the regional industry knowledge bases propose that if there is sufficient correlation between the industry structure and the university, then the university will be in a favourable position for

promoting interaction and knowledge flow, and enhancing contextualized learning. If the situation is the opposite, and the cognitive distance is too large, then we can expect companies to be reluctant to interact with the university and the knowledge will be rejected by the industry or universities need to search for partners, which might be located outside the region. Two main points can be drawn from studies analysing the corresponding profile hypothesis. First, the hypothesis links internal reform to the external environment of stakeholders claiming to have a say in internal university affairs. Several theories and university models, such as the Triple Helix and the entrepreneurial university approach, propose that external public interest has to be locked into internal reform processes (Greenwood 2007, Levin 2007). In particular, the Triple Helix model and RIS approach (external to the university) in addition to concepts such as the entrepreneurial university (internally driven processes) have informed policymakers to initiate reforms aimed at redesigning university work life. Smith and Bagchi-Sen (2012) ask questions about the extent to which universities are capable of handling multiple roles or broad third-mission activities and at the same time respond to user-driven innovation policies. Second, the hypothesis assumes that a corresponding profile will enhance prosperity for regional growth and development. However, as Neffke, Henning, and Boschma (2011) note, too much relatedness or similarity might also be harmful for regional growth dynamics as it might hamper the inflow of unrelated knowledge, which can fuel the region with new growth dynamics, leading to either regional path extension, path creation or diversification (Brekke 2015, Isaksen and Trippel 2017). This topic addresses the hypothesis about university organizational capacities for regional development and path creation.

Studies analysing industrial knowledge dynamics have highlighted the importance of the quality of the intermediary functions and structure (regional knowledge diffusion infrastructure) and companies' absorptive capacities as enablers for spatial innovation and knowledge diffusion. The regional knowledge diffusion infrastructure includes resources such

as science parks, universities, TTOs, etc. that stabilize interaction and knowledge flow between regional actors, and institutional factors (such as culture, norms, rules, etc.) that reflect the regional institutional mindset of opportunity recognitions and change behaviour. According to Isaksen et al. (2018), universities might act as change actors by both taking care of localized systematic trial-and-error learning processes (entrepreneurial experimentation) and by stabilizing change capacity and diffusing (un)related knowledge into the regional business life as a system-level actor. However, the research field seems to be more focused on systemic drivers and change mechanisms occurring at the regional level (system) than analysing how firms search for knowledge in a more open and global knowledge landscape and the effect these continuous endogenous firm search processes have on the role of universities and regional path development (Varga 2009). Thus, there is a current need to better understand how universities' and companies' absorptive capacities to disseminate, utilize and share related knowledge can be embedded at the system level of a region. This hypothesis of intermediary functions, roles and processes is assumed to create capacities for change as well as stabilizing change by diffusing (un)related knowledge from internal and external sources into the wider regional business life.

In recent decades, the study of RIS and Triple Helix models supported by more nuanced KPF measurement has informed policymakers to pay more attention to regional differences, uniqueness and advantages. However, it is reasonable to ask questions about whether these intertwined relationships might also conserve critical thinking or hinder the entrance of a new understanding of what is valued as the common interest of a single actor. A similar problem follows the different university roles that universities play in regional development processes that might create dilemmas and contradiction between the university core mission (education and research) and its broad outreach activities. The growing knowledge and recognition of the fact that regions unfold differently and have different capacities to create changes have led to a

shift in national and subnational policies. Today's policies are about embracing these inequalities by developing more nuanced and targeted policies designed to enable each region to identify and develop its own competitive advantages. These new policies assume that a bottom-up process will bring together local authorities, universities, business life and civil society into a systematic interactive and experimental learning that is aimed at identifying local competitive advantages and future growth potentials. These policies, such as the European Commission Smart Specialisation Platform (S3 Platform), assume that universities can play a key role in the design and implementation of such policies. Universities are "among the few" institutions that act as "boundary spanners" bridging contextualized learning capacities (entrepreneurship experimentation) and diffusion of new knowledge into the region's business life for a new domain of opportunity. By that, the S3 Platform hypothesis assumes that universities take an entrepreneurial system-level role that might change the institutional framework or mindset of the region.

Table 7 links the four presented conceptual key categories and a set of hypotheses that highlight different aspects of the region, path-dependent processes, organizational characteristics, the intermediary and policy support. The purpose is to propose an analytical framework that includes the above discussion in a coherent analytical framework for future research purposes.

Type of RIS characteristics	Path processes	Organizational capacities	Intermediary structures and processes		Policy tools and measurement
			Change	Stability	
Organizationally thick or thin, specialized or diversified, metropolitan or peripheral	Regional change happens through three distinct path characteristics, creation, diversification and extension	Importance of similarities in competence (relatedness), absorptive capacities, knowledge exploration and diffusion capacities	Importance of building localized and collective trial-and-error learning capacities Entrepreneurial experimentation	Importance of embedded change capacities at system level of actors, that has capacities to reshape the regional institutional set-up and mindset	Nuanced and targeted policies that combine top-down and bottom-up demand-driven and technology push policies with objectives to support regional needs

Table 6. A conceptual framework for future research studies

Conclusion and direction of future research

This literature review provides an overview of the most important drivers or mechanisms of the contribution of universities to regional economic development. The motivation for the study is partly based on the curiosity of the growing number of research studies that emphasize the importance of the university contribution to regional economic development, and secondly on the extent to which a university creates prosperity for regional economic development and firm innovation capacity. The literature study shows that the field is growing rapidly and the new theoretical framework progress towards a better grasp of the complexity of formative forces that continuously transform and change regions as spaces for interactive context-based learning. These theories, models and concepts have further informed policymakers to develop targeted policy tools and indicators to measure university–industry interaction and promote regional development dynamics. To conclude, the presented literature review of 193 articles provides a rich source of hypotheses regarding universities’ contribution to regional economic development organized in four key categories and 13 subcategories. Each of these categories raises several questions, hypotheses and research approaches regarding universities and regional economic development, industry innovation performance and knowledge flow, place-

specific knowledge and learning conditions, and policy interventions. As the literature review shows, the research field is represented by several different theoretical approaches, such as innovation system thinking, agglomeration economics, evolutionary economic theory, institutional theory and organizational management theory, all of which have in their own unique way – and they still need to be elaborated further – improved our knowledge of university change and regional economic development. The paper shows that the terms “universities” and “regions” have increasingly become the starting point for various policy interventions in the last few decades. The type of definition adopted will influence the researcher’s view on specific aspects, and thus makes it hard to draw a comparison among them. As an absolute, relative and relational entity, the meaning of region is better captured through the concept of systematic interaction and learning among regional actors, which is formed by dynamic and irreversible processes that recombine existing and related knowledge into new business opportunities. In this sense, the institutional and the regional characteristics, as well as the individual strategy and performance, can represent important basic conditions and thus a subject for new policy tools and research studies. The three bullet points presented below represent some of the shortcomings found in this study, which could act as guidance for future research:

- Organizational capacities and the hypothesis of relatedness or similarity are identified as a key mechanism for systematic interaction, contextualized learning and organizational change. To a lesser extent, the literature explains how the dynamics of firm innovation behaviour influence and impact on organizational change (universities) and regional development.
- The intermediary functions, structure and roles emphasize the bounded interaction as the mechanisms for organizational changes and knowledge diffusion (stabilizations). A future

direction of research studies should explore how intermediary functions, structure and roles might work as a regional system-level entrepreneur that creates changes and stabilizes processes.

- The proposed conceptual framework needs to be further tested and explored in light of the different types of regions (institutionally thick and thin), university roles (engagement, entrepreneurial, development, etc.), institutional characteristics and the historical processes of path development as a subject for future studies.

The objective of undertaking this literature review was to present a comprehensive but constructive critical review of the burgeoning literature that now composes our knowledge of university and regional economic development dynamics. The impression of the exponential growth of articles and theories has broadened and deepened, and is now richer in scope and relevance than ever before. This literature study provides an analytical approach to summarize some of the knowledge of regional growth dynamics and university contribution that have appeared in the last few years: inevitably, several important areas of theoretical and empirical enquiry have not been included due to the characteristics of the selected search string. Nevertheless, the literature review conveys an analytical approach of organizing different theories, concepts, models and methods into a conceptual framework of four key variables (organizational capacities, intermediaries, knowledge dynamic and policies). However, the presented framework needs to be further elaborated to enable a better grasp of the dynamic process of cultural, social, institutional and political processes that shape the economic landscape.

