Innovation, innovation systems and income inequality: a study of causal mechanisms

Innovation, Innovation Systems and Income Inequality

A Study of Causal Mechanisms

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Declaration

I hereby declare that this thesis entitled "*Innovation, Innovation Systems and Income Inequality*" represents the results of my own work, except where specified in the thesis.

Athanasios (Thanos) Fragkandreas

Abstract

Over the past three decades, an increasing number of contributions have confirmed that innovation (i.e., the development of socio-economic significant combinations of resources) is, either on its own or in conjunction with other structural forces (e.g., declining union membership, deregulation, financialisation, neoliberal policies and welfare state retrenchment), a major determinant behind the surge in income inequality (i.e., unequal distribution of income) in contemporary society.

This thesis makes an essential contribution to our understanding of how innovation shapes the distribution of income. Specifically, by mapping out and reviewing, in a systematic manner, the current stock of knowledge on innovation and income inequality in the social sciences, this thesis structures our understanding of three decades of research on innovation and inequality, whilst also developing a typology of eight causal mechanisms. Furthermore, and in contrast with the bulk of existing studies on innovation and income inequality, which are informed by the labour economic theory in general, and the skill-biased technological change account in particular, this thesis is among the first to systematically investigate the causal mechanisms through which collectivities of innovating actors – such as innovation systems – exercise a causal impact on the distribution of income. To do so, the present thesis advances an original conceptual model based on an integration of key theoretical insights from the literature on innovation systems, relational inequality theory, and critical realism.

Based on an in-depth mixed-method case study analysis of a regional innova-

tion system in Germany, the analysis identifies *seven causal mechanisms* through which systemic interactions among focal actors in the innovation process (e.g., firms, research institutes, universities, policy-makers, etc.) affect the distribution of income. These are as follows: *five inequality-inducing causal mechanisms* (i.e., regional competence concentration, concentrated income extraction, skill premiums, precarious employment, old age technological unemployment), and *two inequality-reducing causal mechanisms* (i.e., gender-inclusive competence-building and employment). The causal explanatory ability of the case study analysis in this thesis is also supported through a dialectical analysis of the paradoxical status of case study research within the field of innovation systems studies.

The thesis ends by discussing key findings, limitations, and analytical and policy implications, some of which touch upon the ability of innovation systems research to inform a new generation of innovation policies focused on grand societal challenges such as rising inequality.

Keywords: Innovation, Innovation Systems, Income Inequality, Causal Mechanisms, Critical Realism, Dialectic, Case Study, Germany, Region of Braunschweig

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To my wife, Seval

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Abbreviations

AG	Aktiengesellschaft (Public limited liability company)
BoD	Board of Directors
BRIS	Braunschweig regional innovation system
CP	Causal power
CR	Critical Realism
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Center)
e.V	eingetragener Verein (Registerd association)
EO	Empirical outcomes
EU28	European Union 28 countries
GDP	Gross domestic product
GmbH	Gesellschaft mit beschränkter Haftung (limited liability company)
GVA	Gross value added
HBK	Braunschweig University of Arts (Hochschule für Bildende Künste Braunschweig)
HDME	Hipothetico-deductive model of explanation
IHK	Industrie- und Handelskammer (Chamber of Commerce and Industry)
IPR	Intellectual property rights
IS	Innovation system
NIS	National innovation system
OECD	Organisation for Economic Cooperation and Development
PTB	National meteorological institute of Germany (Physikalisch-Technische Bundesanstalt)
QCA	Qualitative comparative analysis
R&D	Research and development
RC	Relevant conditions
RIS	Regional innovation system
RME	Retroductive model of explanation
RQ	Research question
RRN	Risks and Rewards Nexus
SBTC	Skilled biased technological change
SIS	Sectoral innovation system
SMEs	Small and medium sized enterprises
SS	Smart Specialisation
TIS	Technological innovation system
TUB	Technical University of Braunschweig (Technische Universität Braunschweig)
UK	United Kingdom
US(A)	United States of America
VoC	Varieties of capitalism
VW	Volkswagen AG

Chapter 1

Introduction

One of the most recognisable facts of contemporary economic development lies in the following paradox: the more innovation-intensive and affluent the 21st century capitalist system becomes, the more unequal the distribution of income tends to be.

The paradoxical nature of this observation is that, traditionally, innovation has been a necessary precondition for achieving inclusive growth and social cohesion in capitalist societies (Schumpeter, 1934, Kuznets, 1955, Freeman and Louçã, 2001, Lundvall, 2002). For instance, in the Golden (Fordist) Age of capitalism (between the 1940s and 1970s), innovation-driven growth led to a significant reduction in (male) unemployment and inequality rates (Freeman, 2001, Pianta, 2005, Fagerberg and Godinho, 2005, Cozzens and Kaplinsky, 2009, Atkinson et al., 2011). However, the more recent experience (circa the 1980s) illustrates that due to macro-structural and institutional change (e.g., the emergence of high-tech and service sectors, financialisation, declining union membership, declining minimum wages and welfare state retrenchment), innovation-driven growth appears to be inducing and reproducing income inequality in contemporary societies (Powell and Snellman, 2004, Stiglitz, 2012, Lin and Tomaskovic-Devey, 2013, Martorano and Sanfilippo, 2015, Hope and Martelli, 2019). This is also reflected in the extant literature, particularly in the fact that – unlike

a few decades ago – the more recent work of mainstream and heterodox economists of innovation who, despite having fundamental differences in terms of theory and method (e.g., Fagerberg, 2003, Castellacci, 2007), tend to agree that polarisation and growing inequality are inherent in a globalising innovation-driven economy (see, e.g., Archibugi and Lundvall, 2001, Acemoglu, 2002, Van Reenen, 2011, Lazonick and Mazzucato, 2013, Goos, 2018, Schot and Steinmueller, 2018, Pianta, 2020).

This thesis aims to extend and deepen our knowledge on the question of causality in the relationship between innovation and inequality. It does so by providing one of the first systematic literature reviews on innovation and inequality. Furthermore, it develops a typology of causal mechanisms, whilst also addressing and debunking several methodological inconsistencies and myths in the field of innovation studies. Additionally, the thesis advances a novel conceptual model that enables us to systematically investigate a set of causal mechanisms through which innovation affects the distribution of income in contemporary societies. As will be shown in various parts of this thesis, several novel analytical and policy lessons can be drawn from an explicit causal mechanisms analysis on innovation and inequality. Overall, this research addresses the question of causality in a novel manner, and this applies to both theory and method.

The present chapter introduces the reader to the chief features of this thesis. Section 1.1 begins by discussing the research background, whereas Section 1.2 introduces the underlying research motivation in the thesis. Section 1.3 provides an overview of the research problem. Section 1.4 discusses the research questions that this thesis addresses, while Section 1.5 presents the overarching methodological strategy of the current thesis. Thereafter, Section 1.6 discusses the novelty of this thesis, and Section 1.7 ends the chapter with an overview of the structure of the thesis.

1.1 Research Background: Rising Inequality and Significance

1.1.1 Welcome to The Age of Rising Inequality!

Defined as *the unequal distribution of income* within and among individuals and social units (e.g., social groups, firms, nations, regions, and cities) (Wright, 1994, Tilly, 1998, DeVerteuil, 2009), income inequality – in short, inequality – is, currently, at the forefront of several academic, media and political discourses across the world. Headlines – such as 'The Richest 1% to own more than the rest of the World'[1], 'We are all the 99%'[2], 'Inequality and instability' (Galbraith, 2012), 'Why we can't afford the rich?' (Sayer, 2015), 'Inequality: what can be done?'(Atkinson, 2015), and 'The price of inequality'(Stiglitz, 2012), 'Growing unequal?' (OECD, 2008), and 'Why less inequality benefits all?' (OECD, 2015) – illustrate that we live in the *age of rising inequality*. According to several reports from the Organisation for Economic Cooperation and Development (OECD 2008, 2015, 2011), as well as in line with the findings of numerous studies (Alderson and Nielsen, 2002, Neckerman and Torche, 2007), inequality has risen considerably in the advanced economies since the 1980s. As the OECD states in one of its reports on inequality:

> "*Today, in OECD countries, the richest 10 per cent of the population earn 9.6 times the income of the poorest 10 per cent. In the 1980s this ratio stood at 7:1 rising to 8:1 in the 1990s and 9:1 in the 2000s*."
>
> (OECD, 2015, p.1)

Table 1.1 provides an overview of a few key statistical indicators of economic growth and inequality for two of the main archetypal institutional varieties of ad-

[1] Source:https://www.oxfam.org/en/press-releases/richest-1-will-own-more-all-rest-2016

[2] Source:https://enwikipedia.org/wiki/We_are_the_99%25

vanced capitalist economies (Hall and Soskice, 2001): the *liberal market economy* of the United States (US), and the *coordinated economy* of Germany. In line with the varieties of capitalism (VoC) literature, the institutional arrangements in both countries have facilitated high levels of economic growth: both countries have registered a significant increase in the gross domestic product (GDP) and income per capita statistics.

However, in contrast with the trickle-down economic thesis, whereby the benefits of economic growth will sooner or later benefit the less affluent individuals and social groups (e.g., Kuznets, 1955), neither the US nor Germany have exhibited a significant drop in inequality statistics. On the contrary, after nearly four decades of registering record levels of economic affluence, the distribution of income in both countries has become even more unequal rather than less. For instance, the Gini coefficient – the standard measure with which to gauge the distribution of income (McGregor et al., 2019) – has increased by 12% in the US and by 16% in Germany. However, and in line with the VoC literature, the distribution of income is more egalitarian in Germany than in the US. Similarly, both of Atkinson's coefficients[3] (i.e., 0.5 and 1) have increased considerably: 20 to 25% in the US and 24 to 36% in Germany. Percentile ratios also point to a similar trend: the 90/10 percentile, which measures how much of the overall income the 10% of earners hold in comparison to the remaining 90%, has increased by 7% in the US, and by 24% in Germany. In a nutshell, the above discussion demonstrates that advanced economies have, since the 1980s, made several steps backwards, rather than forwards, when it comes to economic equality.

[3]The Atkinson index, also known as the Atkinson coefficient, parameter or measure, is a measure of income inequality developed by Sir Anthony Barnes Atkinson (Atkinson et al., 1970). The index is used as a measure to determine the end of the distribution which contributed most to the observed inequality (Allison, 1978) Often, two measures of the Atkinson index are used in inequality studies (see, for instance, Lee, 2011, Aghion et al., 2019): the 0.5 parameter which is sensitive to the bottom of the distribution, and the 1 parameter which is sensitive to the top of the income distribution.

Table 1.1: Growth and Inequality in the US and Germany

	Liberal Market Economy Model			Coordinated Market Economy Model		
	US			Germany		
	1986	**2016**	**Change (%)**	**1987**	**2015**	**Change (%)**
Economic growth						
Gross domestic product (in millions US dollars)	4,579,631.00	18,707,189.00	308.49	1,172,989.95	3,919,280.29	234.13
Income per capita (US dollar)	18,192.00	57,797.00	217.71	15,682.00	47,979.00	205.95
Income inequality						
Gini	0.34	0.38	12.06	0.25	0.29	16.27
Atkinson Coefficient (epsilon=0.5)	0.10	0.12	24.49	0.05	0.07	35.19
Atkinson coefficient (epsilon=1)	0.20	0.24	20.50	3.02	3.74	23.69
Percentile ratio (90/10)	5.55	5.94	7.08	3.02	3.74	23.69
Percentile ratio (80/20)	3.04	3.16	3.99	2.06	2.31	11.78

Source: Own elaboration based on data from OECD and Luxembourg Inequality Database

1.1.2 Why Bother with Rising Inequality?

'Why study rising inequality?', one may rightly wonder. After all, the work of eminent economists, such as Simon Kuznets' (1955) theory of growth and inequality, and Milton Friedman's (2002) work on capitalism, as well as the public speeches of iconic conservative politicians (e.g., Margaret Thatcher and Ronald Reagan), have taught us that growing inequality is a transitory – and somewhat necessary – social evil on the path to economic equality in capitalist societies. For instance, Kuznets' (1955) 'inverted-U curve' hypothesis (also known as Kuznets curve) predicts that inequality rises in the early stages of economic growth, then it peaks, before subsequently reaching a historic low (cf. Alderson and Nielsen, 2002). In a somewhat similar manner, mainstream growth economists have long believed that inequality has a long-term positive impact on growth by, for instance, providing strong incentives to economic agents, i.e., the incentive thesis (Stiglitz, 2012).

> "*A gap between rich and poor means that people have strong incentives to do what they can to be rich – including working harder, studying longer, and taking greater risks, all of which can lead to more economic activity, efficiency and growth.*"
>
> (OECD, 2015, p.26)

In this regard, a systematic study of rising inequality can help us find out how inequality motivates economic agents to make the 'right' choices, including the channels through which inequality spurs growth.

In addition to the incentive thesis, research on inequality is necessary to clarify why it has continued to increase during one of the most affluent periods in the history of the capitalist system; even though, according to economic theory, the exact opposite should have occurred (Schumpeter, 1934, Kuznets, 1955, Alderson and Nielsen, 2002). Furthermore, research on inequality is necessary to find out whether

or not inequality itself is beneficial for our societies. For instance, contrary to the incentive thesis, a growing number of studies show that rising inequality has, on average, a strong negative effect on productivity and economic growth (Falkinger and Zweimüller, 1997, Deininger and Squire, 1998, Stiglitz, 2012, OECD, 2015). Other studies demonstrate that rising inequality – or persistently high levels of it – undermine not only the viability of welfare states and the institutional fabric of democratically-organised capitalist societies (Breau and Essletzbichler, 2013, Stiglitz, 2012, Neckerman and Torche, 2007), but also the longevity of the global capitalist system (OECD, 2015).

All in all, several important reasons justify the systematic study of rising inequality. The next section summarises in a critical manner key aspects of research on rising inequality. As will be shown throughout this thesis, innovation is increasingly being regarded as one of the most significant determinants of rising inequality.

1.2 Research Motivation: 'Innovation-Inequality Consensus' and Knowledge Gaps

The underlying motivation in this thesis lies in what can be called the 'innovation-inequality consensus' in the economic literature on inequality, specifically that innovation is the driving force behind the surge in inequality in contemporary societies. For instance, Acemoglu (2002), as well as Van Reenen (2011) more recently, confirm that there exists a consensus among economists that innovation is – either on its own or in conjunction with other factors (e.g., global trade, de-unionisation, and immigration) – the most efficacious determinant of rising inequality (e.g., Krusell et al., 2000, Acemoglu et al., 2001, Autor et al., 2008, Goos et al., 2014). The remainder of this section provides a brief overview of theory and research on innovation and inequality.

1.2.1 Innovation and Inequality Research

Since the late 1990s, numerous studies have investigated the relationship between innovation and inequality (see, for instance, Chapter 2 in this thesis). A common finding in most of these studies is that there exists a statistically significant relationship between the variables innovation and inequality. Krueger (1993), for instance, finds that innovation, as measured by computer usage at work, has significantly affected the distribution of wages in the US. Similarly, Chennels and van Reenen (1998) determine that "*the presence of micro-electronic technologies in workplaces* [in both the US and UK] *is associated with higher earnings, especially for skilled workers*" (p.139). Other firm-level studies show that, while innovation increases the overall distribution of wages within firms, large firms tend to have a more egalitarian distribution of income than small firms in Europe (Cirillo et al., 2017), but not in the US (Song et al., 2019). Studies at the national level reveal that the relationship between innovation and inequality is more robust in some countries than in others (Hühne and Herzer, 2017, Kharlamova et al., 2018, Hope and Martelli, 2019).

Moreover, a growing number of geographical studies illustrate that there is a statistically significant association between the variables of innovative activity (e.g., patenting activity and employment in knowledge-intensive services) and rising inequality at the sub-national level, i.e., cities and regions. Florida (2007), for instance, provides evidence showing that the more innovative a city is in the US, the more likely it is to exhibit rising levels of inequality. To contextualise his finding, Florida (2007) refers to the most innovation-intensive place in the world, namely the region of Silicon Valley. As he puts it:

> "*Not only is Silicon Valley the home of great economic wealth; it's also one of the most innovative and creative regions in the world. If ever a rising tide of prosperity were going to lift all boats, you would expect it to happen here. Yet it doesn't. Instead, the opposite occurs*".

(Florida, 2007, p.186)

More recent studies have extended Florida's observation. They show that not only the region of Silicon Valley, but also many other innovative cities and regions in different parts of the world (i.e., Canada, China, the EU, and the US), exhibit rising levels of inequality (Lee, 2011, Breau et al., 2014, Guo, 2019). For instance, Breau et al.(2014) find that cities in Canada "*with higher levels of innovation have more unequal distributions of earnings*" (p.351).

Although the findings of these studies raise the usual methodological questions about the quality of the variables, methods and data, it is the question of theory that concerns the rest of this section.

1.2.2 Innovation and Inequality Theory: A Brief Critical Overview

The skill-biased technological change (SBTC) account is the most popular theoretical perspective on innovation and inequality in the social sciences. According to this account, which originates from the field of labour economics, innovation has – for much of the 20th century – been complementary to skills in general, and the labour productivity (thus also wages) of the skilled-labour force in particular (Card and DiNardo, 2002, Acemoglu, 2002, Van Reenen, 2011, Bogliacino, 2014). In doing so, innovation induces inequality by increasing the wage gap between skilled and unskilled employees (Acemoglu, 2002, Goos et al., 2014). At the macro-level, the SBTC account predicts that the more technologically-advanced an economy becomes, the more polarising the distribution of skills and wages among workers tends to be (Autor et al., 1998, Krusell et al., 2000, Goos et al., 2014).

Despite being the most popular theoretical perspective on innovation and inequality, the SBTC account has several important flaws, limitations and ommisions. For instance, Card and DiNardo (2002) criticise SBTC research for failing to account for

the changes in inequality in the US. Others point out that gender and racial inequalities are mostly overlooked in the literature (Card and DiNardo, 2002), while there are also those who emphasise that SBTC research remains oblivious to power and class issues (Skott and Guy, 2007, Kristal, 2019), including the question of rising top income inequality (Lazonick and Mazzucato, 2013, Aghion et al., 2019). Yet others argue that the SBTC account fails to acknowledge that it is organisations rather than merely labour market forces that determine skill premiums (Fernandez, 2001, Avent-Holt and Tomaskovic-Devey, 2014, Cobb, 2016).

Furthermore, by mostly focusing on general-purpose technologies (GPTs) such as computers, robots, and artificial intelligence (e.g., Krueger, 1993, Acemoglu and Autor, 2011, Van Reenen, 2011, Brynjolfsson and McAfee, 2012), SBTC research has, to date, failed to investigate the impact that different types of innovation have on the distribution of income; for instance, does innovation in traditional sectors (e.g., low-tech manufacturing) and innovation in recently-emerged sectors (e.g., software and platform economy) affect inequality through the same or different mechanism(s)? Similarly, research informed by the account in question has nothing to say about the distributional consequences of financial innovations (e.g., sub-prime mortgages, collateralised debt obligations and credit default swap), and how financialisation, in general, affect the innovation-inequality nexus (Powell and Snellman, 2004, Lin and Tomaskovic-Devey, 2013, Soete, 2013, Martin, 2016, Schor, 2017). Moreover, much of the SBTC literature tends to equalise the experience in the liberal market economies (e.g., the US and UK) with the experience in the other market economies (e.g., coordinated and mixed market economies); even though both types of capitalist economies have experienced and moved towards a similar path of institutional change (e.g., deregulation), the experience in liberal and coordinated economies remains significantly different in terms of skill regimes and inequality rates (Hall and Soskice, 2001, Lundvall, 2002, Stiglitz, 2012, Kawaguchi and Mori, 2016, Hope and Martelli, 2019). Put it differently, the SBTC account neglects the causal (top-down) significance of macro institutional changes (e.g., deregulation) in the institutional framework

of liberal and coordinated economies have affected the ability of innovation to induce inequality.

Dissatisfied with the SBTC account, and particularly by its lack of a sophisticated theory of innovation, Lazonick and Mazzucato (2013) propose an alternative framework to study the relationship between innovation and inequality in advanced economies. Based on the theoretical core of the field of *innovation studies*[4], these authors criticise the SBTC account for failing to see that innovation is a highly-uncertain, collective, and cumulative process. This, as Lazonick and Mazzucato emphasise, implies that when the distribution of benefits (rewards) reflects the distribution of the actual contributions of actors to innovation (risks), innovation reduces inequality. However, when certain actors (e.g., financiers, top management executives and shareholders) who have not made a significant contribution to the innovation process (in terms of taking the lion's share of the risks associated with innovation) can reap large shares of the economic benefits that innovation generates, then innovation increases inequality. In a nutshell, the RRN framework argues that innovation tends to induce inequality when the risks of innovation development are socialised, whereas the economic rewards of innovation are privatised (see, also Mazzucato, 2015).

Despite providing a more realistic theoretical lens than the SBTC account, the RRN framework has, in its current form, several weaknesses. For instance, it has nothing to say about the classical (Marxian) scenario, whereby innovation induces inequality through technological unemployment (Pianta, 2005, Smith, 2010, Frey and Osborne, 2017). Like the STBC account, the RRN account suffers from 'gender-blindness' in the sense that it does not account for the stylised fact that the great majority of top income earners are men (Essletzbichler, 2015, Aghion et al., 2019).

[4]Innovation studies is a half-century old, cross-disciplinary field of the social sciences. Its primary aim is to study, in a systematic manner, the nature, determinants, social and economic benefits and consequences of innovation (Fagerberg et al., 2012, Lundvall, 2013). While diverse, much innovation studies theory and research falls into three main strands (Fagerberg et al., 2012, Lundvall, 2013): the economics of innovation strand (Fagerberg, 2003); the management and organisation of innovation strand (Tidd and Bessant, 2018); and the socio-economic strand dealing mainly with the diffusion of innovation (Rogers, 1995), innovation systems (Edquist, 2005) and socio-technical systems and transitions (Geels, 2004).

However, from the standpoint of this study, the most critical omission in the RRN framework is empirical rather than theoretical: the framework in question has, to date, not been systematically applied, despite the popularity it has rightly gained through Mazzucato's (2015) inspiring work on the Entrepreneurial State.

Overall, while the existing literature on innovation and inequality offers some interesting theoretical insights, ***it has – to date – been unable to provide a sophisticated, empirically-grounded understanding of how innovation as an uncertain, collective activity affects the distribution of income***.

1.3 Research Problem, Significance and Causal Mechanisms

1.3.1 Research Problem and Significance

Motivated by the dearth of research on innovation as a collective process and inequality, this thesis investigates the below research problem, which is articulated, in the form of a research question, in the following manner:

How does innovation (as a collective activity) affect the distribution of income in contemporary societies?

'*Why is the lack of systematic knowledge on the collective character of innovation and inequality of significance to our knowledge?*', the sceptical reader may rightly wonder. After all, since the (early) work of the grandfather of the field of innovation studies, Joseph Schumpeter (1934), and consistent with the long-term economic experience of rising affluence and declining inequality in capitalist societies (Freeman

and Louçã, 2001, Atkinson et al., 2011), including the post-war 'economic miracles' of West Germany, Japan, South Korea, Singapore and China (Fagerberg and Godinho, 2005, Lee, 2013), innovation has long been seen as key to reducing inequalities in capitalist societies.

This somewhat 'one-sided' and 'naive' view on innovation (Soete, 2013) has also been reinforced by the long-lasting positivist belief that causality manifests itself in the form of large-scale constant sequences of empirical events, best known as empirical regularities (Lawson, 1997, Smith, 1998, Benton and Craib, 2001, Bhaskar, 2008*b*). This empiricist view on causality implies that, as long we do not observe the co-existence of innovation intensity and rising inequality, then there is no causal connection between the two. In other words, causality (including its inference) is not a matter of conceptualisation but a matter of empirical observation.

Grounded in the critical realist philosophy of science (Bhaskar, 1979, Lawson, 1997, Danermark et al., 2002, Bhaskar, 2008*b*), this thesis argues that conceptualisation is of utmost significance when it comes to inferring causality in the relationship between innovation and inequality. For instance, if innovation is understood as a collective activity in the sense that it encompasses the efforts of a wide variety of actors both within and outside the innovating firm (Powell et al., 1996, Edquist, 2005, Dodgson, 2017), it follows that the primary locus of causality lies, not in the skill-complementary nature of general-purpose technologies (e.g., computers and robots) as the bulk of the extant literature on innovation and inequality assumes (Acemoglu, 2002, Violante, 2008, Van Reenen, 2011), but instead, and significantly, causality lies in collectivities of innovating actors such as in innovation (eco)systems, networks and clusters. Correspondingly, innovation policies that remain oblivious to such a causal possibility may inadvertently exacerbate inequality (Cozzens et al., 2002, Zehavi and Breznitz, 2017). For instance, by seeking to address 'soft' or 'hard' network failures among innovating actors (Woolthuis et al., 2005, pp.613-614), innovation policies can reinforce the significance of skill premiums or they can lead to the destruction of

routinised jobs (Cozzens et al., 2002, Frey and Osborne, 2017). In this regard, ***a systematic investigation of the research problem is very likely to produce not only novel theoretical insights, but also interesting policy implications***.

1.3.2 Causal Mechanisms: A Critical Realist Approach

This study is informed by the critical realist approach to *causal mechanisms* (Fleetwood, 2001, Mingers and Standing, 2017, Bhaskar, 2008*b*). However, not only does the choice of critical realism require some clarification, but also the analytical focus on causal mechanisms. This is somewhat necessary given that, to the best of my knowledge, the present study is the very first to utilise the critical realist philosophy as the underlying methodological foundation to study causality in the relationship between innovation and inequality.

Emanating from a synthesis of Roy Bhaskar's work on *transcendental realism* (Bhaskar, 2008*b*) and *critical naturalism* (Bhaskar, 1979), critical realism (CR) is one of the main philosophies of the social sciences (Benton and Craib, 2001, Baert, 2005). As is the case with every realist philosophy of science, CR endorses the realist thesis that our knowledge of causality – and reality in general – does not exhaust their existence (Danermark et al., 2002, Bhaskar, 2008*b*). Bhaskar's (1979, 2008*b*) philosophical analysis of both the natural and social sciences has shown that, despite their ontological differences, the ultimate objects of explanatory research in both fields of science are not empirical regularities (cf. positivist philosophy of science), but the causal powers (i.e., inherently-possessed abilities to do certain things and not others) of structures (i.e., a set of necessary related elements). Causal powers and structures exist and act independently of our cognition and research on them; thus, explanatory research is, for its most part, a process of construing, rather than constructing, independently-existing structured entities (e.g., planets, markets, firms, entrepreneurs, language, etc.) (Sayer, 2000, Danermark et al., 2002, Bhaskar, 2008*b*).

The critical realist approach comprehends causal mechanisms as 'agentic', 'structurally-situated' and 'relationally-emergent' entities (Brannan et al., 2017, Mingers and Standing, 2017, Sorrell, 2018). In particular, unlike causal mechanisms in the natural world (e.g., the orbit of planets, natural selection, cell renewal), the existence and efficacy of causal mechanisms in the social world always depend upon acting human beings (Bhaskar, 1979, Lawson, 1997, Danermark et al., 2002). These mechanisms are *structurally-situated* in the sense that, human agency always draws upon from the social context in which it is situated (e.g., social positions, resources attached to them, norms, rules, etc.)(Bhaskar, 1979, Danermark et al., 2002). Causal mechanisms are *relationally-emergent* as they emerge from, and are reproduced in, social relationships among human agents (Bhaskar, 1979, Danermark et al., 2002).

Furthermore, according to CR, causal mechanisms consist of dynamic configurations of two main components (Fleetwood, 2001, Mingers and Standing, 2017): the inherent abilities of a structured entity, i.e., *causal powers*, and a set of *relevant conditions* that enable the causal powers of the object in question to produce an *empirical outcome*. As Brannan et al. (2017) put it, "[a] *causal mechanism is causal in virtue of the powers it possesses as derived from its properties*" (p.15). For instance, due to its underlying chemical composition, dynamite inherently possesses the *causal power* to explode (*empirical outcome*), especially when it is brought into contact with fire (*relevant condition*). Hence, from the standpoint of critical realism, causal mechanisms can be understood in the following manner:

Causal Powers (CPs) + *Relevant Conditions (RCs)* = *Empirical Outcome (EO)*

Contribution In addition to providing a well-thought, philosophically-informed perspective on causal mechanisms, the critical realist perspective makes two essential contributions to this study. The first contribution is ***critical***, i.e., underlining that deducing formal (mathematical traceable) theoretical statements (i.e., hypotheses) and testing them through the identification of statistically significant associations among

variables (e.g., R&D expenditure, patents, Gini index, log of wages, etc.) in the largest number of cases possible is, at least on its own, unable to study causal mechanisms. The second contribution is ***constructive***: the critical realist approach to causal explanation places significant emphasis to an ontological (rather than to a purely empirical) conceptual analysis of the causal powers that innovation (as a collective activity) must possess in order to be able to shape the distribution of income; and under what conditions, the postulated causal powers emerge as causal mechanisms capable of inducing, either a positive or negative, change to the distribution of income. It is such a question that drives a significant part of the analysis in this thesis.

1.4 Research Questions

To address the research problem in a systematic manner, this thesis develops three research questions, each of which is derived from a specific knowledge gap in the relevant literature.

1.4.1 Research Question I: Innovation and Inequality

As will be shown in Chapter 2 of this thesis, there exists a rapidly-increasing cross-disciplinary interest in innovation and inequality in various disciplines and fields of the social sciences. For instance, economists (e.g., Acemoglu, 2002, Van Reenen, 2011), economic geographers (e.g., Breau et al., 2014, Lee, 2016, 2011), development scholars (e.g., Hilbert, 2010), innovation studies researchers (e.g., Cozzens and Kaplinsky, 2009, Lazonick and Mazzucato, 2013), industrial relations scholars (e.g., Belman and Monaco, 2001), sociologists (e.g., Fernandez, 2001) and political scientists (e.g., Hope and Martelli, 2019) have all studied the relationship between innovation and inequality.