References

- Agrawal, A., and I. Cockburn. 2003. "The Anchor Tenant Hypothesis: Exploring the Role of Large, Local, R&D-Intensive Firms in Regional Innovation Systems." *International Journal of Industrial Organization* 21, no. 9: 1227–53. doi: 10.1016/s0167-7187(03)00081-x.
- Arbo, Peter, and P. Benneworth. 2007. *Understanding the Regional Contribution of Higher Education Institutions: A Literature Review*, edited by OECD Education Working Papers: OECD Publishing.
- Asheim, Bjørn T., Helen Lawton Smith, and Christine Oughton. 2011. "Regional Innovation Systems: Theory, Empirics and Policy." *Regional Studies* 45, no.7: 875–91. doi: 10.1080/00343404.2011.596701.
- Asheim, Bjørn T., Ron Boschma, and Philip Cooke. 2011. "Constructing Regional Advantage: Platform Policies Based on Related Variety and Differentiated Knowledge Bases." *Regional Studies* 45, no. 7: 893–904. doi: 10.1080/00343404.2010.543126.
- Barra, Cristian, and Roberto Zotti. 2017. "Investigating the Human Capital Development–Growth Nexus: Does the Efficiency of Universities Matter?" *International Regional Science Review* 40, no. 6 : 638–78. doi: 10.1177/0160017615626215.
- Bathelt, H., D. F. Kogler, and A. K. Munro. 2010. "A knowledge-based typology of university spin-offs in the context of regional economic development." *Technovation* 30, no. 9–10): 519-32. doi: 10.1016/j.technovation.2010.04.003.
- Bathelt, Harald, Dieter F. Kogler, and Andrew K. Munro. 2011. "Social Foundations of Regional Innovation and the Role of University Spin-Offs: The Case of Canada's Technology Triangle." *Industry and Innovation* 18, no.5 :461–86. doi: 10.1080/13662716.2011.583462.
- Bazeley, Patricia. 2007. *Qualitative Data Analysis with NVivo*. Los Angeles: Sage.
- Belussi, Fiorenza, Alessia Sammarra, and Silvia Rita Sedita. 2010. "Learning at the Boundaries in an 'Open Regional Innovation System': A Focus on Firms' Innovation Strategies in the Emilia Romagna Life Science Industry.(Report)." *Research Policy* 39, no.6 :710. doi: 10.1016/j.respol.2010.01.014.
- Benneworth, P., R. Pinheiro, and J. Karlsen. 2017. "Strategic Agency and Institutional Change: Investigating the Role of Universities in Regional Innovation Systems (RISs)." *Regional Studies* 51, no. 2 :235–48. doi: 10.1080/00343404.2016.1215599.
- Benneworth, Paul. 2007. "Seven Samurai Opening up the Ivory Tower? The Construction of Newcastle as an Entrepreneurial University." *European Planning Studies* 15, no. 4: 487–509. doi: 10.1080/09654310601133286.
- Benneworth, Paul, Lars Coenen, Jerker Moddysson, and Bjørn T. Asheim. 2009. "Exploring the Multiple Roles of Lund University in Strengthen the Scania Regional Innovation System: Towards Institutional Learning?" *European Planning Studies* 17, no. 11: 20.
- Benneworth, Paul, and Gert-Jan Hospers. 2007. "Urban Competitiveness in the Knowledge Economy: Universities as New Planning Animators." *Progress in Planning* 67, no.2: 105–97. doi: <http://dx.doi.org/10.1016/j.progress.2007.02.003>.
- Boucher, Gerry, Cheryl Conway, and Els Van Der Meer. 2003. "Tiers of Engagement by Universities in their Region's Development." *Regional Studies* 37, no. 9: 887–897.
- Bramwell, A., and D. A. Wolfe. 2008. "Universities and Regional Economic Development: The Entrepreneurial University of Waterloo." *Research Policy* 37, no. 8: 1175–87. doi: 10.1016/j.respol.2008.04.016.
- Brekke, Thomas. 2015. "Entrepreneurship and Path Dependency in Regional Development." *Entrepreneurship & Regional Development*, 27:3-4, 202-218. doi: 10.1080/08985626.2015.1030457.

- Brown, R., and C. Mason. 2014. "Inside the High-Tech Black Box: A Critique of Technology Entrepreneurship Policy." *Technovation* 34, no. 12: 773–84. doi: 10.1016/j.technovation.2014.07.013.
- Brown, Ross. 2016. "Mission Impossible? Entrepreneurial Universities and Peripheral Regional Innovation Systems." *Industry and Innovation* 23, no. 2: 189–205. doi: 10.1080/13662716.2016.1145575.
- Buesa, Mikel, Joost Heijs, and Thomas Baumert. 2010. "The Determinants of Regional Innovation In Europe: A Combined Factorial and Regression Knowledge Production Function Approach." *Research Policy* 39, no. 6): 722–35. doi: 10.1016/j.respol.2010.02.016.
- Cai, Y. Z., and C. Liu. 2015. "The Roles of Universities in Fostering Knowledge-Intensive Clusters in Chinese Regional Innovation Systems." *Science and Public Policy* 42, no. 1: 15-29. doi: 10.1093/scipol/scu018.
- Caniels, M. C. J., and H. van den Bosch. 2011. "The Role of Higher Education Institutions in Building Regional Innovation Systems." *Papers in Regional Science* 90, no. 2: 271–U377. doi: 10.1111/j.1435-5957.2010.00344.x.
- Castells, Manuel. 1996. *The Rise of the Network Society*. Vol. 1. Oxford: Blackwell.
- Charles, D., F. Kitagawa, and E. Uyarra. 2014. "Universities in Crisis? New Challenges and Strategies in Two English City Regions." *Cambridge Journal of Regions Economy and Society* 7, no. 2: 327–48. doi: 10.1093/cjres/rst029.
- Chatterton, Paul, and J. B. Goddard. 2000. "The Response of Higher Education Institutions to Regional Needs." *European Journal of Education: Research, Development and Policies* 35, no. 4:475–96.
- Chen, K., and M. Kenney. 2007. "Universities/Research Institutes and Regional Innovation Systems: The Cases of Beijing and Shenzhen." *World Development* 35, no. 6: 1056–74. doi: 10.1016/j.worlddev.2006.05.013.
- Clark, Burton R. 2004. *Sustaining Change in Universities : Continuities in Case Studies and Concepts*. Berkshire: Society for Research into Higher Education & Open University Press.
- Coenen, L. 2007. "The Role of Universities in the Regional Innovation Systems of the North East of England and Scania, Sweden: Providing Missing Links?" *Environment and Planning C-Government and Policy* 25, no. 6): 803–21. doi: 10.1068/c0579.
- Coenen, L., and J. Moodysson. 2009. "Putting Constructed Regional Advantage into Swedish Practice." *European Planning Studies* 17, no. 4: 587–604. doi: 10.1080/09654310802682180.
- Cohen, M. Wesley, and A. Daniel Levinthal. 1990. "Absorptive Capacity: A "" *Administrative Science Quarterly* 35, no. 1: 128–52.
- Cooke, Phil. 2005. "Regionally Asymmetric Knowledge Capabilities and Open Innovation: Exploring 'Globalisation 2' – A New Model of Industry Organisation." *Research Policy* 34, no. 8:1128–49. doi: 10.1016/j.respol.2004.12.005.
- Cooke, Philip, Martin Heidenreich, and Hans-Joachim Braczyk. 1998. *Regional Innovation Systems: The Role of Governance in a Globalized World*. London: Routledge.
- Cowan, R., and N. Zinovyeva. 2013. "University Effects on Regional Innovation." *Research Policy* 42, no. 3: 788–800. doi: 10.1016/j.respol.2012.10.001.
- Dawkins, Casey J. 2003. "Regional Development Theory: Conceptual Foundations, Classic Works, and Recent Developments." *Journal of Planning Literature* 18, no. 2: 131–72. doi: 10.1177/0885412203254706.
- Drucker, J, and H. Goldstein. 2007. "Assessing the Regional Economic Development Impacts of Universities: A Review of Current Approaches." *International Regional Science Review* 30, no. 1: 20–46. doi: 10.1177/0160017606296731.

- Drucker, Joshua. 2016. "Reconsidering the Regional Economic Development Impacts of Higher Education Institutions in the United States." *Regional Studies* 50, no. 7: 1185–202. doi: 10.1080/00343404.2014.986083.
- Eriksson, R. H., and F. Forslund. 2014. "How do Universities Contribute to Employment Growth? The Role of Human Capital and Knowledge Bases." *European Planning Studies* 22, no. 12: 2584–604. doi: 10.1080/09654313.2013.849227.
- Etzkowitz, H. 2013. "Anatomy of the Entrepreneurial University." *Social Science Information Sur Les Sciences Sociales* 52, no. 3: 486–511. doi: 10.1177/0539018413485832.
- Etzkowitz, Henry. 2012. "Triple Helix Clusters: Boundary Permeability at University—Industry – Government Interfaces as a Regional Innovation Strategy." *Environment and Planning C: Government and Policy* 30, no. 5: 766–79. doi: 10.1068/c1182.
- Etzkowitz, Henry, and Loet Leydesdorff. 1997. *Universities and the Global Knowledge Economy: A Triple Helix of University–Industry–Government Relations*. London: Pinter.
- Fallah, B., M. D. Partridge, and D. S. Rickman. 2014. "Geography and High-Tech Employment Growth in US Counties." *Journal of Economic Geography* 14, no. 4: 683–720. doi: 10.1093/jeg/lbt030.
- Fischer, M. M., and A. Varga. 2002. "Technological Innovation and Interfirm Cooperation: An Exploratory Analysis Using Survey Data from Manufacturing Firms in the Metropolitan Region of Vienna." *International Journal of Technology Management* 24, no. 7–8: 724–42. doi: 10.1504/ijtm.2002.003080.
- Flores, M., C. Boer, C. Huber, A. Pluss, R. Schoch, and M. Pouly. 2009. "Universities as Key Enablers to Develop New Collaborative Environments for Innovation: Successful Experiences from Switzerland and India." *International Journal of Production Research* 47, no. 17: 4935–53. doi: 10.1080/00207540902847454.
- Freel, Mark. 2000. "Strategy and Structure in Innovative Manufacturing SMEs: The Case of an English Region." *An International Journal* 15, no. 1: 27–45. doi: 10.1023/A:1012087912632.
- Fukugawa, N. 2016. "Knowledge Spillover from University Research before the National Innovation System Reform in Japan: Localisation, Mechanisms, and Intermediaries." *Asian Journal of Technology Innovation* 24, no. 1: 100–22. doi: 10.1080/19761597.2016.1141058.
- Gioia, Dennis A., Kevin G. Corley, and Aimee L. Hamilton. 2013. "Seeking Qualitative Rigor in Inductive Research: Notes on the Gioia Methodology." *Organizational Research Methods* 16, no. 1: 15–31. doi: 10.1177/1094428112452151.
- Goddard, J. B., and P. Chatterton. 2000. "The Responses of University to Regional Needs." *European Journal of Education* 35, no.4. 475–496.
- Goldstein, H. A., and C. S. Renault. 2004. "Contributions of Universities to Regional Economic Development: A Quasi-Experimental Approach." *Regional Studies* 38, no. 7: 733–46. doi: 10.1080/0034340042000265232.
- Goldstein, H., and J. Drucker. 2006. "The Economic Development Impacts of Universities on Regions: Do Size and Distance Matter?" *Economic Development Quarterly* 20, no. 1: 22–43. doi: 10.1177/0891242405283387.
- Greenwood, Davydd J. 2007. "Who Are the Real 'Problem Owners'? On the Social Embeddedness of Universities." In *Bright Satanic Mills: Universities, Regional Development and the Knowledge Economy*, edited by Alan Harding, Alan Scott, Stephan Laske and Christian Burtcher. ASHGATE.
- Griliches, Zvi. 1979. "Issues in Assessing the Contribution of Research and Development to Productivity Growth." *The Bell Journal of Economics* 10 (1):92–116. doi: 10.2307/3003321.