Despite being cross-disciplinary, our understanding of how innovation affects the

distribution of income is, currently, informed by economic research, in particular by research informed by the SBTC account. Correspondingly, we know a great deal about the work of economists on innovation and inequality(Acemoglu, 2002, Van Reenen, 2011, Bogliacino, 2014), but far too little about the work of the other social scientists. As a result of this, several important questions remain unaddressed. For example, are there any significant differences between, for instance, the work of economists, geographers and sociologists on innovation and inequality? If yes, what are they? If no, why is this the case? Does the work of other social scientists confirm or refute the validity of the skill-premiums hypothesis? If yes, in what ways? If no, why is this?

Although these questions deserve our research attention, it is the question of causal mechanisms that is of significance to this study.

> *Research Question I* - ***Does the extant research on innovation and inequality identify causal mechanisms? If yes, which ones? If no, how could a set of possible causal mechanisms be conceptualised before a fully-fledged empirical study has been conducted?***

1.4.2 Research Question II: Case Study Research on Innovation and Inequality

Case study research is one of the most popular research designs in the social sciences in general (Yin, 2009), and innovation research in particular (Carlsson, 2007, Goffin et al., 2019). However, as will be shown in Chapter 2 of this thesis, there is a significant dearth of case study research on innovation and inequality. This can, among other things, be attributed to the conventional belief that, compared to other 'hard' forms of research (e.g., econometrics), case study research cannot identify the general aspects of causality in the relationship between innovation and income inequality.

More specifically, the existing work of innovation and inequality researchers – es-

pecially economists – suggests that mathematical formalisation and hypothesis-testing are necessary methodological tools for research seeking to study causality in the relationship between innovation and inequality (Lawson, 1997, Krusell et al., 2000, Violante, 2008). Concomitantly, the explanatory power of our theories is best illustrated by studying the largest possible number of cases through advanced statistical research. Since case study research investigates one or a very few cases (small N-research) by utilising – although not exclusively – qualitative data based on interviews (Eisenhardt, 1989, Yin, 2009), it follows, from the standpoint of a formal approach to research, that a case study analysis on innovation and inequality produces findings that are exploratory, descriptive and non-generalisable rather than explanatory and generalisable.

However, such a conventional belief contradicts the work of numerous philosophers and methodologists of social science (Benton and Craib, 2001, Bhaskar, 2008*b*, 1979, Lawson, 1997, Sayer, 2000). Specifically, inspired by Bhaskar (1979, 2008*b*), Lawson (1997) argues that, due to their fundamentally open-system and interpretive character of social world, economic phenomena are not readily amenable to formalism and closed systems research (e.g., econometrics and experimental research) in the way that natural phenomena are. Furthermore, leading case study experts (e.g., Flyvbjerg, 2006, Yin, 2009) argue that the findings of case study research are relatable to the existing theory – a process known as *analytical generalisation*. Lastly, the work of an increasing number of social scientists suggests that case study research is ideal for studying causal mechanisms (see, for instance, Tsoukas, 1989, Mahoney, 2001, Easton, 2010, Tsang, 2014).

Given the existence of fundamentally different perspectives on the nature and qualities of case study research in the literature, including the crucial epistemological implications that follow from accepting one or the other perspective, the below methodological question is thus formulated:

Research Question II - ***Is a case study analysis on innovation and***

inequality capable of identifying a set of causal mechanisms through which innovation affects the distribution of income in contemporary capitalist societies? If yes, to what extent are the findings of such a type of analysis generalisable?

1.4.3 Research Question III: Innovation Systems and Inequality

Since the early 1980s, numerous contributions have either argued or shown that firms actively seek to forge new, and tap into existing, networks as a means to boost their innovative capability and competitive advantage (e.g., Powell et al., 1996, Porter, 1998, Lundvall, 2013, Dodgson, 2017, Tidd and Bessant, 2018). Consider, for instance, the over-quoted example of Procter & Gamble's 'Connect & Develop strategy', whose primary aim is to source as much as 50% of new ideas from outside the firm (Sakkab, 2002). Other well-known high-tech corporations (e.g., Cisco, Deutsche Telecom and IBM) encourage their employees to use digital platforms for prototyping their ideas and collaborating with others (Rohrbeck et al., 2009, Hollands, 2015). Furthermore, another important strand of innovation research shows that innovation is, undoubtedly, not a smooth, linear process that begins with R&D- activities before it reaches the market through production, marketing and sales. On the contrary, innovation is a highly risky, contingent, complex and collective activity (Kline and Rosenberg, 1986, Lundvall, 1992, Lundvall et al., 2002, Edquist, 2005); in particular, it takes place through both formal (market) and informal (non-market) interactions among firms, suppliers, users, universities, research institutes, government institutes, banks and venture capitalists.

In terms of theory, the above developments have prompted a significant shift in our understanding of innovation: from the firm as the primary site for innovation development, to distributed networks of innovating firms and numerous other organisations

(Howells, 2006, Powell and Grodal, 2005, Edquist, 2005, Granstrand and Holgersson, 2020). Today, these stylised findings of innovation research provide the theoretical backbone to various theoretical models and frameworks on innovation. To mention a few: *open innovation* (Enkel et al., 2009), *clusters* (Porter, 1998), *innovation ecosystems* (Granstrand and Holgersson, 2020), *networks of innovators* (Powell and Grodal, 2005), *innovation systems* (Edquist, 2005, Chaminade et al., 2018, Asheim et al., 2019), *sociotechnical transitions* (Geels, 2004), and the *triple helix model* of innovation (Etzkowitz and Leydesdorff, 2000).

In this research, the collective character of the innovation process is conceptualised from the standpoint of the innovation systems (ISs) approach (Lundvall, 1992, Edquist, 2005, Chaminade et al., 2018, Asheim et al., 2019). What makes the ISs approach ideal for this study lies, among other things, in the fact that – like the other approaches to innovation (and unlike the SBTC account) – it rejects the linear model of innovation. In its place, the ISs approach puts forth the interactive-learning model of innovation (Nelson and Winter, 1982, Kline and Rosenberg, 1986, Lundvall, 1992), whereby innovation is a highly-uncertain (risky), path-dependent (cumulative), multi-actor (collective), learning (trial-and-error) process. However, unlike the other approaches to innovation, the approach in question places significant emphasis upon *relatively-enduring* institutional arrangements and systemic interactions among innovating actors and organisations at different levels of socio-economic organisation (Lundvall, 1992, Malerba, 2002, Edquist, 2005, Bergek et al., 2008, Asheim et al., 2011). Charles Tilly (1998) argues in his seminal book on *Durable Inequality* that inequality research is more likely to be explanatorily successful when it seeks to identify the most enduring aspects of inequality rather than its ephemeral characteristics. In this regard, the ISs approach offers a promising theoretical framework through which to conceptualise and analyse how the collective structure of the innovation process affects the distribution of income.

Since the late 1980s, ample research has confirmed that ISs are not only an im-

portant engine of competitiveness and economic growth, but also of social cohesion (Freeman, 1987, 2002, Lundvall, 2002, Lundvall et al., 2002, Fagerberg and Srholec, 2008, Lee, 2013). However, what this prolific line of research on ISs (Rakas and Hain, 2019) has so far neglected to do, is – among other things – to investigate the ***distributional question***, i.e., who gets what and how from the systemic character of innovation? The significance of such neglect is reinforced by the findings of a growing number of studies showing that there is a statistically significant association between the variables innovative activity and rising inequality at both national and regional levels (e.g., Krusell et al., 2000, Goos et al., 2014, Permana et al., 2018, Lee, 2011, Breau et al., 2014, Guo, 2019). Therefore, given that innovation-intensive national and sub-national economies exhibit rising levels of income inequality, as well as the fact that the successful development of innovative activity presupposes enduring systemic interactions among numerous innovating actors (in short, ISs), the following research question is formulated:

Research Question III - ***What are the causal mechanisms through which ISs shape the distribution of income in contemporary societies? Is the overall causal impact of ISs on inequality positive or negative?***

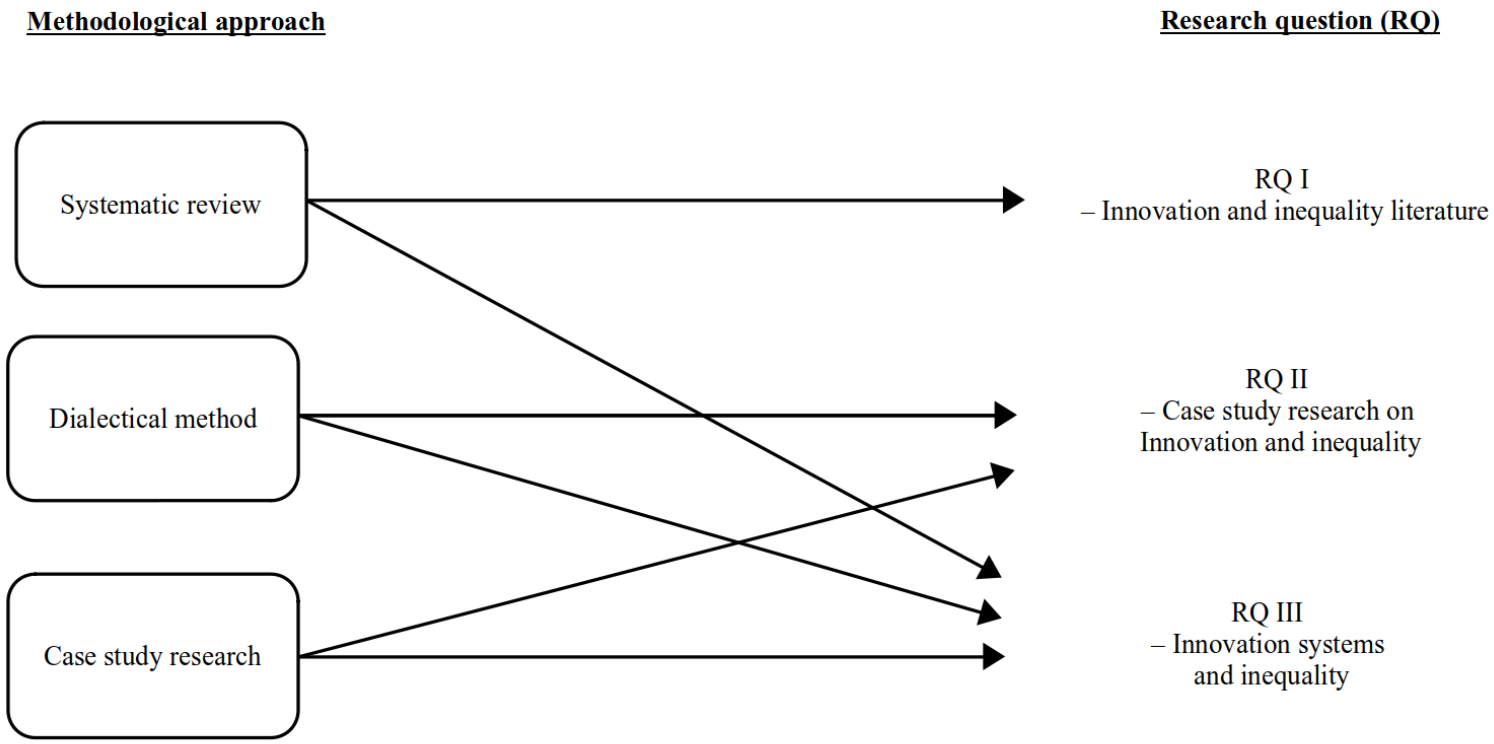
1.5 Methodological Architecture

This thesis adopts a tripartite methodological approach to address each of the research questions (RQs), as follows: *systematic literature review*, *dialectical method* and *case study research*. Figure 1.2 (overleaf) provides a graphical representation of the 'methodological architecture' of this thesis.

To address RQI, the present thesis adopts a systematic approach to identifying and reviewing the literature on innovation and inequality. Unlike the conventional 'disciplinary-narrative' approach to review (the sole focus of which is on research

within a particular discipline or field of science), the review process in this thesis is *systematic* (i.e., using a systematic approach to review) and *post-disciplinary* in the sense that it follows published research on the subject in whichever field it has been conducted. In total, 166 contributions were identified and reviewed in a systematic manner by using the bibliometric (quantitative) approach and the (qualitative) meta-analysis. The purpose of the review was not only to identify key trends and themes in the relevant literature, but also to provisionally conceptualise a set of causal mechanisms.

Figure 1.1: Methodological Approach and Links among Research Questions



To address RQII, this thesis utilises the dialectical method (also known as dialectics), in particular the analytical scheme of the thesis, antithesis and synthesis (Popper, 1940, Bhaskar, 2008*a*, Hargrave and Van de Ven, 2017). The analysis is motivated by what can be called *the paradox of case study research* on ISs; specifically, case study research is the most popular and appropriate research design with which to study the highly-idiosyncratic nature of ISs, in addition to having made a significant contribution to the emergence, establishment and popularity of the ISs approach (see, for instance Freeman, 1987, Rakas and Hain, 2019). A great many IS scholars endorse, either implicitly or explicitly, the conventional view (Flyvbjerg, 2006) that case study research on ISs cannot examine the general aspects of causality (Yin, 2009). In doing so, IS scholars have implicitly acknowledged that case study research on ISs is not scientific enough. By dialectically analysing the paradoxical status of case study research on ISs, the analysis not only offers novel insights into the scientific quality of case study research on ISs, but also clears the methodological ground, as much as is needed, to address RQIII in a manner that otherwise would have been impossible.

To address RQIII, this study adopts the single-case study research design (Yin, 2009). The research case consists of the region of Braunschweig in northern Germany. This region was ranked by both Eurostat and the regional innovation scoreboard as one of the top innovation performing regions in Europe (Fragkandreas, 2013, European Commission, 2019). In this regard, the region of Braunschweig offers an ideal opportunity to investigate how an IS affects the distribution of income. Both primary and secondary data was gathered in a longitudinal manner. Primary data was collected through 22 semi-structured interviews with focal actors in the IS of the region of Braunschweig. The latter includes business executives, project managers, business association representatives, policy-makers, technological transfer officers and labour union representatives. Secondary qualitative data was collected from organisational websites, reports of focal organisations and reputable news sources (e.g., Reuters and Deutsche Welle). Secondary quantitative data was also collected by using the statistical databases of the EU (Eurostat) and Germany (Destatis), as well as the regional

innovation scoreboard (European Commission). Although each of these data sources was analysed accordingly, i.e., by utilising an appropriate data analysis method, the overall methodological strategy was that of data triangulation (Yin, 2009, Downward and Mearman, 2007).