- Gumport, P. J. 2000. "Academic Restructuring: Organizational Change and Institutional Imperatives." *Higher Education* 39, no. 1: 67–91. doi: 10.1023/a:1003859026301.
- Gumport, Patricia J., and Barbara Sporn. 1999. "Institutional Adaptation: Demands for Management Reform and University Administration." In *Higher Education: Handbook of Theory and Research*, edited by John C. Smart and William G. Tierney, 103–45. Dordrecht: Springer Netherlands.
- Harding, Alan. 2007. *Bright Satanic Mills Universities, Regional Development and the Knowledge Economy*. Aldershot: Ashgate.
- Hayter, C. S. 2015. "Social Networks and the Success of University Spin-offs: Toward an Agenda for Regional Growth." *Economic Development Quarterly* 29, no. 1: 3–13. doi: 10.1177/0891242414566451.
- Huggins, R. 2008. "Universities and Knowledge-Based Venturing: Finance, Management and Networks in London." *Entrepreneurship and Regional Development* 20, no. 2: 185–206. doi: 10.1080/08985620701748342.
- Huggins, R., A. Johnston, and C. Stride. 2012. "Knowledge Networks and Universities: Locational and Organisational Aspects of Knowledge Transfer Interactions." *Entrepreneurship and Regional Development* 24, no. 7–8: 475–502. doi: 10.1080/08985626.2011.618192.
- Isaksen, A., and M. Trippel. 2017. "Innovation in Space: The Mosaic of Regional Innovation Patterns." *Oxford Review of Economic Policy* 33, no. 1: 122–40. doi: 10.1093/oxrep/grw035.
- Isaksen, Arne, Nina Kyllingstad, Jan Ole Rypestøl, and Ann Camilla Schulze-Krogh. 2018. "Differentiated regional entrepreneurial discovery processes. A conceptual discussion and empirical illustration from three emergent clusters." *European Planning Studies*: 26-11, 2200-2215, doi: 10.1080/09654313.2018.1530143.
- Jaffe, Adam B., Manuel Trajtenberg, and Rebecca Henderson. 1993. "Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations." *The Quarterly Journal of Economics* 108, no. 3: 577–98. doi: 10.2307/2118401.
- Karlsen, J., J. Beseda, K. Sima, and B. Zyzak. 2017. "Outsiders or Leaders? The Role of Higher Education Institutions in the Development of Peripheral Regions." *Higher Education Policy* 30, no. 4: 463–79. doi: 10.1057/s41307-017-0065-5.
- Lee, Y. H., and Y. Kim. 2016. "Analyzing Interaction in R&D Networks Using the Triple Helix Method: Evidence from Industrial R&D Programs in Korean Government." *Technological Forecasting and Social Change*, no 110, 93–105. doi: 10.1016/j.techfore.2015.10.017.
- Lee, Y. S. 1996. "'Technology Transfer' and the Research University: A Search for the Boundaries of University–Industry Collaboration." *Research Policy* 25, no. 6: 843–63. doi: 10.1016/0048-7333(95)00857-8.
- Lenger, A. 2008. "Regional Innovation Systems and the Role of State: Institutional Design and State Universities in Turkey." *European Planning Studies* 16, no. 8: 1101–20. doi: 10.1080/09654310802315781.
- Levin, Morten. 2007. "Knowledge and Technology Transfer: Can University Promote Regional Development?" In *Bright Satanic Mills*, edited by Alan Harding, Alan Scott, Stephan Laske and Christian Burtscher. Aldershot: ASGHATE.
- Leydesdorff, L., and M. Deakin. 2011. "The Triple-Helix Model of Smart Cities: A Neo-Evolutionary Perspective." *Journal of Urban Technology* 18, no. 2: 53–63. doi: 10.1080/10630732.2011.601111.
- Leydesdorff, L., and M. Fritsch. 2006. "Measuring the Knowledge Base of Regional Innovation Systems in Germany in Terms of a Triple Helix Dynamics." *Research Policy* 35, no. 10: 1538–53. doi: 10.1016/j.respol.2006.09.027.

- Li, X. J., Y. F. Kong, and B. Y. Peng. 2007. "Development of Geography in Higher Education in China Since 1980." *Journal of Geography in Higher Education* 31, no. 1: 19–37. doi: 10.1080/03098260601032912.
- Liefner, Ingo, and Gang Zeng. 2008. "Cooperation Patterns of High-Tech Companies in Shanghai and Beijing: Accessing External Knowledge Sources for Innovation Processes." *Erdkunde* 62, no. 3: 245–58. doi: 10.3112/erdkunde.2008.03.05.
- Looy, Bart Van, Koenraad Debackere, and Petra Andries. 2003. "Policies to Stimulate Regional Innovation Capabilities Via University–Industry Collaboration: An Analysis and an Assessment." *R&D Management* 33, no. 2: 209–29. doi: 10.1111/1467-9310.00293.
- Martin, Ron. 2017. *Economy: Critical Essays in Human Geography*. 1st ed. Taylor and Francis. Routledge. New York.
- Miller, K., M. Mcadam, and R. Mcadam. 2014. "The Changing University Business Model: A Stakeholder Perspective." *R & D Management* 44, no. 3: 265–87. doi: 10.1111/radm.12064.
- Miner, Anne, Yan Gong, Michael Ciuchta, Anthony Sadler, and John Surdyk. 2012. "Promoting University Startups: International Patterns, Vicarious Learning and Policy Implications." *The Journal of Technology Transfer* 37, no. 2: 213–33. doi: 10.1007/s10961-010-9194-3.
- Neffke, Frank, Martin Henning, and Ron Boschma. 2011. "How Do Regions Diversify over Time? Industry Relatedness and the Development of New Growth Paths in Regions." *Economic Geography* 87, no. 3: 237–65. doi: 10.1111/j.1944-8287.2011.01121.x.
- Niosi, J., and M. Banik. 2005. "The Evolution and Performance of Biotechnology Regional Systems of Innovation." *Cambridge Journal of Economics* 29, no. 3: 343–57. doi: 10.1093/cje/bei044.
- OECD. 2014. *OECD Science, Technology and Industry Outlook 2014*. Paris: OECD Publishing.
- Parker, Rachel, and Damian Hine. 2014. "The Role of Knowledge Intermediaries in Developing Firm Learning Capabilities." *European Planning Studies* 22, no. 5: 1048–61. doi: 10.1080/09654313.2012.758688.
- Peer, Verena, and Marianne Penker. 2016. "Higher Education Institutions and Regional Development." *International Regional Science Review* 39, no. 2: 228–53. doi: 10.1177/0160017614531145.
- Pinto, Hugo, Manuel Fernandez-Esquinas, and Elvira Uyarra. 2015. "Universities and Knowledge-Intensive Business Services (KIBS) as Sources of Knowledge for Innovative Firms in Peripheral Regions." *Regional Studies* 49, no. 11: 1873–91. doi: 10.1080/00343404.2013.857396.
- Pittaway, Luke, and Jason Cope. 2007. "Entrepreneurship Education: A Systematic Review of the Evidence." *International Small Business Journal* 25, no. 5: 479–510. doi: 10.1177/0266242607080656.
- Ponds, Roderik, Frank van Oort, and Koen Frenken. 2010. "Innovation, Spillovers and University Industry Collaboration: An Extended Knowledge Production Function Approach." *Journal of Economic Geography* 10, no. 2: 231–55. doi: 10.1093/jeg/lbp036.
- Roper, Stephen, Jan Youtie, Philip Shapira, and Andrea Fernández-Ribas. 2010. "Knowledge, Capabilities and Manufacturing Innovation: A USA–Europe Comparison." *Regional Studies* 44, no. 3: 253–79. doi: 10.1080/00343400802360410.
- Shapiro, Matthew A., Minh So, and Han Woo Park. 2010. "Quantifying the National Innovation System: Inter-Regional Collaboration Networks in South Korea." *Technology Analysis & Strategic Management* 22, no. 7: 845–57. doi: 10.1080/09537325.2010.511158.

- Smith, H. L. 2007. "Universities, Innovation, and Territorial Development: A Review of the Evidence." *Environment and Planning C: Government and Policy* 25, no. 1: 98–114.
- Smith, H. L., and S. Bagchi-Sen. 2012. "The Research University, Entrepreneurship and Regional Development: Research Propositions and Current Evidence." *Entrepreneurship and Regional Development* 24, no. 5–6: 383–404. doi: 10.1080/08985626.2011.592547.
- Sohn, D. W., H. Kim, and J. H. Lee. 2009. "Policy-Driven University–Industry Linkages and Regional Innovation Networks in Korea." *Environment and Planning C-Government and Policy* 27, no. 4:647–64. doi: 10.1068/c0890b.
- Sorensen, A. 2008. "Use of QSR NVivo 7 Qualitative Analysis Software for Mixed Methods Research. In *Journal of Mixed Methods Research*, 2(1), 106-108. <https://doi.org/10.1177/1558689807309082>
- Steffensen, M., E. M. Rogers, and K. Speakman. 2000. "Spin-Offs from Research Centers at a Research University." *Journal of Business Venturing* 15, no. 1: 93–111. doi: 10.1016/s0883-9026(98)00006-8.
- Strand, O., and L. Leydesdorff. 2013. "Where is Synergy Indicated in the Norwegian Innovation System? Triple-Helix Relations Among Technology, Organization, and Geography." *Technological Forecasting and Social Change* 80, no. 3: 471–84. doi: 10.1016/j.techfore.2012.08.010.
- Strauss, Anselm L., and Juliet M. Corbin. 1990. *Basics of Qualitative Research Grounded Theory Procedures and Techniques*. Newbury Park, CA.: Sage.
- Sunley, Peter. 2008. "Relational Economic Geography: A Partial Understanding or a New Paradigm?" *Economic Geography* 84, no. 1: 1–26. doi: 10.1111/j.1944-8287.2008.tb00389.x.
- Trippl, Michaela, Tanja Sinozic, and Helen Lawton Smith. 2015. "The Role of Universities in Regional Development: Conceptual Models and Policy Institutions in the UK, Sweden and Austria." *European Planning Studies*, 23:9, 1722-1740, doi:10.1080/09654313.2015.1052782.
- Tödting, Franz, Lukas Lengauer, and Christoph Höglinger. 2011. "Knowledge Sourcing and Innovation in 'Thick' and 'Thin' Regional Innovation Systems – Comparing ICT Firms in Two Austrian Regions." *European Planning Studies* 19, no. 7: 1245–76. doi: 10.1080/09654313.2011.573135.
- Uyarra, Elvira. 2010. "Conceptualizing the Regional Roles of Universities, Implications and Contradictions." *European Planning Studies* 18, no. 8: 1227–46. doi: 10.1080/09654311003791275.
- Varga, Attila, ed. 2009. *Universities, Knowledge Transfer and Regional Development : Geography, Entrepreneurship and Policy*. Edward Elgar Publishing.
- Youtie, Jan, and Philip Shapira. 2008. "Building an Innovation hub: A Case Study of the Transformation of University Roles in Regional Technological and Economic Development." *Research Policy* 37, no. 8: 1188–204. doi: <https://doi.org/10.1016/j.respol.2008.04.012>.
- Yun, S., and J. Lee. 2013. "An Innovation Network Analysis of Science Clusters in South Korea and Taiwan." *Asian Journal of Technology Innovation* 21, no. 2: 277–89. doi: 10.1080/19761597.2013.866310.

Appendix 1: Reviewed articles

- Abramo, G., and C. A. D'Angelo. 2015. "A methodology to compute the territorial productivity of scientists: The case of Italy." *Journal of Informetrics* 9 (4):675-685. doi: 10.1016/j.joi.2015.07.007.
- Acs, Z. J., L. Anselin, and A. Varga. 2002. "Patents and innovation counts as measures of regional production of new knowledge." *Research Policy* 31 (7):1069-1085. doi: 10.1016/s0048-7333(01)00184-6.
- Adams, S. B. 2009. "Follow the Money: Engineering at Stanford and UC Berkeley During the Rise of Silicon Valley." *Minerva* 47 (4):367-390. doi: 10.1007/s11024-009-9138-y.
- Addie, J. P. D., M. Angrisani, and S. De Falco. 2018. "University-led innovation in and for peripheral urban areas: new approaches in Naples, Italy and Newark, NJ, US." *European Planning Studies* 26 (6):1181-1201. doi: 10.1080/09654313.2018.1459505.
- Agrawal, A., and I. Cockburn. 2003. "The anchor tenant hypothesis: exploring the role of large, local, R&D-intensive firms in regional innovation systems." *International Journal of Industrial Organization* 21 (9):1227-1253. doi: 10.1016/s0167-7187(03)00081-x.
- Allison, J., and R. Eversole. 2008. "A new direction for regional university campuses: catalyzing innovation in place." *Innovation-the European Journal of Social Science Research* 21 (2):95-109. doi: 10.1080/13511610802214321.
- Audretsch, D. B., D. P. Leyden, and A. N. Link. 2013. "Regional Appropriation of University-Based Knowledge and Technology for Economic Development." *Economic Development Quarterly* 27 (1):56-61. doi: 10.1177/0891242412472536.
- Avdeitchikova, S. 2009. "False expectations: Reconsidering the role of informal venture capital in closing the regional equity gap." *Entrepreneurship and Regional Development* 21 (2):99-130. doi: 10.1080/08985620802025962.
- Avnimelech, G., and M. P. Feldman. 2015. "The stickiness of university spin-offs: a study of formal and informal spin-offs and their location from 124 US academic institutions." *International Journal of Technology Management* 68 (1-2):122-149. doi: 10.1504/ijtm.2015.068755.
- Baldini, N., R. Grimaldi, and M. Sobrero. 2006. "Institutional changes and the commercialization of academic knowledge: A study of Italian universities' patenting activities between 1965 and 2002." *Research Policy* 35 (4):518-532. doi: 10.1016/j.respol.2006.01.004.
- Baltzopoulos, A., and A. Brostrom. 2013. "Attractors of Entrepreneurial Activity: Universities, Regions and Alumni Entrepreneurs." *Regional Studies* 47 (6):934-949. doi: 10.1080/00343404.2011.602335.
- Bathelt, H., D. F. Kogler, and A. K. Munro. 2010. "A knowledge-based typology of university spin-offs in the context of regional economic development." *Technovation* 30 (9-10):519-532. doi: 10.1016/j.technovation.2010.04.003.
- Baycan, T., and R. R. Stough. 2013. "Bridging knowledge to commercialization: the good, the bad, and the challenging." *Annals of Regional Science* 50 (2):367-405. doi: 10.1007/s00168-012-0510-8.
- Belitski, M., and K. Heron. 2017. "Expanding entrepreneurship education ecosystems." *Journal of Management Development* 36 (2):163-177. doi: 10.1108/jmd-06-2016-0121.
- Belso-Martinez, J. A., F. X. Molina-Morales, and F. Mas-Verdu. 2013. "Perceived usefulness of innovation programs for high-tech and low-tech firms." *Management Decision* 51 (6):1190-1206. doi: 10.1108/md-04-2012-0314.
- Benneworth, P., L. Coenen, J. Moodysson, and B. Asheim. 2009. "Exploring the Multiple Roles of Lund University in Strengthening Scania's Regional Innovation System: Towards Institutional Learning?" *European Planning Studies* 17 (11):1645-1664. doi: 10.1080/09654310903230582.
- Benneworth, P., and G. J. Hospers. 2007. "Urban competitiveness in the knowledge economy: Universities as new planning animateurs." *Progress in Planning* 67:105-+. doi: 10.1016/j.progress.2007.02.003.
- Benneworth, P., R. Pinheiro, and J. Karlsen. 2017. "Strategic agency and institutional change: investigating the role of universities in regional innovation systems (RISs)." *Regional Studies* 51 (2):235-248. doi: 10.1080/00343404.2016.1215599.
- Bhadury, J., and S. P. Troy. 2014. "STAIID: An Operational Framework to Guide Cluster-Based Engagements by Higher Education Institutions." *Economic Development Quarterly* 28 (4):364-376. doi: 10.1177/0891242414550187.
- Bianchi, G. 1996. "Galileo used to live here. Tuscany hi tech: The network and its poles." *R & D Management* 26 (3):199-211. doi: 10.1111/j.1467-9310.1996.tb00956.x.
- Bjarnason, T., and I. R. Edvardsson. 2017. "University pathways of urban and rural migration in Iceland." *Journal of Rural Studies* 54:244-254. doi: 10.1016/j.jrurstud.2017.07.001.
- Bonaccorsi, A., C. Daraio, and A. Geuna. 2010. "Universities in the New Knowledge Landscape: Tensions, Challenges, Change-An Introduction." *Minerva* 48 (1):1-4. doi: 10.1007/s11024-010-9144-0.