1.6 Originality

This thesis has several important novelties. First, and to the best of my knowledge, it is the very first study to investigate, in a systematic manner, how innovation as a collective process shapes the distribution of income in contemporary societies. In doing so, this thesis not only generates novel insights into the relationship between innovation and inequality, but also redresses the dearth of research on inequality within the field of innovation studies. Martin (2016), for instance, lists the study of inequality as one of the most important research challenges for the field of innovation studies. Second, this thesis is among the first to identify and review, in a systematic manner, three decades of research on innovation and inequality by using a mixed-method systematic review approach. Third, and to the best of my knowledge, this study is the first to introduce and operationalise the critical realist approach to causal mechanisms to investigate the relationship between innovation (systems) and inequality. This enables the thesis to develop knowledge about the deeper and more complex aspects of causality, which is something that the extant studies on innovation and inequality have, thus far, not achieved, or have neglected. Fourth, this research is among the first to identify and scrutinise the methodological assumptions that inform three decades of case study research on ISs. As will be discussed in Chapter 3 of this thesis, there is no methodological contribution to ISs research, even though the ISs approach is one of the most utilised theoretical perspectives on innovation in the social sciences. Fifth, this thesis is the first to combine key insights from the literature on ISs and relational inequality theory (e.g., Tilly, 1998, Avent-Holt and Tomaskovic-

Devey, 2014, Tomaskovic-Devey and Avent-Holt, 2019) to theorise and analyse a set of causal mechanisms through which ISs shape the magnitude of inequality in contemporary societies. Lastly, and as will be discussed in the concluding chapter of this thesis, several novel analytical and policy implications emanate from this study, one of which concerns the ability of case study research on ISs to produce policy-relevant knowledge about the grand societal challenge of rising inequality.

In summary, this thesis pushes significantly the boundaries of knowledge not only on the relationship between innovation and inequality, but also on ISs, hence the title: *Innovation, Innovation Systems, and Income Inequality: A Study of Causal Mechanisms*.

1.7 Outline

This thesis follows the '3-paper-format', and thus it is organised accordingly. In particular, it consists of three original, yet publishable papers (Chapters 2-4), each of which addresses one of the three research questions. In particular, *Chapter 2* addresses RQI by providing a systematic review of the existing empirical literature on innovation and inequality in the social sciences. *Chapter 3* provides a dialectical methodological analysis of the ironical epistemological status of case study research in the field of ISs studies. Moreover, *Chapter 4* deals with RQIII, by identifying seven causal mechanisms through the regional IS in the region of Braunschweig shapes the distribution of income. *Chapter 5* brings the thesis to an end by summarising the main findings, as well as the analytical and policy implications.

Chapter 2

Three Decades of Research on Innovation and Income Inequality: Research Themes, Causal Mechanisms and Avenues

Highlights

- There exists a rapidly-growing literature on innovation and income inequality
- Most studies under review confirm that innovation is positively associated with income inequality
- Nine research themes are identified
- A typology of *eight* hypothetical causal mechanisms is developed

Abstract

Over the past three decades, a considerable number of studies across various fields and disciplines of social science have analysed the relationship between innovation and income inequality. This paper is among the first to identify and review, in a systematic manner, the extant research on innovation and inequality (in short, inequality). Based on a mixed-method review of 166 studies published in the last 30 years (1990-2019), it is shown that, in contrast with the conventional belief that innovation tends to reduce inequality in capitalist societies, the great majority of studies document that innovation is positively associated with inequality. Furthermore, and despite coming from different fields, much of the existing research on innovation and inequality falls into nine research themes: Skills, Geographical aspects, Horizontal inequalities, Conditional, Diffusion, Employment, Policy, Bidirectionality, and Digital divide. To synthesise key insights from each theme, the paper develops an explanatory typology based on *two* causal scenarios and *eight* hypothetical causal mechanisms. The paper ends with conclusions, implications and suggestions for innovation studies focused on inequality.

Keywords: Innovation, income inequality, systematic review

JEL Classification: O30, D30

2.1 Introduction

What do the contributions of notable thinkers – such as the writings of Adam Smith, David Ricardo, Karl Marx, Thorstein Veblen, Joseph Schumpeter and Werner Sombart – have in common, other than their obvious significance for contemporary socio-economic thought? In a nutshell, the classics of socio-economic thought are replete with passages demonstrating that *innovation* (i.e., the development of novel and socio-economic combinations of resources which can take the form of new products, services, institutions and organisational models) is (bi-)causally related to *inequality* (i.e., the unequal distribution of income) in capitalist societies. Nonetheless, social scien-

tists have – for much of the previous century – either ignored or remained oblivious to such a causal possibility. Today, this is no longer the case, as there exists a sustained interest in innovation and inequality in several fields of social science. For instance, *economists* (e.g., Acemoglu, 2002, Van Reenen, 2011), *geographers* (e.g., Breau et al., 2014, Lee, 2016), *development studies* scholars (e.g., Hilbert, 2010), *innovation studies* scholars (e.g., Cozzens and Kaplinsky, 2009, Lazonick and Mazzucato, 2013), *industrial relations* researchers (e.g., Belman and Monaco, 2001), *sociologists* (e.g., Fernandez, 2001) and *political scientists* (e.g., Hope and Martelli, 2019) have either reflected or studied the causal effects of innovation on the distribution of income.

However, despite being disciplinary diverse, our knowledge of this disparate and rapidly growing literature is severely overshadowed by the work of economists in general, and labour economics research in particular (see, for instance, Section 2.3 in this paper). To help us comprehend the extant stock of knowledge on innovation and inequality in a more holistic manner than hitherto, this paper provides the first 'systematic post-disciplinary' review of the relevant literature innovation and inequality. Based on a systematic review of 166 studies published in 104 social science journals, the analysis shows that, while a relatively small number of studies find that innovation reduces inequality, most studies register a positive relationship between innovation (as represented by research and development investments, patents and computer use) and inequality (as gauged by the Gini coefficient and percentiles). Furthermore, while economists are, indeed, the most active participants in this emerging field of knowledge, innovation studies researchers, geographers, employment relations scholars and sociologists have also been more active since the late 2000s. In spite of their disciplinary origins and influences, the great majority of studies deal, in one way or another, with one or more of the following nine research themes: (1) Skills, (2) Geographical aspects, (3) Horizontal (gender and race) inequalities, (4) Conditional, (5) Employment, (6) Diffusion, (7) Policy, (8) Bidirectionality, and (9) Digital divide. To facilitate knowledge integration among research on these themes and ignite a new type of cross-disciplinary explanatory research based on causal mechanisms, the paper ad-

vances (through a reconceptualisation of the current stock of knowledge) explanatory typology of eight hypothetical causal mechanisms. These are as follows: (1) skill premiums, (2) competence concentration, (3) technological unemployment, (4), precarious employment, (5) new position closure, (6) inclusive competence-building, (7) inclusive employment, and (8) Schumpeterian social mobility.

The analysis in this paper contributes to a rapidly-growing interest in the distributional consequences of innovation within the field of innovation studies[1] (Freeman, 2001, Cozzens and Kaplinsky, 2009, Lazonick and Mazzucato, 2013, Martin, 2016, Mongelli and Rullani, 2017, Zehavi and Breznitz, 2017, Echeverri-Carroll et al., 2018, Schot and Steinmueller, 2018, Biggi and Giuliani, 2021). By identifying nine cross-disciplinary research themes, the paper transforms a highly-fragmented cross-disciplinary body of knowledge into nine theoretical categories that innovation studies researchers could use either as a guide to the literature, or as the point of departure in their studies on inequality. In doing so, the paper helps innovation studies researchers, including policy-makers, to comprehend the current stock of knowledge on innovation and inequality in a consistent, yet holistic manner than hitherto, on a topic of increasing scientific and policy relevance. Furthermore, the paper significantly broadens our understanding of how innovation affects the distribution of income. It does so by (a) identifying various streams of research, hence, (b) showing that the Skills research theme (which is, currently, the most popular line of research) offers a narrow view of the innovation-inequality nexus in contemporary societies; as well as by (c) developing a typology of eight hypothetical causal mechanisms through which innovation could shape, either positively or negatively, the distribution of income in contemporary societies. Lastly, the paper contributes to future innovation studies research on inequality by identifying knowledge gaps and promising research avenues.

The remainder of this paper consists of five sections. Section 2.2 begins by intro-

[1] By the field of innovation studies, this paper refers to research that is informed by one or more of the following theoretical perspectives on innovation: evolutionary/neoschumpeterian economics; innovation management theory (e.g., core competencies, dynamic capabilities); innovation (eco)systems; innovation networks; and socio-technical systems and transitions.

ducing the theoretical backdrop of the paper, as well as by discussing the key elements and procedures of the review strategy. Section 2.3 provides a bibliometric analysis of the literature, focusing on prolific authors, journals, disciplines, and keywords developments. Section 2.4 identifies, in an inductive manner, nine common research themes in the literature. Section 2.5 integrates key aspects of the literature into a typology of causal scenarios and mechanisms, before, finally, Section 2.6 ends the paper by discussing key findings, suggestions and limitations.

2.2 Theoretical Background and Review Method

2.2.1 Rising Inequality: A Brief Overview of the Literature

Over the past three decades, numerous studies have shown that, while inequality across countries has converged over time – especially in the 1988-2008 period (Neckerman and Torche, 2007, Lakner and Milanovic, 2016, McGregor et al., 2019), inequality within countries has either grown or reached relatively high levels in nearly all advanced economies (e.g., Alderson and Nielsen, 2002, Atkinson et al., 2011, Stiglitz, 2012, OECD, 2015). OECD data confirms that, as measured by the Gini coefficient[2], inequality has risen considerably in nearly all of the 37 OECD member states: from 0.29 in the mid-1980s to 0.315 in 2013 (OECD, 2015). Similarly, the 90/10 percentile (another widely-used measure of inequality[3]) shows that the wealthiest 10% of the population in OECD countries earned 10 times more than the remaining 90% of the population in 2013 (OECD, 2015). Compared to the 1980s, this ratio has increased by 37% (ibid.). Other studies show that the top 1% of income earners (i.e., 90/1 percentile) have made unprecedented income gains (Atkinson et al., 2011), and this has occurred at a time when some quite old and worrisome social phenomena – such as the 'working poor', 'underpaid and overworked' – have been re-emerging from the

[2]For a recent overview on the measures of inequality, see McGregor et al. (2019).

[3]For instance, Piketty (2014) regards percentiles as the most intuitive measure of inequality.

dustbin of economic history (Lohmann, 2009, Pianta, 2018). In a nutshell, these developments demonstrate that, when it comes to economic equality, our societies have – since the late 1980s – made several steps backwards rather than forwards.

'Why is inequality rising?', one may rightly wonder. After all, the work of eminent economists implies that rising inequality is a necessary, transitory social evil on the path to economic equality in capitalist societies. For instance, Kuznet's (1955) seminal theory stipulates that inequality increases only in the early stages of economic development, before then falling gradually to (possibly historically) low levels.

Traditionally, social scientists – especially Marxian economists, geographers and sociologists – have approached the question of rising inequality from the standpoint of the 'class struggles' perspective (Braverman, 1974, Peet, 1975, Wright, 1994, Smith, 2010, Papaioannou, 2016). According to this perspective, inequality is the outcome of processes of (over-)exploitation between the two antagonistic social classes in capitalist societies, i.e., the capitalists and labourers. Dissatisfied with the somewhat 'too abstract' and deterministic outlook of the class-exploitation perspective, the more recent research (circa the 1990s) has sought to understand rising inequality in a more theoretically-diverse and nuanced manner (Neckerman and Torche, 2007, Lemieux, 2008, Vallas and Cummins, 2014, Cavanaugh and Breau, 2018). Inequality researchers tend to agree, rather than to disagree, that income inequality is a 'multi-dimensional' and 'multi-determined' phenomenon in the sense that it contains various interrelated forms (e.g., wealth, education, health inequality etc.), as well as being shaped by various factors and processes such as education, gender, race, international trade, immigration, declining union membership, neoliberal policies, and welfare state retrenchment (Neckerman and Torche, 2007, DiPrete, 2007, Lemieux, 2008, Tomaskovic-Devey, 2014, Stockhammer, 2017, Cavanaugh and Breau, 2018). From these factors, however, it is innovation which, according to a growing number of contributions, constitutes the most significant causal determinant of rising inequality in contemporary societies (e.g., Fernandez, 2001, Acemoglu, 2002, Angelini et al.,

2009, Cozzens and Kaplinsky, 2009, Van Reenen, 2011, Lazonick and Mazzucato, 2013, Lee, 2016, Pianta, 2018).

2.2.2 Review Method: Sampling Strategy, Data and Analysis

This study analyses a sample of 166 studies (henceforth, *review sample*[4]) in 104 journals over a third-of-a-year period (1990[5]-2019). The review sample was identified through an iterative search in the Scopus database. A set of keywords was used (in the form of a Boolean equation) to identify the most relevant contributions. These included the following: innovation, technology, technological change, income, wage, or earning(s) inequality, poverty, income distribution, distribution of income, wages and/or earnings. The first search, which was performed in the summer of 2019, identified 1,832 contributions. After excluding conference papers, conceptual (including formal mathematical modelling) papers, reviews, book chapters and editorials, as well as after scrutinising the abstract section of each study for false-positives (i.e., articles containing keywords that are relevant but not directly related to the subject), 166 peer-reviewed studies[6] met the following inclusion criteria: being an empirical study (*1st inclusion criterion*); published in English (*2nd inclusion criterion*); and available in a digital form (e.g., pdf) (*3rd inclusion criterion*).

The review sample was analysed in an iterative manner by utilising two review methods: the *bibliometric method* and the *meta-synthesis method*. In particular, the bibliometric method was used to provide a quantitative (visual) overview of the literature (especially of popular journals, prolific authors, disciplines and fields, including keywords trends). However, since the bibliometric method barely yields novel theoretical insights into the literature under review, the review sample was also analysed by using the interpretive *meta-synthesis* method (Weed, 2005, Cronin et al., 2008).

[4]For a detailed overview on the sample, see Appendix A.

[5]Based on the earliest observation in the data.

[6]In line with Biggi and Giuliani (2021, pp.3-4), the sole focus on peer-reviewed studies is based on the assumption that peer-reviewed published studies often yield reliable and novel findings by applying rigorous methodological standards.

This method was employed in order to synthesise, in an inductive manner, the key elements (e.g., theoretical focus and findings) of each study.

In terms of data analysis, the review sample was analysed by using a coding scheme, consisting of the following 14 codes: (1) author(s), (2) year, (3) title, (4) journal, (5) field (e.g., economics, geography, etc.),(6) research context (e.g., country), (7) research unit(s) (e.g., individual, firms, nation, etc.), (8) data (quantitative, qualitative or both), (9) primary research design (e.g., survey, case study, etc.), (10) data analysis (e.g., descriptive, advanced statistics, triangulation), (11) measures of innovation (e.g., research and development, patents, computer usage, etc.), (12) inequality (e.g., Gini index, percentiles, etc.), (13) findings (e.g., positive, negative, complex, not significant), and (14) research themes[7] (e.g., skills, employment changes, digital divide, etc.). Most of the codes were derived from previous systematic reviews on innovation (Doloreux and Porto Gomez, 2017, Fragkandreas, 2017) and inequality (Cavanaugh and Breau, 2018), whereas a few other codes (e.g., findings and research theme) were developed inductively through the analysis. Overall, the review strategy (including its associated analytical steps and procedures) was consciously designed to be as rigorous, transparent and replicable as possible.