- Bramwell, A., J. Nelles, and D. A. Wolfe. 2008. "Knowledge, innovation and institutions: Global and local dimensions of the ICT cluster in Waterloo, Canada." *Regional Studies* 42 (1):101-116. doi: 10.1080/00343400701543231.
- Bramwell, A., and D. A. Wolfe. 2008. "Universities and regional economic development: The entrepreneurial University of Waterloo." *Research Policy* 37 (8):1175-1187. doi: 10.1016/j.respol.2008.04.016.
- Brescia, F., G. Colombo, and P. Landoni. 2016. "Organizational structures of Knowledge Transfer Offices: an analysis of the world's top-ranked universities." *Journal of Technology Transfer* 41 (1):132-151. doi: 10.1007/s10961-014-9384-5.
- Breznitz, S. M. 2011. "Improving or Impairing? Following Technology Transfer Changes at the University of Cambridge." *Regional Studies* 45 (4):463-478. doi: 10.1080/00343401003601909.
- Breznitz, S. M., R. P. O'Shea, and T. J. Allen. 2008. "University commercialization strategies in the development of regional bioclusters." *Journal of Product Innovation Management* 25 (2):129-142. doi: 10.1111/j.1540-5885.2008.00290.x.
- Brown, R., and C. Mason. 2014. "Inside the high-tech black box: A critique of technology entrepreneurship policy." *Technovation* 34 (12):773-784. doi: 10.1016/j.technovation.2014.07.013.
- Budyldina, N. 2018. "Entrepreneurial universities and regional contribution." *International Entrepreneurship and Management Journal* 14 (2):265-277. doi: 10.1007/s11365-018-0500-0.
- Buesa, Mikel, Joost Heijs, and Thomas Baumert. 2010. "The determinants of regional innovation in Europe: A combined factorial and regression knowledge production function approach." *Research Policy* 39 (6):722-735. doi: 10.1016/j.respol.2010.02.016.
- Buesa, M., J. Heijs, M. M. Pellitero, and T. Baumert. 2006. "Regional systems of innovation and the knowledge production function: the Spanish case." *Technovation* 26 (4):463-472. doi: 10.1016/j.technovation.2004.11.007.
- Cai, Y. Z., and C. Liu. 2015. "The roles of universities in fostering knowledge-intensive clusters in Chinese regional innovation systems." *Science and Public Policy* 42 (1):15-29. doi: 10.1093/scipol/scu018.
- Cai, Y. Z., P. Yang, A. Lyytinen, and S. Holtta. 2015. "Seeking solutions through the mirror of Finnish experience: policy recommendations for regional university transformation in China." *Journal of Higher Education Policy and Management* 37 (4):447-458. doi: 10.1080/1360080x.2015.1056597.
- Calcagnini, G., I. Favaretto, G. Giombini, F. Perugini, and R. Rombaldoni. 2016. "The role of universities in the location of innovative start-ups." *Journal of Technology Transfer* 41 (4):670-693. doi: 10.1007/s10961-015-9396-9.
- Calzonetti, F. J., D. M. Miller, and N. Reid. 2012. "Building both technology-intensive and technology-limited clusters by emerging research universities: The Toledo example." *Applied Geography* 34:265-273. doi: 10.1016/j.apgeog.2011.11.012.
- Caniels, M. C. J., and H. van den Bosch. 2011. "The role of Higher Education Institutions in building regional innovation systems." *Papers in Regional Science* 90 (2):271-U377. doi: 10.1111/j.1435-5957.2010.00344.x.
- Castrogiovanni, G. J., J. Domenech, and F. Mas-Verdu. 2012. "Variations in SME Characteristics and the Use of Service Intermediaries for R&D." *Canadian Journal of Administrative Sciences-Revue Canadienne Des Sciences De L Administration* 29 (2):154-164. doi: 10.1002/cjas.231.
- Chaminade, C., and J. Vang. 2008. "Globalisation of knowledge production and regional innovation policy: Supporting specialized hubs in the Bangalore software industry." *Research Policy* 37 (10):1684-1696. doi: 10.1016/j.respol.2008.08.014.
- Charles, D., F. Kitagawa, and E. Uyarra. 2014. "Universities in crisis?-new challenges and strategies in two English city-regions." *Cambridge Journal of Regions Economy and Society* 7 (2):327-348. doi: 10.1093/cjres/rst029.
- Chen, K., and M. Kenney. 2007. "Universities/Research institutes and regional innovation systems: The cases of Beijing and shenzhen." *World Development* 35 (6):1056-1074. doi: 10.1016/j.worlddev.2006.05.013.
- Christopherson, S., and J. Clark. 2007. "Power in firm networks: What it means for regional innovation systems." *Regional Studies* 41 (9):1223-1236. doi: 10.1080/00343400701543330.
- Clancy, G. P. 2012. "Commentary: Linking Health Equity With Economic Development: Insights From My Year as Chairman of the Board of the Chamber of Commerce." *Academic Medicine* 87 (12):1665-1667. doi: 10.1097/ACM.0b013e318272113f.
- Clark, J. 2010. "Coordinating a conscious geography: the role of research centers in multi-scalar innovation policy and economic development in the US and Canada." *Journal of Technology Transfer* 35 (5):460-474. doi: 10.1007/s10961-009-9137-z.
- Coenen, L. 2007. "The role of universities in the regional innovation systems of the North East of England and Scania, Sweden: providing missing links?" *Environment and Planning C-Government and Policy* 25 (6):803-821. doi: 10.1068/c0579.
- Coenen, L., and J. Moodysson. 2009. "Putting Constructed Regional Advantage into Swedish Practice." *European Planning Studies* 17 (4):587-604. doi: 10.1080/09654310802682180.

- Colombo, M. G., D. D'Adda, and E. Piva. 2010. "The contribution of university research to the growth of academic start-ups: an empirical analysis." *Journal of Technology Transfer* 35 (1):113-140. doi: 10.1007/s10961-009-9111-9.
- Colyvas, J. A., and W. W. Powell. 2006. "ROADS TO INSTITUTIONALIZATION: THE REMAKING OF BOUNDARIES BETWEEN PUBLIC AND PRIVATE SCIENCE." In *Research in Organizational Behavior, Vol 27*, edited by B. M. Staw, 305-353.
- Couchman, P. K., I. McLoughlin, and D. R. Charles. 2008. "Lost in translation? Building science and innovation city strategies in Australia and the UK." *Innovation-Management Policy & Practice* 10 (2-3):211-223. doi: 10.5172/impp.453.10.2-3.211.
- Cowan, R., and N. Zinovyeva. 2013. "University effects on regional innovation." *Research Policy* 42 (3):788-800. doi: 10.1016/j.respol.2012.10.001.
- Culkin, N. 2016. "Entrepreneurial universities in the region: the force awakens?" *International Journal of Entrepreneurial Behaviour & Research* 22 (1):4-16. doi: 10.1108/ijeb-12-2015-0310.
- Dada, O., S. Jack, and M. George. 2016. "University-Business Engagement Franchising and Geographic Distance: A Case Study of a Business Leadership Programme." *Regional Studies* 50 (7):1217-1231. doi: 10.1080/00343404.2014.995614.
- de la Fe, T. G. 2009. "TRIPLE HELIX MODEL OF RELATIONS AMONG UNIVERSITY, INDUSTRY AND GOVERNMENT: A CRITICAL ANALYSIS." *Arbor-Ciencia Pensamiento Y Cultura* 185 (738):739-755. doi: 10.3989/arbor.2009.738n1049.
- Demeritt, D., and L. Lees. 2005. "Research relevance, 'knowledge transfer' and the geographies of CASE studentship collaboration." *Area* 37 (2):127-137. doi: 10.1111/j.1475-4762.2005.00615.x.
- Drucker, J. 2016. "Reconsidering the Regional Economic Development Impacts of Higher Education Institutions in the United States." *Regional Studies* 50 (7):1185-1202. doi: 10.1080/00343404.2014.986083.
- Drucker, J., and H. Goldstein. 2007. "Assessing the regional economic development impacts of universities: A review of current approaches." *International Regional Science Review* 30 (1):20-46. doi: 10.1177/0160017606296731.
- Eerola, S., T. Tura, V. Harmaakorpi, and P. Jarvela. 2015. "Advisory Professorship Model as a Tool for Practice-Based Regional University-Industry Cooperation." *European Planning Studies* 23 (3):475-493. doi: 10.1080/09654313.2013.869558.
- Eriksson, R. H., and F. Forslund. 2014. "How Do Universities Contribute to Employment Growth? The Role of Human Capital and Knowledge Bases." *European Planning Studies* 22 (12):2584-2604. doi: 10.1080/09654313.2013.849227.
- Etzkowitz, H. 2011. "Normative change in science and the birth of the Triple Helix." *Social Science Information Sur Les Sciences Sociales* 50 (3-4):549-568. doi: 10.1177/0539018411411403.
- Etzkowitz, H. 2013. "Anatomy of the entrepreneurial university." *Social Science Information Sur Les Sciences Sociales* 52 (3):486-511. doi: 10.1177/0539018413485832.
- Faggian, A., R. Comunian, S. Jewell, and U. Kelly. 2013. "Bohemian Graduates in the UK: Disciplines and Location Determinants of Creative Careers." *Regional Studies* 47 (2):183-200. doi: 10.1080/00343404.2012.665990.
- Fallah, B., M. D. Partridge, and D. S. Rickman. 2014. "Geography and High-Tech Employment Growth in US Counties." *Journal of Economic Geography* 14 (4):683-720. doi: 10.1093/jeg/lbt030.
- Feldman, J. M. 2001. "Towards the post-university: Centres of higher learning and creative spaces as economic development and social change agents." *Economic and Industrial Democracy* 22 (1):99-142. doi: 10.1177/0143831x01221005.
- Ferrand, Y., C. M. L. Kelton, K. Chen, and H. A. Stafford. 2009. "Biotechnology in Cincinnati Clustering or Colocation?" *Economic Development Quarterly* 23 (2):127-140. doi: 10.1177/0891242408327811.
- Fischer, M. M., and A. Varga. 2002. "Technological innovation and interfirm cooperation: an exploratory analysis using survey data from manufacturing firms in the metropolitan region of Vienna." *International Journal of Technology Management* 24 (7-8):724-742. doi: 10.1504/ijtm.2002.003080.
- Flores, M., C. Boer, C. Huber, A. Pluss, R. Schoch, and M. Pouly. 2009. "Universities as key enablers to develop new collaborative environments for innovation: successful experiences from Switzerland and India." *International Journal of Production Research* 47 (17):4935-4953. doi: 10.1080/00207540902847454.
- Forrant, R. 2001. "Pulling together in Lowell: The university and the regional development process." *European Planning Studies* 9 (5):613-628.
- Fukugawa, N. 2016. "Knowledge spillover from university research before the national innovation system reform in Japan: localisation, mechanisms, and intermediaries." *Asian Journal of Technology Innovation* 24 (1):100-122. doi: 10.1080/19761597.2016.1141058.
- Fukugawa, N. 2017. "University spillover before the national innovation system reform in Japan." *International Journal of Technology Management* 73 (4):206-234.

- Garcia, B. C., and D. Chavez. 2014. "Network-based innovation systems: A capital base for the Monterrey city-region, Mexico." *Expert Systems with Applications* 41 (12):5636-5646. doi: 10.1016/j.eswa.2014.02.014.
- Ghinamo, Mauro L. 2012. "EXPLAINING THE VARIATION IN THE EMPIRICAL ESTIMATES OF ACADEMIC KNOWLEDGE SPILLOVERS*." *Journal of Regional Science* 52 (4):606-634. doi: 10.1111/j.1467-9787.2012.00764.x.
- Gianiodis, P. T., G. D. Markman, and A. Panagopoulos. 2016. "Entrepreneurial universities and overt opportunism." *Small Business Economics* 47 (3):609-631. doi: 10.1007/s11187-016-9753-6.
- Goddard, J., D. Robertson, and P. Vallance. 2012. "Universities, Technology and Innovation Centres and regional development: the case of the North-East of England." *Cambridge Journal of Economics* 36 (3):609-627. doi: 10.1093/cje/bes005.
- Goddard, J. B., and P. Chatterton. 1999. "Regional Development Agencies and the knowledge economy: harnessing the potential of universities." *Environment and Planning C-Government and Policy* 17 (6):685-699. doi: 10.1068/c170685.
- Goldstein, H., E. M. Bergman, and G. Maier. 2013. "University mission creep? Comparing EU and US faculty views of university involvement in regional economic development and commercialization." *Annals of Regional Science* 50 (2):453-477. doi: 10.1007/s00168-012-0513-5.
- Goldstein, H., and J. Drucker. 2006. "The economic development impacts of universities on regions: Do size and distance matter?" *Economic Development Quarterly* 20 (1):22-43. doi: 10.1177/0891242405283387.
- Goldstein, H. A., and K. Glaser. 2012. "Research universities as actors in the governance of local and regional development." *Journal of Technology Transfer* 37 (2):158-174. doi: 10.1007/s10961-010-9193-4.
- Goldstein, H. A., and C. S. Renault. 2004. "Contributions of universities to regional economic development: A quasi-experimental approach." *Regional Studies* 38 (7):733-746. doi: 10.1080/0034340042000265232.
- Grimpe, C., and H. Fier. 2010. "Informal university technology transfer: a comparison between the United States and Germany." *Journal of Technology Transfer* 35 (6):637-650. doi: 10.1007/s10961-009-9140-4.
- Guerrero, M., D. Urbano, A. Fayolle, M. Klofsten, and S. Mian. 2016. "Entrepreneurial universities: emerging models in the new social and economic landscape." *Small Business Economics* 47 (3):551-563. doi: 10.1007/s11187-016-9755-4.
- Gumpert, P. J. 2000. "Academic restructuring: Organizational change and institutional imperatives." *Higher Education* 39 (1):67-91. doi: 10.1023/a:1003859026301.
- Gunasekara, C. 2006. "Universities and associative regional governance: Australian evidence in non-core metropolitan regions." *Regional Studies* 40 (7):727-741. doi: 10.1080/00343400600959355.
- Hassink, R. 2002. "Regional innovation support systems: Recent trends in Germany and East Asia." *European Planning Studies* 10 (2):153-164. doi: 10.1080/09654310120114463.
- Hauge, E. S., R. M. Pinheiro, and B. Zyzak. 2018. "Knowledge bases and regional development: collaborations between higher education and cultural creative industries." *International Journal of Cultural Policy* 24 (4):485-503. doi: 10.1080/10286632.2016.1218858.
- Hayter, C. S. 2015. "Social Networks and the Success of University Spin-offs: Toward an Agenda for Regional Growth." *Economic Development Quarterly* 29 (1):3-13. doi: 10.1177/0891242414566451.
- He, Z. Y., G. F. Zhai, Y. Asami, and S. Tsuchida. 2016. "Migration intentions and their determinants: Comparison of college students in China and Japan." *Asian and Pacific Migration Journal* 25 (1):62-84. doi: 10.1177/0117196815621203.
- Hernandez, C. M. 2012. "UNIVERSITY-INDUSTRY RELATIONSHIPS: STRATEGIES AND DYNAMICS OF THE COLLABORATION PROCESS AT REGIONAL LEVEL." *Arbor-Ciencia Pensamiento Y Cultura* 188 (753):193-209. doi: 10.3989/arbor.2012.753n1012.
- Hershberg, E., K. Nabeshima, and S. Yusuf. 2007. "Opening the ivory tower to business: university-industry linkages and the development of knowledge-intensive clusters in Asian cities." *World Development* 35 (6):931-940. doi: 10.1016/j.worlddev.2006.05.006.
- Herstad, S., and T. Brekke. 2012. "Globalization, Modes of Innovation and Regional Knowledge Diffusion Infrastructures." *European Planning Studies* 20 (10):1603-1625. doi: 10.1080/09654313.2012.713334.
- Herstad, Sverre J., Tore Sandven, and Bernd Ebersberger. 2015. "Recruitment, knowledge integration and modes of innovation." *Research Policy* 44 (1):138-153. doi: 10.1016/j.respol.2014.06.007.
- Hong, W. 2008. "Decline of the center: The decentralizing process of knowledge transfer of Chinese universities from 1985 to 2004." *Research Policy* 37 (4):580-595. doi: 10.1016/j.respol.2007.12.008.
- Huggins, R. 2008. "Universities and knowledge-based venturing: finance, management and networks in London." *Entrepreneurship and Regional Development* 20 (2):185-206. doi: 10.1080/08985620701748342.
- Huggins, R., A. Johnston, and C. Stride. 2012. "Knowledge networks and universities: Locational and organisational aspects of knowledge transfer interactions." *Entrepreneurship and Regional Development* 24 (7-8):475-502. doi: 10.1080/08985626.2011.618192.