2.3 Key Trends and Fields

This section begins by discussing key trends that emerged from the bibliometric analysis. Figure 1 provides an overview of the overall number of published studies on innovation and inequality. As illustrated by the linear regression line, there has been a seven-fold increase in published research on innovation and inequality: from 12 studies (1,2 studies per year) in the 1990s, to 97 studies (9,7 studies per year) in the 2010s. However, such an increase is not linear. For instance, while 7 studies were published in 2001, this number drops to 1 study just one year later. Similarly, 12 studies were

[7] Studies that deal with, or touch upon, multiple themes were categorised according to key findings.

published in 2009, before this figure then drops to 6 studies in 2010. Due to such significant variations, it is analytically useful to distinguish between three main phases: the ***early phase*** (1990-1990) with 12 contributions; the ***growth phase*** (2000-2009) with 56 contributions; and the ***expansion phase*** (2010-2019) with 97 contributions.

Figure 2.1: Publications by Year

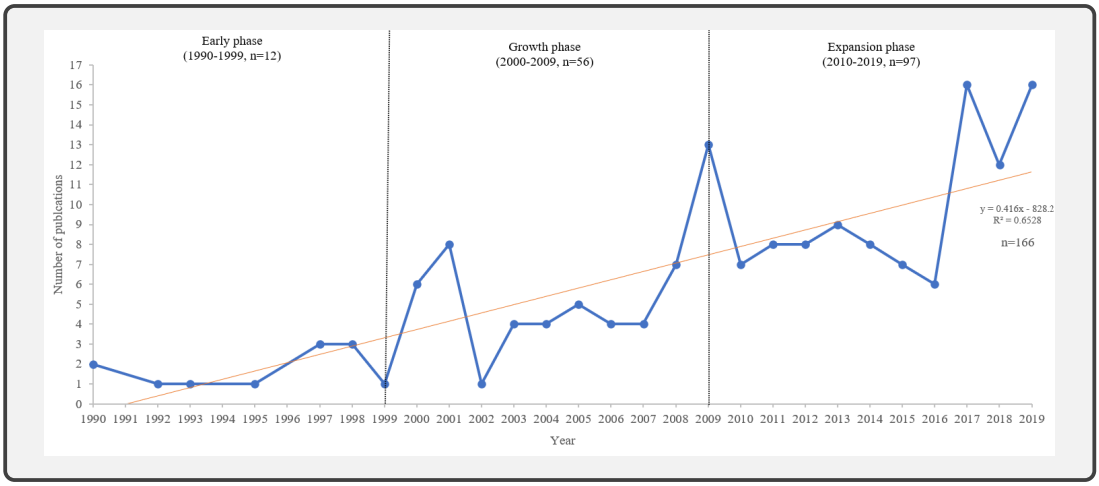


Table 2.1 lists the most preferred journals on innovation and inequality. In general, there appears to be a high degree of concentration in terms of popular journals: 50% of studies have been published in the 32 most popular journals. This ratio is 15% higher than the equivalent ratio for all published studies on inequality (Cavanaugh and Breau, 2018, p.4). However, as is shown by the 'trend direction' column in the table in question, the significance of the most popular journals has declined in the expansion phase. This suggests that there might have been a shift in terms of popular journals. Although 16 out of 31 journals are economic journals (e.g., Applied Economics, Applied Economic Letters, Economic Journals, etc.), there are only a few relatively highly-ranked economic journals (e.g., American Economic Journal: Macroeconomics, Journal of the European Economic Association). Surprisingly, the two most popular journals are the interdisciplinary journals of Development Studies (9 studies) and Technological Forecasting and Social Change (6 studies). These two journals account for 9% of all publications. In other words, nearly 10% of all studies on innovation and inequality have been published in these two journals. Other popular non-economic journals include Labour (3 studies), the American Journal of Sociology

Table 2.1: Popular Journals, Fields and Authors

Journal	Total (n=166)			Time period			
	Field(*)	Number	%	1990-1999 (n=12) %	2000-2009 (n=56) %	2010-2019 (n=97) %	Trend direction
World Development	Development studies	9	5.4	16.67	9.68	4.12	Decreasing
Technological Forecasting and Social Change	Innovation studies	6	3.6	0.00	6.45	6.19	Slightly decreasing
Applied Economics	Economics	4	2.4	0.00	4.30	3.09	Decreasing
Applied Economics Letters	Economics	4	2.4	0.00	4.30	4.12	Slightly decreasing
Journal of Development Economics	Economics, development economics	4	2.4	0.00	4.30	1.03	Increasing, then decreasing
Economic Journal	Economics	3	1.8	8.33	3.23	0.00	Increasing, then decreasing
Economics of Transition	Economics	3	1.8	0.00	3.23	1.03	Increasing, then decreasing
International Review of Applied Economics	Economics	3	1.8	0.00	3.23	1.03	Increasing, then decreasing
Labour	Industrial, work and employment relations	3	1.8	0.00	3.23	0.00	Increasing, then decreasing
Agricultural Economics	Economics	2	1.2	16.67	2.15	0.00	Decreasing
American Economic Journal Macroeconomics	Economics	2	1.2	0.00	2.15	2.06	Slightly decreasing
American Journal of Sociology	Sociology	2	1.2	0.00	2.15	1.03	Slightly decreasing
American Sociological Review	Sociology	2	1.2	0.00	2.15	1.03	Slightly decreasing
Economic Geography	Geography	2	1.2	0.00	2.15	1.03	Slightly decreasing
Economics of Innovation And New Technology	Economics, Innovation studies	2	1.2	8.33	2.15	1.03	Slightly decreasing
Food Policy	Multidisciplinary, food studies	2	1.2	0.00	2.15	1.03	Slightly decreasing
Industrial and Corporate Change	Innovation studies	2	1.2	0.00	2.15	2.06	Slightly decreasing
Industrial and Labor Relations Review	Industrial, work and employment relations	2	1.2	0.00	2.15	0.00	Decreasing
Industrial Relations	Industrial, work and employment relations	2	1.2	0.00	2.15	0.00	Decreasing
Journal of Economic Issues	Economics	2	1.2	0.00	2.15	2.06	Slightly decreasing
Journal of International Economics	Economics	2	1.2	8.33	2.15	0.00	Decreasing
Journal of International Studies	Sociology, Economics	2	1.2	0.00	2.15	2.06	Slightly decreasing
Journal of The European Economic Association	Geography	2	1.2	0.00	2.15	2.06	Slightly decreasing
Professional Geographer	Geography	2	1.2	0.00	2.15	1.03	Decreasing
Quarterly Journal Of Economics	Economics	2	1.2	8.33	2.15	0.00	Decreasing
Regional Studies	Geography	2	1.2	0.00	2.15	2.06	Slightly decreasing
Review of Development Economics	Economics, development economics	2	1.2	0.00	2.15	2.06	Slightly decreasing
Review of Economics and Statistics	Economics	2	1.2	0.00	2.15	2.06	Slightly decreasing
Scandinavian Journal Of Economics	Economics	2	1.2	0.00	2.15	2.06	Slightly decreasing
Social Indicators Research	Other, interdisciplinary	2	1.2	0.00	2.15	2.06	Slightly decreasing
Work and Occupations	Industrial, work and employment relations	2	1.2	8.33	2.15	0.00	Decreasing
Other 83 journals with 1 publications		83	50.0	25.00	11.00	52.6	Decreasing, then increasing

Journals by field(*)	Total (n=166)		1990-1999 (n=12)	2000-2009 (n=56)	2010-2019 (n=97)	Trend direction
	Number	%	%	%	%	
Economic journals	71	42.77	66.67	33.93	44.00	Decreasing, then increasing
Development studies journals	19	11.45	16.67	14.29	9.00	Decreasing
Innovation studies journals	16	9.64	8.33	3.57	13.00	Decreasing, then increasing
Geography journals	16	9.64	0.00	10.71	10.00	Increasing
Employment relations journals	13	7.83	8.33	17.86	2.00	Increasing, then decreasing
Sociology journals	12	7.23	0.00	8.93	7.00	Decreasing
Other	19	11.45	0.00	10.71	13.00	Increasing

Most prolific authors				Time period			
	Faculty (**)	University (country)	Total % (n=166)	1990-1999 (n=12) %	2000-2009 (n=56) %	2010-2019 (n=97) %	Trend direction
Afonso, Ó	Economics	Universidade do Porto (Portugal)	2.2	0.0	0.92	1.74	Increasing
Antonelli, C.	Economics	University of Turin (Italy)	1.3	0.0	1.8	0.00	Decreasing
Bobb, K.	Sociology	Georgia Institute of Technology (USA)	1.3	4.2	0	0.00	Decreasing
Cozzens, S.E.	Sociology	Georgia Institute of Technology (USA)	1.3	0.0	0.92	0.58	Increasing, then decreasing
Kristal, T.	Sociology	University of Haifa (Israel)	1.3	0.0	0	1.16	Increasing
Lee, N.	Geography	London School of Economics and Political Science (UK)	1.3	0.0	0	1.16	Increasing
Machin, S.	Economics	London School of Economics and Political Science (UK)	1.3	0.0	0	0.58	Increasing
Martorano, B.	Development economics	Maastricht University (Netherlands)	1.3	0.0	0	1.16	Increasing
McCall, L.	Sociology	City University of New York (USA)	1.3	4.2	0	0.00	Decreasing
Nogueira, M.C.	Economics	Higher Institute of Social Service of Porto (Portugal)	1.3	0.0	0	1.16	Increasing
Ojala, J.	Business History	University of Jyvaskyla (Finland)	1.3	0.0	0	1.16	Increasing
Otsuka, K.	Economics	JapanKobe University (Japan)	1.3	4.2	0	0.00	Decreasing
Pehkonen, J.	Economics	University of Jyvaskyla (Finland)	1.3	0.0	0	1.16	Increasing
Sanfilippo, M.	Development economics	University of Turin (Italy)	1.3	0.0	0	1.16	Increasing
Thakur, D.	Democracy and Technology	Web Foundation, Washington (USA)	1.3	0.0	0	1.16	Increasing
Vona, F.	Economics	Science Po Paris (France)	1.3	0.0	0	1.16	Increasing
Other authors with 1 contribution			81.3	66.6	96.4	86.6	Increasing, then decreasing
Collaboration index (number of authors per contribution)			1.04	1.1	1.9	1.65	Increasing, then decreasing

(*) based on the description obtained from the website of each journal
(**) based on author's latest affiliation
Source: own elaboration, Scopus

(2 studies), American Sociological Review (2 studies), Economic Geography (2 studies), Industrial and Labour Relations Review (2 studies), Regional Studies (2 studies), Professional Geographer (2 studies), and Work and Organisation (2 studies)[8].

The diverse disciplinary profile of the literature is also confirmed by the overall number of publications in each field (see the middle part in Table 2.2). Having published 43% of all studies, economic journals are the most popular choice for innovation and inequality researchers. The second most popular field is development studies, with 19 studies (11%), followed by innovation studies and geographical journals with

[8]Recent reviews on inequality research (e.g., Cavanaugh and Breau, 2018) have also identified some of these journals.

16 studies each. Employment relations and sociological journals are the least popular fields with 13 and 12 contributions, respectively. Except for geographical journals, the relative importance of all journals in the other fields has decreased over time. This suggests that geographical research regarding innovation and inequality is on the rise (see, also Cavanaugh and Breau, 2018). Lastly, the fact that 70 % of studies were published in the most popular journals during the early period (i.e., 1990-1999), whereas this ratio dropped to 50 % studies in the 2010-2019 period. This suggests that there might have been a reshuffle in terms of popular journals and fields in the expansion phase.

Based on the affiliation of the most prolific authors at the time of their latest publication (Table 2), researchers in the US, UK, Portugal, Italy, Finland and the Netherlands are the most active; particularly those affiliated with the Georgian Institute of Technology (US), London School of Economics (LSE), and University of Jyvaskyla (Finland). Oscar Alfonso, who is affiliated with the University of Porto (Portugal), tops the list with 4 studies (2.2% of all studies), followed by 15 other scholars with 2 studies each. Reflecting the disciplinary profile of popular journals, 7 authors work in an economics faculty, 4 authors in a sociology faculty, 2 authors in development economics, 2 authors in business history, 1 author in geography, and 1 author in democracy and technology. The somewhat Western and Anglo-centric character of the literature[9] is also confirmed by the overall number (40%) of authors who are affiliated with organisations in the US and UK (see the middle part in Table 2). However, there is evidence of internationalisation illustrated by the increasing number of researchers affiliated with universities in China and South Korea. The somewhat Western profile of the literature can, in part, be attributed to the fact that the most active funding sponsors in the field are based in the US and UK (see the last part in Table 2). However, these organisations were mostly active in the early and growth phases, and far less in the expansion phase, which suggests that other factors explain the concentration of

[9]While this can be attributed to the inclusion criteria in the search process (i.e., papers published in English), additional research (which is not reported here) shows that only less than 10% (173 studies) of the total number of contributions (1,832) are written in a language other than English.

research in a few countries.

Table 2.2: Most Popular Keywords, Affiliation by Country and Sponsors

	All years		Period			
	Number (n=854)	%	1990-1999 (n=91)	2000-2009 (n=355)	2010-2019 (n=542)	Trend direction
Keyword Theme I: Income, Wages, and Inequality	*217*	*25.4*	*14.29*	*19.72*	*24.72*	*Increasing*
Income Distribution	64	7.47	4.40	7.32	6.27	Increasing, then decreasing
Wage Gap	33	3.85	1.10	2.82	4.06	Increasing
Wage Inequality	24	2.80	1.10	1.97	2.95	Increasing
Inequality	20	2.33	1.10	1.13	2.77	Increasing
Income inequality	18	2.10	0.00	1.69	2.21	Increasing
Wage	18	2.10	3.30	1.97	1.48	Decreasing
Wages	6	*0.70*	1.10	0.28	0.74	Increasing, then decreasing
Household Income	5	0.58	1.10	0.56	0.37	Decreasing
Income	5	0.58	0.00	0.00	0.92	Increasing
Keyword Theme II:Technological Change, Innovation and Technologies	*111*	*12.95*	*5.49*	*10.14*	*12.92*	*Increasing*
Technological Change	40	4.67	2.20	3.38	4.80	Increasing
Innovation	20	2.33	0.00	1.41	2.77	Increasing
Information and Communication Technology	9	1.05	0.00	0.00	1.66	Increasing
Skill-biased Technological Change	8	0.93	1.10	0.85	0.74	Decreasing
Digital Divide	7	0.82	0.00	1.13	0.55	Increasing, then decreasing
Information Technology	6	0.70	1.10	1.13	0.18	Increasing, then decreasing
Technology Adoption	6	0.70	1.10	0.56	0.55	Decreasing
Technological Development	5	0.58	0.00	0.56	0.55	Increasing, then stabilising
Technology Diffusion	5	0.58	0.00	0.56	0.55	Increasing, then stabilising
Internet	5	0.58	0.00	0.56	0.55	Increasing, then stabilising
Keyword theme III: Skills, Employment, Labour Market	*102*	*11.90*	*4.40*	*10.14*	*11.44*	*Inreasing*
Skilled Labor	24	2.80	0.00	3.10	2.40	Increasing, then decreasing
Labour market	24	2.80	4.40	2.82	1.85	Decreasing
Employment	11	1.28	0.00	0.85	1.48	Increasing
Educational Attainment	7	0.82	0.00	0.56	0.92	Increasing
Labor Supply	6	0.70	0.00	0.28	0.92	Increasing
Human Capital	6	0.70	0.00	0.28	0.92	Increasing
Unemployment	5	0.58	0.00	0.85	0.37	Increasing, then decreasing
Education	5	0.58	0.00	0.56	0.55	Increasing, then decreasing
Productivity	5	0.58	0.00	0.56	0.55	Increasing, then stabilising
Occupation	5	0.58	0.00	0.28	0.74	Increasing
Returns To Education	4	0.47	0.00	0.00	0.74	Increasing
Keyword theme IV:Area	*67*	*7.82*	*2.20*	*12.96*	*3.51*	*Decreasing*
United States	24	2.80	0.00	3.94	1.85	Increasing, then decreasing
Europe	11	1.28	1.10	1.97	0.55	Increasing, then decreasing
North America	11	1.28	0.00	2.54	0.37	Increasing, then decreasing
Eurasia	10	1.17	0.00	2.82	0.00	Increasing, then decreasing
United Kingdom	6	0.70	0.00	0.85	0.55	Increasing,then decreasing
Asia	5	0.58	1.10	0.85	0.18	Decreasing
Other keywords with up to 1-5 citations	427	42.01	73.63	47.04	47.42	Decreasing, then slightly increasing

Affiliation by country (all authors)	Time period				Trend direction
	Total % (n=258)	1990-1999 (n=19) %	2000-2009 (n=69) %	2010-2019 (n=139) %	
United States	24.03	36.84	44.93	17.27	Decreasing
United Kingdom	13.18	15.79	14.5	15.11	Decreasing, then increasing
Italy	4.65	0.00	4.35	5.76	Increasing
Germany	3.88	5.30	4.35	4.32	Decreasing
Canada	2.71	0.00	5.8	2.16	Increasing, then decreasing
China	2.33	0.00	1.42	3.60	Increasing
Netherlands	2.33	5.30	2.89	2.16	Decreasing
Portugal	2.33	0.00	0	4.3	Increasing
Spain	2.33	0.00	2.89	2.88	No change
Finland	1.94	0.00	0	3.6	Increasing
France	1.94	0.00	0	3.6	Increasing
Japan	1.94	10.53	1.42	1.44	Decreasing
South Korea	1.94	0.00	1.42	2.88	Increasing
Other countries	34.50	26.24	16.03	30.94	Increasing
Total	100.00	100.00	100.00	100.00	

Funding sponsors	Country	Time period				Trend direction
		Total % (n=166)	1990-1999 % (n=12)	2000-2009 % (n=56)	2010-2019 % (n=97)	
National Science Foundation	United States	3.61	16.67	5.36	1.04	Decreasing
Deutsche Forschungsgemeinschaft	Germany	1.81	0.00	3.6	0	Increasing, then decreasing
Economic and Social Research Council	UK	1.81	0.00	0	3.1	Increasing
National Research Foundation of Korea	Korea	1.81	0.00	0	3.1	Increasing
Nederlandse Organisatie voor Wetenschappelijk Onderzoek	Netherlands	1.81	16.67	1.8	0	Decreasing

(*) based on author's affiliation at the time of publication Source: own research and elaboration, Scopus

In addition to the above, a few other interesting observations need particular mention. First, the literature is somewhat 'ascetic' in the sense that most studies are single-author contributions, with the growth phase (2000-2009) being the most collaborative phase of all (1,9 author per contribution). Secondly, 854 keywords were used by the 166 studies, which is approximately 5 keywords per study (see the first part in Table

2). Specifically, 25% (1 out of every 4 keywords) are about income, wages and inequality (Keyword Theme I), followed by Keyword Theme II (Technological Change, Innovation and Technologies), Keyword Theme III (Skills, Employment and Labour), and Keyword Theme IV (Area), with 13%, 11% and 8% of all keywords respectively. While the significance of the first three keyword themes has increased over time, Keyword Theme IV (Area) is in decline. This implies that the interest in certain countries and continents (e.g., US, UK, Europe) has decreased over time, especially in the expansion phase.

Summary The bibliometric analysis shows that published research on innovation and inequality has witnessed significant growth since the 1990s, especially since the late 2000s. Economists, mainly the ones affiliated with universities in the US and UK, are the most prolific authors, followed by development studies scholars, innovation studies researchers, geographers, employment relations scholars and sociologists. Although this confirms the cross-disciplinary nature of research, it also underlines that much of our understanding is informed by the work of economists. The absence of management and organisation studies journals is noteworthy (although this seems to be changing); so it is the relatively low number of sociological studies, as well as the absence of the flagship journal of the field of innovation studies – i.e., Research Policy – from the most popular journals. This observation confirms that the study of inequality does, indeed, constitute a major research challenge for the field of innovation studies (Martin, 2016).

2.4 Research Themes

This section identifies and reviews the relevant literature on nine research themes, each of which offers a different answer to the question of how innovation shapes the distribution of income. The discussion begins with the most popular theme (i.e.,

Skills), ending with the least popular theme (i.e., Digital divide). The last part of this section provides a quantitative summary of each research theme. However, it must be stressed here that the order of the identified themes does not imply causal significance, but instead popularity in the existing literature.

2.4.1 Skills

The *Skills* research theme is the most popular topic in the literature (n=78). Central to this theme is the work of certain economists, and in particular economic studies informed by the *skill-biased technological change* (STBC) account[10]. Specifically, emanating from the work of (mainstream) labour economists in the 1990s, the SBTC account argues that innovation is neither neutral to skills (cf. neoclassical growth theory – Solow 1957), nor is it purely a skill-replacing or deskilling technological process (cf. Marxist social theory – Braverman 1974). Instead, and due to an increasing supply of educated labour force (especially in advanced economies), innovation has – since the second half of the 20th century – been complementary to skills in general, and skilled labour in particular (Krueger, 1993, Autor et al., 1998, Bresnahan, 1999, Acemoglu, 2002). In doing so, innovation does not only benefit the marginal productivity and employment prospects of skilled workers relative to non-skilled workers (Krusell et al., 2000, Acemoglu, 2002, Violante, 2008), but it also leads to a significant increase in the wages of skilled labour relative to those of unskilled labour (i.e., skill premiums), as well as to polarising (skilled versus unskilled) occupational and labour market structures (Bresnahan, 1999, Krusell et al., 2000, Acemoglu, 2002, Kijima, 2006, Goos et al., 2014).

Overall, two main groups of studies prevail in the Skills research theme: a large number of studies confirming the explanatory ability of the SBTC hypothesis (e.g.,

[10]It is interesting to note here the existence of an important discrepancy between the bibliometric analysis and the metasynthesis review. According to the first, keywords associated with the SBTC account (e.g., skill-biased technological change, educational attainment, skilled labour, returns to education) are in decline. However, the second method shows that the opposite occurs. This, among other things, underlines the value of combining both quantitative and qualitative review methods.

Krueger, 1993, Autor et al., 1998, Bresnahan, 1999, Krusell et al., 2000), and a rapidly growing number of studies criticising, refuting and modifying the original SBTC hypothesis (e.g., Fernandez, 2001, Goos et al., 2014, Hanley, 2014, Kristal and Cohen, 2017). Specifically, Krueger (1993) was among the first to provide evidence confirming the empirical significance of skill premiums. In particular, his analysis suggests that US workers who use computers at work earn, on average, 10 to 15% higher wages. Krusell et al. (2000) attribute "*most of the variations in the skill premium*" (p.1031) to capital-skill complementarities, particularly to a significant reduction in the costs of acquiring technological innovations in the 1970s and 1980s. Lastly, Attanasio et al. (2004) and Kijima (2006) confirm that skill premiums were the primary factor behind the rise in wage inequalities in Colombia and India during the 1980s and 1990s.

While the above studies provide evidence supporting the SBTC hypothesis, the findings of a growing number of studies either refute or question key aspects of the hypothesis in question. For instance, Kim and Sakamoto (2008) find in their analysis of the US manufacturing industries that skill premiums did not have a positive effect on labour productivity over 26 years (1970 to 1996). Other studies (Mishel and Bernstein, 2003, Borghans and Ter Weel, 2007) find that, unlike the US, skill premiums have not risen to the same extent in other advanced economies (e.g., Canada and Germany); in contrast, Kawaguchi and Mori (2016) find out that skill premiums have decreased in Japan.

Such theory-practice discrepancies raise the question of how generalisable the SBTC hypothesis is. Stockhammer's (2017) analysis in 71 countries (28 advanced and 43 developing and emerging economies) provides evidence against "*the view that changes in income distribution have mainly been driven by technological change*" (p.27). Santos et al. (2017) examine the impact of 20 old and new technological innovations (e.g., aviation, cell phones, electricity production, internet, TV) on income inequality in a sample of 111 developed and developing countries. The findings suggest that, while all technologies intensify skill premiums, old technologies are more

likely to do so than the newer ones, and this is more likely to occur in developed, rather than in developing, countries.

Such findings have, among other things, triggered the development of a new generation of SBTC studies (for an overview, see Acemoglu and Autor, 2011, Van Reenen, 2011). Unlike the standard version of the SBTC account, which treats innovation as exogenous to the economic system, the more recent studies (best known as task-based studies) comprehend innovation as an endogenous process (Violante, 2008, Van Reenen, 2011, Goos et al., 2014). Most task-based studies seek to understand the relationship between innovation and job polarisation; in particular, how innovation – in the form of information, communication technologies (ICTs) – complements abstract (high-education) and non-manual analytical tasks, whilst substituting for routine (middle-education) tasks (Autor et al., 2003, Borghans and Ter Weel, 2007, Autor et al., 2008, Van Reenen, 2011, Goos et al., 2014, Adermon and Gustavsson, 2015). However, several studies suggest that the relationship between innovation, tasks and wages is more complex than the task-based studies assume. For instance, Adermon and Gustavsson (2015) find that, while there has been a statistically and economically significant growth of non-routine jobs and a decline of routine jobs in Sweden since the 1970s, the task-based hypothesis is consistent with changes in within-occupation wage differentials rather than with changes in between-occupation wage differentials.

Nonetheless, and regardless of whichever version of the SBTC account informs the analysis, STBC research is severely challenged by, among others, the findings of sociological studies; in particular, by those showing that skill-premiums are often set in organisations, rather than in labour markets (Fernandez, 2001, Hanley, 2014, Tomaskovic-Devey and Avent-Holt, 2019). For instance, Hanley's (2014) historical case study at the General Electric shows that technological innovation is often developed and adopted in such a way by managers to reduce the 'organisational citizenship', and thus also the income share of low-skilled workers (see, also Lin and Tomaskovic-Devey, 2013). Kristal (2013) attributes such patterns to declining labour union repre-

sentation in several US industries. While such findings raise several doubts about the theoretical assumptions underpinning SBTC research, the work of Acemoglu et al. (2001) anticipates some of these issues by associating declining union membership (in both the US and UK) with the skill-biased nature of innovation. Nonetheless, it remains to be seen whether future SBTC studies will address this important line of sociological critique.

2.4.2 Geographical Aspects

With 23 studies, the Geographical aspects research theme is the second most popular, as well as the fastest-growing theme in the literature on innovation and inequality. In line with the stylised fact that innovative activities are concentrated in a few cities and regions (Asheim and Gertler, 2005, Feldman and Kogler, 2010), as well as with geographical research on inequality showing that the magnitude of within-country inequality is often as large as that between countries (Glaeser et al., 2009, Cavanaugh and Breau, 2018), an increasing number of studies seek to find how the sub-national scale (i.e., cities, regions, provinces and states) mediates the relationship between innovation and inequality.

Three main groups of studies are worth mentioning here: the first group explores the extent to which variables of innovation (e.g., patents, R&D investments) and inequality (e.g., Gini coefficient, Theil's index, and percentiles) are correlated at the sub-national level (e.g., Hudson, 2006, Lee, 2011, Tselios, 2011, Lee and Rodríguez-Pose, 2013, Breau et al., 2014, Guo, 2019); the second group of studies investigates the geographical dimension of skill premiums, including co-location externalities of skilled and unskilled labour (Pastor and Marcelli, 2000, Wheeler, 2005, Kijima, 2006, Echeverri-Carroll and Ayala, 2009, Glaeser et al., 2009, Consoli et al., 2013, Florida and Mellander, 2016); and the last group of studies examines the geographical dimensions of gender, race, and digital inequalities (Gibson, 2003, Chakraborty and

Bosman, 2005, Mukhopadhyay and Nandi, 2007, Otioma et al., 2019). Since the last group of studies overlaps with the Horizontal inequalities and Digital divide themes (to be discussed shortly), the rest of this sub-section focuses exclusively on the first two groups of studies.

In line with Lee's (2011) analysis in 106 European regions, as well as with the findings of other studies in the UK (Hudson, 2006) and China (Guo, 2019), Florida (2007) suggests that rising inequality is one of the pervasive features of innovative cities and cities in the US (see, also Florida, 2007). Similarly, Breau et al. (2014) find in their study on 85 Canadian cities that "*cities with higher levels of innovation have more unequal distributions of earnings*" (Breau et al., 2014, p.351). Like Lee (2011), Breau et al. (2014) attribute such a finding to skill premiums and localised knowledge-spillovers (Wheeler, 2005, Echeverri-Carroll and Ayala, 2009, Consoli et al., 2013), including the collocation and interdependence of well-paid jobs (also known as the creative class) and relatively less-well-paid services jobs (also known as the service class) in innovative cities and regions (Pastor and Marcelli, 2000, Florida, 2007, Donegan and Lowe, 2008, Glaeser et al., 2009). For instance, Wheeler (2005), Kijima (2006) and Consoli et al. (2013) find that skill premiums are more pronounced in urban regions of the US, India and Finland. Echeverri-Carroll and Ayala (2009) find that employees in US cities with a high-tech industry earn, on average, 17% higher salaries than employees in other regions. However, Florida and Mellander (2016) have recently shown, in their study on 360 US metropolitan regions, that skill premiums are closely associated with wage inequality, and, to a lesser extent, with income inequality; the latter is also associated with unionisation, race and poverty. Such a finding raises a few important questions about the role that race and institutional factors play in the relationship between innovation and inequality. These questions are discussed in the next two research themes.