- Hussler, C., F. Picard, and M. F. Tang. 2010. "Taking the ivory from the tower to coat the economic world: Regional strategies to make science useful." *Technovation* 30 (9-10):508-518. doi: 10.1016/j.technovation.2010.06.003.
- Jiao, H., J. H. Zhou, T. S. Gao, and X. L. Liu. 2016. "The more interactions the better? The moderating effect of the interaction between local producers and users of knowledge on the relationship between R&D investment and regional innovation systems." *Technological Forecasting and Social Change* 110:13-20. doi: 10.1016/j.techfore.2016.03.025.
- Jones-Evans, D., M. Klofsten, E. Andersson, and D. Pandya. 1999. "Creating a bridge between university and industry in small European countries: the role of the Industrial Liaison Office." *R & D Management* 29 (1):47-56. doi: 10.1111/1467-9310.00116.
- Kalafsky, R. V., and T. Sonnichsen. 2015. "Employing SWOT Analysis in Coursework on the Geographies of Regional Economic Development and Trade." *Journal of Geography* 114 (5):177-187. doi: 10.1080/00221341.2014.980438.
- Karlsen, J., J. Beseda, K. Sima, and B. Zyzak. 2017. "Outsiders or Leaders? The Role of Higher Education Institutions in the Development of Peripheral Regions." *Higher Education Policy* 30 (4):463-479. doi: 10.1057/s41307-017-0065-5.
- Karlsen, J., M. Larrea, J. R. Wilson, and M. J. Aranguren. 2012. "Bridging the Gap between Academic Research and Regional Development in the Basque Country." *European Journal of Education* 47 (1):122-138. doi: 10.1111/j.1465-3435.2011.01512.x.
- Kirby, D. A., D. Urbano, and M. Guerrero. 2011. "Making Universities More Entrepreneurial: Development of a Model." *Canadian Journal of Administrative Sciences-Revue Canadienne Des Sciences De L Administration* 28 (3):302-316. doi: 10.1002/cjas.220.
- Kitagawa, F. 2004. "Universities and regional advantage: Higher education and innovation policies in English regions." *European Planning Studies* 12 (6):835-852. doi: 10.1080/0965431042000251882.
- Kitagawa, F. 2005. "Regionalization of innovation policies: The case of Japan." *European Planning Studies* 13 (4):601-618. doi: 10.1080/09654310500107332.
- Kolympiris, C., N. Kalaitzandonakes, and D. Miller. 2015. "Location choice of academic entrepreneurs: Evidence from the US biotechnology industry." *Journal of Business Venturing* 30 (2):227-254. doi: 10.1016/j.jbusvent.2014.02.002.
- Krucken, G. 2003. "Learning the 'New, New Thing': On the role of path dependency in university structures." *Higher Education* 46 (3):315-339. doi: 10.1023/a:1025344413682.
- Kuhlmann, S. 2001. "Future governance of innovation policy in Europe - three scenarios." *Research Policy* 30 (6):953-976. doi: 10.1016/s0048-7333(00)00167-0.
- Lazzeretti, L., and E. Tavoletti. 2005. "Higher education excellence and local economic development: The case of the entrepreneurial university of twente." *European Planning Studies* 13 (3):475-493. doi: 10.1080/09654310500089779.
- Lebeau, Y., and A. Bennion. 2014. "Forms of embeddedness and discourses of engagement: a case study of universities in their local environment." *Studies in Higher Education* 39 (2):278-293. doi: 10.1080/03075079.2012.709491.
- Lee, Y. S. 1996. "'Technology transfer' and the research university: A search for the boundaries of university-industry collaboration." *Research Policy* 25 (6):843-863. doi: 10.1016/0048-7333(95)00857-8.
- Leitch, C. M., and R. T. Harrison. 2005. "Maximising the potential of university spin-outs: the development of second-order commercialisation activities." *R & D Management* 35 (3):257-272. doi: 10.1111/j.1467-9310.2005.00388.x.
- Lenger, A. 2008. "Regional innovation systems and the role of state: Institutional design and state universities in Turkey." *European Planning Studies* 16 (8):1101-1120. doi: 10.1080/09654310802315781.
- Leydesdorff, L. 2000. "The triple helix: an evolutionary model of innovations." *Research Policy* 29 (2):243-255. doi: 10.1016/s0048-7333(99)00063-3.
- Leydesdorff, L. 2010. "The Knowledge-Based Economy and the Triple Helix Model." *Annual Review of Information Science and Technology* 44:367-417.
- Leydesdorff, L., and M. Deakin. 2011. "The Triple-Helix Model of Smart Cities: A Neo-Evolutionary Perspective." *Journal of Urban Technology* 18 (2):53-63. doi: 10.1080/10630732.2011.601111.
- Leydesdorff, L., and M. Fritsch. 2006. "Measuring the knowledge base of regional innovation systems in Germany in terms of a Triple Helix dynamics." *Research Policy* 35 (10):1538-1553. doi: 10.1016/j.respol.2006.09.027.
- Leydesdorff, L., and M. Meyer. 2003. "The Triple Helix of university-industry-government relations." *Scientometrics* 58 (2):191-203. doi: 10.1023/a:1026276308287.
- Leydesdorff, L., and M. Meyer. 2006. "Triple Helix indicators of knowledge-based innovation systems - Introduction to the special issue." *Research Policy* 35 (10):1441-1449. doi: 10.1016/j.respol.2006.09.016.

- Leydesdorff, L., H. W. Park, and B. Lengyel. 2014. "A routine for measuring synergy in university-industry-government relations: mutual information as a Triple-Helix and Quadruple-Helix indicator." *Scientometrics* 99 (1):27-35. doi: 10.1007/s11192-013-1079-4.
- Leydesdorff, L., and P. Zhou. 2014. "Measuring the knowledge-based economy of China in terms of synergy among technological, organizational, and geographic attributes of firms." *Scientometrics* 98 (3):1703-1719. doi: 10.1007/s11192-013-1179-1.
- Li, X. J., Y. F. Kong, and B. Y. Peng. 2007. "Development of geography in higher education in China since 1980." *Journal of Geography in Higher Education* 31 (1):19-37. doi: 10.1080/03098260601032912.
- Lilles, A., and K. Roigas. 2017. "How higher education institutions contribute to the growth in regions of Europe?" *Studies in Higher Education* 42 (1):65-78. doi: 10.1080/03075079.2015.1034264.
- Lombardi, R., A. Lardo, B. Cuozzo, and R. Trequattrini. 2017. "Emerging trends in entrepreneurial universities within Mediterranean regions. An international comparison." *Euromed Journal of Business* 12 (2):130-145. doi: 10.1108/emjb-10-2015-0052.
- Lundequist, P., and A. Waxell. 2010. "REGIONALIZING "MODE 2"? THE ADOPTION OF CENTRES OF EXCELLENCE IN SWEDISH RESEARCH POLICY." *Geografiska Annaler Series B-Human Geography* 92B (3):263-279.
- Ma, K. R., E. T. Kang, and O. K. Kwon. 2017. "Migration behavior of students and graduates under prevailing regional dualism: the case of South Korea." *Annals of Regional Science* 58 (1):209-233. doi: 10.1007/s00168-016-0799-9.
- Macpherson, A., and M. Ziolkowski. 2005. "The role of university-based industrial extension services in the business performance of small manufacturing firms: case-study evidence from Western New York." *Entrepreneurship and Regional Development* 17 (6):431-447. doi: 10.1080/0898562050038500385601.
- Malecki, E. J. 2018. "Entrepreneurship and entrepreneurial ecosystems." *Geography Compass* 12 (3). doi: 10.1111/gec3.12359.
- Mansfield, E., and J. Y. Lee. 1996. "The modern university: Contributor to industrial innovation and recipient of industrial R&D support." *Research Policy* 25 (7):1047-1058. doi: 10.1016/s0048-7333(96)00893-1.
- Marek, D., and J. Blazek. 2016. "The challenge of breaking the academia-business firewall in Czechia: comparing the role of differentiated knowledge bases in collaborative R&D projects." *European Planning Studies* 24 (4):809-831. doi: 10.1080/09654313.2015.1121204.
- Marinelli, E. 2013. "Sub-national Graduate Mobility and Knowledge Flows: An Exploratory Analysis of Onward- and Return-Migrants in Italy." *Regional Studies* 47 (10):1618-1633. doi: 10.1080/00343404.2012.709608.
- Marques, J. P. C., J. M. G. Caraca, and H. Diz. 2006. "How can university-industry-government interactions change the innovation scenario in Portugal? - The case of the University of Coimbra." *Technovation* 26 (4):534-542. doi: 10.1016/j.technovation.2005.04.005.
- Martin, B. R. 2012. "Are universities and university research under threat? Towards an evolutionary model of university speciation." *Cambridge Journal of Economics* 36 (3):543-565. doi: 10.1093/cje/bes006.
- Meyer, M., K. Grant, P. Morlacchi, and D. Weckowska. 2014. "Triple Helix indicators as an emergent area of enquiry: a bibliometric perspective." *Scientometrics* 99 (1):151-174. doi: 10.1007/s11192-013-1103-8.
- Miller, K., M. McAdam, and R. McAdam. 2014. "The changing university business model: a stakeholder perspective." *R & D Management* 44 (3):265-287. doi: 10.1111/radm.12064.
- Moodysson, J., and E. Zukauskaitė. 2014. "Institutional Conditions and Innovation Systems: On the Impact of Regional Policy on Firms in Different Sectors." *Regional Studies* 48 (1):127-138. doi: 10.1080/00343404.2011.649004.
- Morgan, B. 2002. "Higher education and regional economic development in Wales: An opportunity for demonstrating the efficacy of devolution in economic development." *Regional Studies* 36 (1):65-73. doi: 10.1080/00343400120099861.
- Moutinho, R., M. Au-Yong-Oliveira, A. Coelho, and J. P. Manso. 2015. "Beyond the "Innovation's Black-Box": Translating R&D outlays into employment and economic growth." *Socio-Economic Planning Sciences* 50:45-58. doi: 10.1016/j.seps.2015.04.001.
- Mowery, D. C., and A. A. Ziedonis. 2015. "Markets versus spillovers in outflows of university research." *Research Policy* 44 (1):50-66. doi: 10.1016/j.respol.2014.07.019.
- Muscio, A. 2013. "University-industry linkages: What are the determinants of distance in collaborations?" *Papers in Regional Science* 92 (4):715-740. doi: 10.1111/j.1435-5957.2012.00442.x.
- Muscio, A., D. Quaglione, and M. Scarpinato. 2012. "The effects of universities' proximity to industrial districts on university-industry collaboration." *China Economic Review* 23 (3):639-650. doi: 10.1016/j.chieco.2011.07.001.
- Nastase, C., and M. Kajanus. 2008. "The role of the universities in a regional innovation system - A comparative A'WOT - analysis." *Amfiteatru Economic* 10 (23):219-224.