2.4.3 Horizontal Inequalities

The *Horizontal inequalities* research theme is the third most popular topic in the literature (n=17). Research in this theme seeks to find out how innovation affects *horizontal inequalities* (Cozzens and Kaplinsky, 2009, p.62-65), i.e., the distribution of income across culturally-defined social distinctions such as gender, race and ethnicity. Two main groups of studies were identified as central to this research theme: the first group of studies finds that innovation positively affects horizontal inequalities (e.g., Colclough and Tolbert, 1990, Fernandez, 2001, Warman and Worswick, 2015), whereas the second group of studies records the complexities in the relationship between innovation and horizontal inequalities (e.g., Mukhopadhyay and Nandi, 2007, Juhn et al., 2014, Echeverri-Carroll et al., 2018).

Starting from the first group of studies, Fernandez (2001) finds that the adoption of technological innovation in a US food firm led to "*greater racial inequalities in wages*" (Fernandez, 2001, p.273). Similarly, Warman and Worswick (2015) find that rising educational attainment on the part of immigrants in Canada has not led to a significant improvement in their earnings. This finding supports Colclough and Tolbert's (1990) analysis in local labour markets in the US, whereby female employees and employees of colour experience economic discrimination, especially in high-tech sectors.

Although the above studies confirm that there is a positive relationship between innovation and horizontal inequalities, the findings of another group of studies show that the relationship is more complex, both in terms of causality and outcomes. For instance, Dueñas-Fernández et al. (2015) suggest, based on findings, that while ICT-related employment improves the wages of female employees, it has not substantially reduced the gender wage gap in Spain. Similarly, Echeverri-Carroll et al. (2018) examine gender wage differentials in the high-tech industry in Austin, Texas. Their analysis suggests that high-tech activities have unintended consequences; specifically, de-

spite "*providing relatively fewer job opportunities in high-skill occupations to women than men...[they offer] much higher gains in relative real median wages to women than men*" (Echeverri-Carroll et al., 2018, p.209). Brynin and Perales (2016) confirm that, while the gender income gap has narrowed in the UK, income differentials have significantly increased among women, especially among high-skilled and low-skilled women. Lastly, Juhn et al. (2014) examine the effect that trade liberalisation (e.g., tariffs reduction) has on employment patterns among men and women in Mexico. They find that tariff reductions did not only incentivise Mexican firms to upgrade their technological competencies, but also led to the replacement of male blue-collar workers with female blue-collar workers, thus having a strong effect only on the gender employment gap rather than on the gender wage gap.

2.4.4 Conditional

The *Conditional* research theme is the fourth most popular in the literature (n=15). Studies belonging to this theme underline, in one way or another, that the relationship between innovation and inequality is contingent upon the types of innovation, institutional, socio-economic and organisational factors (e.g., Fernandez, 2001, Lee and Rodríguez-Pose, 2013, Kristal and Cohen, 2017, Santos et al., 2017, Bogliacino et al., 2018, Aghion et al., 2019). More specifically, in their study on 109 developing and developed countries, Richmond and Triplett (2018) show that the effect of technological innovation (especially ICTs) on inequality depends on the type of innovation (e.g., product or process innovation) (see, also Angelini et al., 2009, Santos et al., 2017). Their analysis also confirms that the causal association between innovation and inequality is conditioned by the economic and political characteristics of each country. In line with the analysis of Kristal and Cohen (2017) in the US, Hope and Martelli (2019) show that the transition from Fordism to Postfordism (which was also accompanied by the increasing technological intensity in the production process) has increased inequality in a sample of 18 OECD countries. However, "*the presence of*

strong labour market institutions, such as coordinated wage bargaining, strict employment legislation, high union density, and high collective bargaining coverage" (p.236) mitigates, to a great extent, the magnitude of inequality. Belman and Monaco (2001) extend this finding to the firm level by showing that, due to technological change, wages of truck drivers in the US have – since the 1980s – declined by 21%.

2.4.5 Employment Changes

The *Employment Changes* research theme investigates the relationship between innovation - induced employment changes and inequality. This theme consists of 14 studies which can be grouped into three main types: the first group of studies analyses the impact of innovation-induced changes on (un-)employment (e.g., Black et al., 2004, Commander and Kollo, 2008, Ojala et al., 2016, Frey and Osborne, 2017); the second group of studies examines the role that declining union membership plays in terms of innovation-induced employment changes and inequality (Mosher, 2007, Kristal and Cohen, 2017, Thewissen et al., 2018, Hope and Martelli, 2019); and the last group of studies analyses the impact of organisational innovation (e.g., new work practices) on wage inequality (Black et al., 2004, Handel and Gittleman, 2004).

Specifically, Frey and Osborne (2017) analyse the extent to which occupations in the US are susceptible to technological unemployment. According to their estimates "*around 47% of total US employment is in the high-risk category...i.e. jobs we expect could be automated relatively soon, perhaps over the next decade or two*" (Frey and Osborne, 2017, p.268). In a somewhat similar manner, Mehic (2018) uses a dynamic panel of 27 high- and middle-income countries from 1991 to 2014 to estimate the effects of declining industrial employment shares on income inequality. His analysis confirms the general sentiment that middle-earners and jobs in the manufacturing sectors have borne the largest burden in terms of wage losses (Bogliacino et al., 2018, see, also). Lastly, Commander and Kollo (2008) find, through a firm-based survey

in three transition countries (e.g., Hungary, Romania and Russia), that technological change has increased inequality by exerting "*a strong bias against unskilled labour that has lost employment disproportionately*"(Commander and Kollo, 2008, p.199).

According to the second group of studies, the ability of innovation to induce inequality through employment changes is subject to institutional factors (e.g., declining union membership and collective wage bargaining), as well as sectoral and organisational factors (e.g., human resource strategies). Specifically, Mosher (2007), Kristal (2013) and Kristal and Cohen (2017) provide evidence that declining union power and falling real minimum wages explain approximately half of rising inequality in the US. According to Kristal and Cohen (2017), such a finding suggests that rising inequality in the US is primarily driven by workers' disempowerment rather than by skill premiums. Similarly, Thewissen et al. (2018) explore the drivers of earnings inequality at the sectoral level. They find that waning labour union power is an important driver of earnings inequality. In line with previous studies (e.g., Fernandez, 2001, Hanley, 2014), Black et al. (2004) find that, while some organisational practices (e.g., self-managed teams) are associated with declining employment, other practices (e.g., job rotation) are associated with lower employment reductions but higher wage inequality (cf. Handel and Gittleman, 2004).

2.4.6 Diffusion

The *Diffusion* research theme is the sixth most researched in the literature (n=12). Research in this theme seeks to find out how the process of introducing and adopting innovation in a given territorial unit (e.g., city, region or nation) affects the distribution of income. The majority of studies in this theme show that the diffusion process increases inequality (e.g., Scott, 2011, Cozzens, 2012, Brouwer and Brito, 2012, Thakur, 2012, Santos et al., 2017, Chang et al., 2019, Hall, 2019, Comin and Mestieri, 2018). In contrast, a comparatively smaller number of studies demonstrate the exact oppo-

site, i.e., that the diffusion of innovation reduces inequality (e.g., Otsuka et al., 1990, Bonjean, 2019).

Specifically, Hall (2019) quantifies "*the pace of technological diffusion*" (p.445) and the impact which the latter has on inequality. In line with other cross-country studies (Santos et al., 2017), Hall's paper suggests that technological progress significantly increases inequality. Brouwer and Brito (2012) study the diffusion of mobile phones in Mozambique. They find that "*while pre-paid telephone plans have made basic cellular service affordable to many Mozambicans*" (p.231), the diffusion process is gendered and geographically-uneven, benefitting mostly affluent men and users located in urban regions. Similarly, Thakur (2012) and Scott (2011) analyse the diffusion of open source software and telephone in contemporary Canada and early 20th century Great Britain. Thakur's study suggests, based on its findings, that while open source software has real economic benefits, the distribution of the latter is skewed towards mostly large firms and highly-educated male IT employees. Scott's (2011) study finds that the diffusion of the telephone in interwar Britain was slow and highly skewed towards affluent subscribers. Lastly, Comin and Mestieri (2018) examine the cross-country evolution of technology diffusion over the last two centuries. Their analysis documents that, while adoption lags between poor and rich countries have converged, "*the intensity of the use of adopted technologies of poor countries relative to rich countries has diverged*" (Comin and Mestieri, 2018, p.137).

Although the findings of the above studies underscore that the diffusion of innovation is either socially uneven or leads to unequal economic benefits, the second group of studies shows that innovation diffusion could also lead to a significant reduction in inequalities. For instance, Otsuka et al. (1990) analyse the distributional impact of modern rice varieties in the Philippines. The findings indicate that the adoption of modern rice varieties leads to an equal distribution of income among rice-growing farmers. More recently, Antonelli and Gehringer (2017) advance the Schumpeterian hypothesis "*whereby increasing levels of income inequality are the consequence,*

rather than the cause, of slow growth, and, more specifically, of the slowing pace of technological change" (Antonelli and Gehringer, 2017, p.85). The proposed hypothesis is tested in a large sample of advanced economies, showing that "*the introduction of innovation is a powerful factor in reducing income inequality.*" (Antonelli and Gehringer, 2017, p.86).

2.4.7 Innovation Policy

The innovation policy research theme consists of 10 studies, all of which have either analysed or touched upon the question of how innovation (including science and technology) and policies[11] affect the distribution of income. The review process identifies two main groups of studies: the first group of studies shows that innovation policies, either on their own or in conjunction with other policies, induce inequality (e.g., Attanasio et al., 2004, Adams, 2008, Cozzens, 2012); and the second group of studies finds that innovation policies lead to a more balanced distribution of income (e.g., Langer, 2001, Adams, 2008, Arndt et al., 2009).

Adams (2008) examines the relationship between intellectual property rights (IPR) and trade openness when it comes to inequality in 62 countries over 17 years (1985-2001). Adams' study suggests, based on its findings, that, in conjunction with increasing international trade, strengthening the IPR regime in a country has a negative effect on the distribution of income; however, as Martorano and Sanfilippo (2015) have suggested, well-designed educational policies can significantly mitigate the effect of innovation on inequality. Cozzens et al. (2002) find in their case study analysis in four US states (Alaska, Arkansas, Ohio, and Virginia) that science and technologies policies often aim at creating high-skill and high-wage jobs in the local economy. In doing so, they increase wage inequality among skilled and less-skilled workers. Cozzi and Impullitti (2010) extend this finding by showing that US government spending

[11] For an overview on the relationship between science, technology and innovation policies, see Radosevic (2012), Edler and Fagerberg (2017).

accounts for approximately "*15% of the observed increase in wage inequality in the period spanning 1976–1991*" (Cozzi and Impullitti, 2010, p.1325).

However, according to the second group of studies, innovation policies have a positive impact on the distribution of income. For instance, Langer (2001) assesses, through a cross-sectional time-series analysis, the effects of economic development strategies on the distribution of income in US states for an 18-year period (1976-1994). The findings of his analysis suggest that states which promote investments in R&D and technology have more equitable distribution of income than states which pursue traditional policies (e.g., tax reductions and capital subsidies). In a somewhat similar manner, Ding et al. (2011) investigate the effects of government policy to promote new rice technologies in a Chinese province, finding that it benefited the income of both high- and low-income farmers equally. Arndt et al. (2009) assess the implications of large-scale government-funded investments in biofuels on inequality in Mozambique. Their findings suggest that "*biofuels investment enhances growth and poverty reduction, despite some displacement of food crops by biofuels*" (Arndt et al., 2009, p.81). In line with Mukhopadhyay and Nardi's (2007) analysis of the impact on gender inequality of a government-funded project concerning high-tech entrepreneurship in Kerala State in India, Arndt et al. (2009) show that, when carefully designed and managed, innovation policies hold the potential for achieving inclusive growth (see, also Zehavi and Breznitz, 2017).

2.4.8 Biderectionality

The idea that inequality shapes the nature and direction of innovative activity in capitalist societies has a very long intellectual pedigree. For instance, Karl Marx's (1818-1883) work on social classes, Thorstein Veblen's (1857-1929) analysis of leisure, Werner Sombart's (1863-1941) theory of economic development, and, more recently, Pierre Bourdieu's (1930-2002) work on social distinction confirm, in one way or an-

other, that inequality has a profound effect on both innovation and growth. Nonetheless, this causal possibility has only recently been considered systematically, both in terms of theory and research (Falkinger and Zweimüller, 1997, Cozzens and Kaplinsky, 2009, Riaz, 2015). A search revealed a total of 8 studies dealing with the question of *bidirectionality*, of which a relatively small number finds that inequality affects innovation positively (e.g., Hyytinen and Toivanen, 2011, Tselios, 2011). In contrast, a larger number of studies show that inequality has a negative effect on innovation (e.g., Fuchs, 2009, Hilbert, 2010, Hatipoglu, 2012).

More specifically, and in line with the incentive thesis whereby inequality provides strong incentives to economic agents to do the right things, such as to work harder (e.g., productivity gains) and to engage in growth-boosting (Schumpeterian) activities such as innovation and entrepreneurship (Falkinger and Zweimüller, 1997, Stiglitz, 2012), Hyytinen and Toivanen (2011) suggest, based on their findings, that income inequality (as measured by the income share of the highest-earning deciles) has a positive effect on the early diffusion of mobile phones in a sample of developing countries in the 1980s and 1990s. Similarly, Tselios (2011) examines the relationship between inequality and innovation in a sample of 102 regions of Europe over a 15-year period (1995-2000). His analysis indicates that, while the relationship between inequality and innovation (and vice versa) is heterogeneous, "*an increase in a region's inequality favours innovation*" (Tselios, 2011, p.75). Following Falkinger and Zweimüller (1997), Tselios (2011) attributes this finding to a 'price effect', such as when the more affluent consumers choose to buy a more technologically-advanced and expensive innovation.

On the other hand, however, a growing number of studies not only show that the socio-economic costs of rising inequality surpass, by far, its putative benefits (Neckerman and Torche, 2007, Cavanaugh and Breau, 2018), but also show that rising inequality has an overall negative effect on innovation and growth (OECD, 2011, 2015). Specifically, Močnik and Širec (2010) suggests, based on the findings of the study,

that the income distribution within a nation exercises a significant impact on the use and adoption of the internet in 160 countries. Moreover, Vona and Patriarca (2011) conclude, following their work, that "*an excessive inequality harms the development of environmental technologies, especially in rich countries*" (p.2201). Yanadori and Cui (2013) examine the relationship between wage inequality in R&D teams and innovation performance in US high-technology firms. In contrast with the incentive thesis, the results indicate that earnings inequality in R&D teams hampers innovation. Xavier-Oliveira et al. (2015) provide a multi-level analysis of entrepreneurial choices in 31 countries between 2001 and 2008. Their statistical analysis suggests that, while economic inequality fosters entrepreneurship, it has a more substantial effect on necessity entrepreneurship, rather than on opportunity entrepreneurship. Unlike Xavier-Oliveira et al. (2015), Nakara et al. (2019) and Jung et al. (2018) extend this finding to the relationship between inequality, entrepreneurship and regional growth. Their findings posit that income inequality negatively affects both entrepreneurship and regional growth. Jung et al. (2018) attribute this finding to inequality exercising a regional market size effect: "*An unequal distribution of income means that there are small regional markets for new products and those markets grow slowly, as only a small number of consumers can afford to buy them*" (Tselios, 2011, p.79).