- Niosi, J., and M. Banik. 2005. "The evolution and performance of biotechnology regional systems of innovation." *Cambridge Journal of Economics* 29 (3):343-357. doi: 10.1093/cje/bei044.
- Niosi, J., and M. Zhegu. 2010. "Anchor tenants and regional innovation systems: the aircraft industry." *International Journal of Technology Management* 50 (3-4):263-284.
- Nwagwu, W. E. 2008. "The Nigerian university and the triple helix model of innovation systems: adjusting the wellhead." *Technology Analysis & Strategic Management* 20 (6):683-696. doi: 10.1080/09537320802426374.
- Ooms, Ward, Claudia Werker, Marjolein C. J. Daniels, and Herman Van den Bosch. 2015. "Research orientation and agglomeration: Can every region become a Silicon Valley?" *Technovation* 45-46:78.
- Oyarce-Gatica, A., and M. Mardones. 2012. "Logic of economic development: university library and industrial clusters." *Profesional De La Informacion* 21 (6):621-626. doi: 10.3145/epi.2012.nov.09.
- Padilla-Melendez, A., A. R. Del Aguila-Obra, and N. Lockett. 2013. "Shifting sands: Regional perspectives on the role of social capital in supporting open innovation through knowledge transfer and exchange with small and medium-sized enterprises." *International Small Business Journal* 31 (3):296-318. doi: 10.1177/0266242612467659.
- Pastor, M., C. Benner, and R. Rosner. 2003. "An "option for the poor": A research audit for community-based regionalism in California's central coast." *Economic Development Quarterly* 17 (2):175-192. doi: 10.1177/0891242403252392.
- Peer, V., and G. Stoeglehner. 2013. "Universities as change agents for sustainability - framing the role of knowledge transfer and generation in regional development processes." *Journal of Cleaner Production* 44:85-95. doi: 10.1016/j.jclepro.2012.12.003.
- Pickernell, D., P. A. Rowe, M. J. Christie, and D. Brooksbank. 2007. "Developing a framework for network and cluster identification for use in economic development policy-making." *Entrepreneurship and Regional Development* 19 (4):339-358. doi: 10.1080/08985620701275411.
- Power, D., and A. Malmberg. 2008. "The contribution of universities to innovation and economic development: in what sense a regional problem?" *Cambridge Journal of Regions Economy and Society* 1 (2):233-245. doi: 10.1093/cjres/rsn006.
- Pugh, R., E. Hamilton, S. Jack, and A. Gibbons. 2016. "A step into the unknown: universities and the governance of regional economic development." *European Planning Studies* 24 (7):1357-1373. doi: 10.1080/09654313.2016.1173201.
- Rodrigues, C. 2011. "Universities, the Second Academic Revolution and Regional Development: A Tale (Solely) Made of "Techvalleys"?" *European Planning Studies* 19 (2):179-194. doi: 10.1080/09654313.2011.532664.
- Rosenlund, J., W. Hogland, A. W. Johansson, and J. Seddon. 2015. "A cross-national environmental cluster collaboration: Shifting between an analytical and management level of the triple helix." *Science and Public Policy* 42 (4):583-593. doi: 10.1093/scipol/scu075.
- Sa, C. M. 2011. "Redefining university roles in regional economies: a case study of university-industry relations and academic organization in nanotechnology." *Higher Education* 61 (2):193-208. doi: 10.1007/s10734-010-9332-8.
- Saad, M., and G. Zawdie. 2011. "Introduction to special issue: The emerging role of universities in socio-economic development through knowledge networking." *Science and Public Policy* 38 (1):3-6. doi: 10.3152/030234211x12960315267453.
- Sampat, B. N., D. C. Mowery, and A. A. Ziedonis. 2003. "Changes in university patent quality after the Bayh-Dole act: a re-examination." *International Journal of Industrial Organization* 21 (9):1371-1390. doi: 10.1016/s0167-7187(03)00087-0.
- Schartinger, D., C. Rammer, M. M. Fischer, and J. Frohlich. 2002. "Knowledge interactions between universities and industry in Austria: sectoral patterns and determinants." *Research Policy* 31 (3):303-328. doi: 10.1016/s0048-7333(01)00111-1.
- Schlossstein, D. F., and J. H. J. Yun. 2008. "Innovation Cluster Characteristics of Baden-Wuerttemberg and Gyeonggi-Do." *Asian Journal of Technology Innovation* 16 (2):83-112. doi: 10.1080/19761597.2008.9668658.
- Shaw, Julie Keane, and Janelle Allison. 1999. "The Intersection of the Learning Region and Local and Regional Economic Development: Analysing the Role of Higher Education." *Regional Studies* 33 (9):896-902. doi: 10.1080/00343409950075533.
- Skolnik, M. L. 1998. "Higher education in the 21st century - Perspectives on an emerging body of literature." *Futures* 30 (7):635-650. doi: 10.1016/s0016-3287(98)00071-8.
- Smith, H. L., and S. Bagchi-Sen. 2012. "The research university, entrepreneurship and regional development: Research propositions and current evidence." *Entrepreneurship and Regional Development* 24 (5-6):383-404. doi: 10.1080/08985626.2011.592547.

- Smith, Helene Lawton, Dave Chapman, Peter Wood, Timothy Barnes, and Saverio Romeo. 2014. "Entrepreneurial academics and regional innovation systems: the case of spin-offs from London's universities." *Environment and Planning C-Government and Policy* 32 (2):341-359. doi: 10.1068/11159b.
- Sohn, D. W., H. Kim, and J. H. Lee. 2009. "Policy-driven university - industry linkages and regional innovation networks in Korea." *Environment and Planning C-Government and Policy* 27 (4):647-664. doi: 10.1068/c0890b.
- Sotarauta, M. 2010. "Regional development and regional networks: The role of regional development officers in Finland." *European Urban and Regional Studies* 17 (4):387-400. doi: 10.1177/0969776409352581.
- Srinivas, S., and K. Viljamaa. 2008. "Emergence of economic institutions: Analysing the Third Role of universities in Turku, Finland." *Regional Studies* 42 (3):323-341. doi: 10.1080/00343400701291534.
- Steffensen, M., E. M. Rogers, and K. Speakman. 2000. "Spin-offs from research centers at a research university." *Journal of Business Venturing* 15 (1):93-111. doi: 10.1016/s0883-9026(98)00006-8.
- Strand, O., I. Ivanova, and L. Leydesdorff. 2017. "Decomposing the Triple-Helix synergy into the regional innovation systems of Norway: firm data and patent networks." *Quality & Quantity* 51 (3):963-988. doi: 10.1007/s11135-016-0344-z.
- Strand, O., and L. Leydesdorff. 2013. "Where is synergy indicated in the Norwegian innovation system? Triple-Helix relations among technology, organization, and geography." *Technological Forecasting and Social Change* 80 (3):471-484. doi: 10.1016/j.techfore.2012.08.010.
- Su, D., M. Ali, and D. W. Sohn. 2011. "A model to create high-tech start-ups from the academic environment: The case of Peking University (PKU) and Tsinghua University (THU)." *African Journal of Business Management* 5 (26):10821-10833. doi: 10.5897/ajbm11.1047.
- Subramonian, H., and R. Rasiah. 2016. "University-industry collaboration and technological innovation: sequential mediation of knowledge transfer and barriers in automotive and biotechnology firms in Malaysia." *Asian Journal of Technology Innovation* 24 (1):77-99. doi: 10.1080/19761597.2016.1151177.
- Svensson, P., M. Klofsten, and H. Etzkowitz. 2012. "An Entrepreneurial University Strategy for Renewing a Declining Industrial City: The Norrköping Way." *European Planning Studies* 20 (4):505-525. doi: 10.1080/09654313.2012.665616.
- Thakur, S. K., and E. J. Malecki. 2015. "Regional determinants of research and development institutions in India." *Geojournal* 80 (4):533-554. doi: 10.1007/s10708-014-9562-x.
- Trencher, G., X. M. Bai, J. Evans, K. McCormick, and M. Yarime. 2014. "University partnerships for co-designing and co-producing urban sustainability." *Global Environmental Change-Human and Policy Dimensions* 28:153-165. doi: 10.1016/j.gloenvcha.2014.06.009.
- Vega-Jurado, J., I. Fernandez-de-Lucio, and R. Huanca. 2008. "University-industry relations in Bolivia: implications for university transformations in Latin America." *Higher Education* 56 (2):205-220. doi: 10.1007/s10734-007-9098-9.
- Wang, S., J. Fan, D. T. Zhao, and S. Y. Wang. 2016. "Regional innovation environment and innovation efficiency: the Chinese case." *Technology Analysis & Strategic Management* 28 (4):396-410. doi: 10.1080/09537325.2015.1095291.
- Woolgar, L. 2007. "New institutional policies for university-industry links in Japan." *Research Policy* 36 (8):1261-1274. doi: 10.1016/j.respol.2007.04.010.
- Wright, M., B. Clarysse, A. Lockett, and M. Knockaert. 2008. "Mid-range universities' linkages with industry: Knowledge types and the role of intermediaries." *Research Policy* 37 (8):1205-1223. doi: 10.1016/j.respol.2008.04.021.
- Xiao, J. Z., X. Y. Xing, J. M. Lu, J. P. Weng, W. P. Jia, L. N. Ji, Z. Y. Shan, J. Liu, H. M. Tian, Q. H. Ji, D. L. Zhu, J. P. Ge, G. Chen, L. Chen, X. H. Guo, Z. G. Zhao, Q. Li, Z. G. Zhou, Z. J. Yang, G. L. Shan, J. He, W. Y. Yang, and Disorders China Natl Diabet Metab. 2013. "Prevalence and associated factors of microalbuminuria in Chinese individuals without diabetes: cross-sectional study." *Bmj Open* 3 (11). doi: 10.1136/bmjopen-2013-003325.
- Yoon, Hyungseok, Sunyoung Yun, Joosung Lee, and Fred Phillips. 2015. "Entrepreneurship in East Asian Regional Innovation Systems: Role of social capital." *Technological Forecasting and Social Change* 100:83-95. doi: 10.1016/j.techfore.2015.06.028.
- Yun, S., and J. Lee. 2013. "An innovation network analysis of science clusters in South Korea and Taiwan." *Asian Journal of Technology Innovation* 21 (2):277-289. doi: 10.1080/19761597.2013.866310.