2.4.9 Digital Divide

The *Digital Gap* theme is the least researched theme in the literature. In total, 8 studies constitute this research theme, all of which confirm that there is not only unequal access to digital technologies (in both developed and developing countries), but also that digital inequalities significantly affect the ability of actors to participate in the innovation process (Cozzens and Kaplinsky, 2009, Fuchs, 2009). Gibson (2003), for instance, examines the use of ICTs in Australia. Using data gathered by Australia's national census (2001), the author suggests that there is a significant digital gap among households and territories. Like Martin and Robinson's (2007) analysis in

the US, and Mendonça et al.'s (2015) analysis in Portugal, Chakraborty and Bosman (2005) indicate that the digital gap has a strong horizontal dimension: "*while income inequalities among PC owners (households) decreased between 1994 and 2001 in all regions and states, the magnitude of this inequality has declined more rapidly among white households compared to African Americans*" (Chakraborty and Bosman, 2005, p.395). Hilbert (2010) investigates the unequal access to ICTs in four Latin American countries (i.e., Mexico, Uruguay, Brazil and Costa Rica). His analysis reveals that a 4% reduction in ICT prices could significantly reduce the digital gap between rich and poor households. Lastly, and more recently, Otioma et al. (2019) examine access to ICTs in Kigali City in Rwanda. Their analysis suggests that ICTs access is significantly clustered in the most affluent parts of the city.

Summary Table 2.3 classifies the key dimensions in each research theme, and in doing so it provides a quantitative summary of each theme. The three most popular themes are Skills (78 studies), Geographical aspects (23 studies) and Horizontal inequalities (17 studies), followed by the Conditional (15 studies), Employment changes (14 studies), Diffusion (12 studies), Innovation policy (10 studies), Biderectionality (studies), and Digital divide themes (8 studies). Even though the absolute number of studies in all themes has increased over time, the themes with the highest growth in the expansion phase are the following: Diffusion, Biderectionality, Context, and Innovation policy. The most cited themes are Skills (15,903 times), Employment (7,981 times) and Horizontal inequalities (3,052).

Table 2.3: Research Themes: Overview

Research Theme	Total	Early phase, 1990-1999 (% of total)	Growth phase, 2000-2009 (% of total)	Expansion phase, 2010-2019 (% of total)	Total citations (Google Scholar)	Average citation (Google Scholar)	Fields (number)
Skills	78	5 (6.4)	29 (37.2)	44 (56.4)	15,903	204	Economics (56), employment relations (7), geography (7), development studies (3), other (5)
Geographical aspects	23	1 (4.4)	10 (43.5)	12 (52.1)	1,339	58	Geography (15), economics (5), development studies (2), sociology (1), geography (7)
Horizontal inequalities	17	2 (11)	6 (33.3)	9 (50)	3,052	180	Sociology (6), economics (4), innovation studies (2), employment relations (2), other (3)
Conditional	15	0	6 (40)	9 (60)	968	65	Economics (6), Employment relations (2), innovation studies (2), other (2)
Employment	14	2 (14.3)	5 (35.7)	7 (50)	7,981	570	Economics (5), employment relations (4), innovation studies (2), political science (2), other (1)
Diffusion	12	1 (8.3)	1 (8.3)	10 (83.4)	224	60	Economics (6), innovation studies (3), other (3)
Innovation policy	10	0	4 (40)	6 (60)	272	27	Economics (4), innovation studies (2), other (4)
Biderectionality	10	1 (10)	1 (10)	8 (80)	259	26	Economics (7) development studies (2), geography (1)
Digital Divide	8	0	4 (50)	5 (50)	823	103	Geography (3), other fields with 1 study (5)
Other	18	1 (5.5)	5 (27.8)	12 (66.7)	665	37	Innovation studies (7), economics (6), management (2), sociology (2), other (1)

	Popular research context (number)	Popular primary unit(s) (number)	Popular data type (number)	Popular research design/data analysis (number)	Popular measures of innovation (number)	Popular measures of inequality (number)	Findings (number)
Skills	US (24), UK (6), China (4), Korea (4), Finland (4), Germany (3), India (3), Singapore (2), Sweden (2)	Individuals and employees (45), sectors (14), cities and regions (8), firms (7), other (3)	Quantitative (75), mixed (2), qualitative (1)	Advanced inferential statistics and econometrics (64), Descriptive statistics (6)	Latent (16), R&D intensity and investments (26), computer usage (11), total factor productivity (5)	Log wages (18), wage gaps skilled and unskilled workers (15), gini index (11), percentiles (11)	Positive (55), complex or mixed (16), negative (5), no significant effect (1)
Geographical aspects	US (10), EU (3), China (2), India (2)	Cities and regions (19), employees and individuals (4)	Quantitative (20), mixed (3)	Advanced inferential statistics (19), Descriptive (2), case study (1), triangulation (1)	Latent (6), patents (4), computer usage (3), employment (2)	Gini (7), Long wages (7), percentiles (6)	Positive (18), complex or mixed (2), negative (2), biderectionality (1)
Horizontal inequalities	US(9), Finland (2)	Individuals (10), employees (2), other (5)	Quantitative (15), mixed (2)	advanced inferential statistics (econometrics) (14), descriptive statistics (2), case study (1)	Percentage High-tech firms and employment (4), latent (4), computer usage (3)	Gender income gap (9), percentiles (2)	Positive (11), complex or mixed (2), no significant effect (2), negative (2)
Conditional	US (8), Germany (2)	Individuals (4), countries (4), other (7)	Quantitative (12), mixed (2), qualitative (1)	Advanced quantitative analysis (11), Case studies (2), descriptive statistics (2)	Technology adoption and usage (4), ICT investments (4), patents (2), latent (2)	Percentiles (7), Gini (3), wage gap (2), other (3)	Positive (7), complex or mixed (7), negative (1)
Employment	US (7), OECD countries (2)	Individuals (4), employees (2), firms (2) and sectors (2)	Quantitative (13)	Advanced inferential statistics (econometrics) (13)	ICT investments (2), computer usage (2)	Percentiles (4), Gini (3), log wages (2)	Positive (8), complex or mixed (3), negative (2), no significant effect (1)
Diffusion	Cross-country (7)	Individuals (7), employees (1), countries (2), and technology (2)	Quantitative (11), qualitative (1)	Advanced inferential statistics (econometrics) (11), case study (1)	ICT usage and adoption (7), R&D expenditure (2)	Gini (4), percentiles (3), other (7)	Positive (5), complex or mixed (5), negative (2)
Policy	US (3), cross-country (3)	Individuals, households (3), sectors (2),country (3)	Quantitative (8), mixed (2)	Advanced inferential statistics (econometrics) (8)	Latent (2), high-tech employment (2)	Gini (3), percentiles (2)	Positive (7), negative (2), complex (1)
Biderectionality	Cross-country analysis, both developed and developing countries	Countries (5), individuals (3)	Quantitative (8), mixed (2)	Advanced inferential statistics or econometrics (9)	Patents (2), other measure (8)	Gini (4), percentiles (3)	Biderectional and complex (10)
Digital Divide	US (2)	Individuals and households (4)	Quantitative (7), mixed (1)	Advanced inferential statistics (6), case study (2), descriptive statistics (1)	ICT usage (7)	Gini (2), percentiles (2)	Positive (6), complex or mixed (2)
Other	EU(5), UK (2)	Country (7), firms (2)	Quantitative (17), interviews (1)	Advanced inferential statistics or econometrics (18), case study (1)	Patents (4), R&D investments (3), ICT usage (3), product and process innovation (2)	Gini (10), percentiles (4)	Positive (8), complex or mixed (8), biderectionality (1), not significant (1)

Source: own elaboration, Scopus

However, as far as the number of average citations is concerned, the most influential theme is the Employment theme, with 570 citations per study[12]. As illustrated by the Fields columns in Table 3, there is a multi-disciplinary division of labour in nearly all themes. However, except for the Geographical aspects, Employment and Digital divide themes, where geographical and sociological research prevail, economics research figures prominently in all the other themes. Developed economies (mainly the US, UK, Finland, and Germany) and a few developing ones (e.g., China, India and Singapore) are the most researched. The more preferred units of analysis are individuals, employees, sectors, firms, cities and regions. The great majority of studies use quantitative data, hence the popularity of advanced inferential statistical methods and econometrics in all themes. Less than 5% of all studies use an alternative research method, such as case study research. This kind of methodological uniformity is also reflected in the popular measures of innovation (e.g., R&D intensity, patents, and high-tech employment) and inequality (e.g., Gini coefficient, percentiles, log of wages and wages gaps). Lastly, except for the Biderectionality research theme, the great majority of studies in all themes confirm that innovation induces inequality.

2.5 A Typology of Causal Mechanisms

What are the causal mechanisms through which innovation shapes the distribution of income? While several studies refer to causal mechanisms, none of them has specified the scope and content of the causal mechanisms. For instance, Krusell et al. (2000) state that "*we develop a framework that provides a simple, explicit* ***economic mechanism***" (p.1029, bold emphasis added). However, what these authors have in mind is a variable in a mathematical model rather than an actual causal mechanism derived from the causal powers of the innovation process. To provisionally address the lack of a sophisticated understanding and knowledge on causal mechanisms through in-

[12]Here, it is important to note that the number of citations in the Employment theme is inflated due to Frey and Osborne's (2017) 'super star paper', which has been cited more than 6,900 times in February, 2020.

novation shapes the distribution of income, and to integrate key aspects from each research theme in a creative, yet causally explanatory manner, this section utilises the critical realist approach to causal mechanisms[13] as the theoretical foundation to conceptualise the possible existence and anatomy of a set of causal mechanisms through which innovation shapes, either positively or negatively, the distribution of income. The hypothesised causal mechanisms are classified into two main causal scenarios, i.e., *intensification* and *amelioration*.

2.5.1 Causal Scenario I: Intensification

The argument that innovation is capable of creating and exacerbating inequality is by no means novel nor modern. For instance, Adam Smith's analysis of the division of labour, David Ricardo's theory of comparative advantage, Karl Marx's theory of class-based exploitation, John Maynard Keynes' analysis of technological unemployment, and Joseph Schumpeter's shift from the entrepreneur (Schumpeter Mark I) as the primary agent of innovation to large firms (Schumpeter Mark II), all highlight – in one way or another – that innovation holds the causal power to reinforce socio-economic inequalities (Schumpeter, 1944/2006*a*, Heilbroner, 2011). Based on the extant literature concerning innovation and inequality, the following five causal mechanisms can be hypothesised as potentially active[14].

- **Causal Mechanism$_1$**– *Skill Premiums*. The causal power of this mechanism emanates from the ability of the innovation process to raise the demand for new skills, whilst at the same time lowering the demand for existing skills. In a rapidly-changing, innovation-driven globalising capitalist system, the creative-

[13] As mentioned in the introductory chapter, the critical realist approach comprehends causal mechanisms as dynamic configurations of causal powers and relevant conditions capable of inducing an empirical event or outcome: *Causal Powers (CPs)* + *Relevant Conditions (RCs)* = *Empirical Outcome (EO)*.

[14] The order of the causal mechanisms is based on the number of studies which refer to, or touch upon, some of the key constituents (i.e., causal power, favourable conditions and empirical outcomes) of the causal mechanism in question.

destructive nature of the innovation process produces several temporary and enduring skill shortages (Archibugi and Lundvall, 2001, Freeman, 2001, Acemoglu, 2002, Lundvall, 2002). Skill shortages are likely to form the skill- premium causal mechanism when an appropriate set of conditions is favourable. This implies that the causal power of the mechanism in question exists independently of its empirical manifestation (e.g., rising wage gaps). Put it differently, the inequality-inducing ability of skill premiums mechanism is *ontological*, whereas its causal efficacy, thus also its empirical manifestation, are *contingent* upon the existence of relevant factors. Although the existing research has paid very little attention to the context-specific nature of causality, the following factors seem to affect the composition of the *skill premiums* causal mechanism: human resource strategies (Fernandez, 2001), institutional factors (e.g., declining unionisation) (Kristal and Cohen, 2017, Hope and Martelli, 2019), and innovation and economic policies that reduce trade tariffs and favour high-tech activities (Cozzens et al., 2002, Cozzi and Impullitti, 2010).

- **Causal Mechanism$_2$** – *(Horizontal) Competence Concentration*. According to a synthesis of the work of Karl Marx and Joseph Schumpeter – i.e., the Marx-Schumpeter model of development (Fagerberg, 2003, pp.126-131) – innovation leads to intensifying technological competition among firms, and thus also to the constant (re-)development of new products and services. In doing so, innovation simultaneously creates new competencies (i.e., abilities to participate in the innovation process) whilst gradually destroying those that are no longer needed in the innovation process(Archibugi and Lundvall, 2001, Lundvall et al., 2002). In this regard, innovation is fundamentally a dynamic (creative-destructive) learning process (Schumpeter, 1944/2006*a*, Archibugi and Lundvall, 2001, Lundvall, 2002), i.e., a collective process through which actors learn several new things, whilst forgetting, by necessity, old ones. However, as illustrated by the Geographical Aspects, Horizontal Inequalities and Digital Divide themes, the competence-building process is often quite unequal, thus intensifying inequality

among and within social groups (e.g., men versus women, native versus immigrant, skilled versus unskilled etc.), firms (e.g., small versus large firms), cities and regions (e.g., core-periphery) as well as nations (e.g., north-south income gap).

- ***Causal Mechanism$_3$*** *– Technological Unemployment*. The question of whether innovation creates or destroys jobs has long been discussed in the social sciences (Pianta, 2005, Frey and Osborne, 2017, Pianta, 2018). For instance, Marx and Engels (2002) argue that, by embodying the constant drive to achieve capital accumulation, innovation is a labour-saving process which reduces employment in the production process. In a somewhat similar manner, John Maynard Keynes (1883-1946) believed that, since innovation is used to devise new means of economising the use of labour, it leads – in one way or another – to technological unemployment (Frey and Osborne, 2017, p.254). However, for the job-destructive abilities of innovation to be able to induce inequality, there must be a set of favourable conditions. Based on the relevant literature (especially the Employment and Conditional themes), favourable conditions can include organisational structures favouring management over labour (Fernandez, 2001, Hanley, 2014), labour-saving process innovation strategies (Angelini et al., 2009, Pianta, 2018), declining market demand for product innovation (Jung et al., 2018), (de-)regulated labour markets (Kristal and Cohen, 2017), and price-intensive international trade (Attanasio et al., 2004).

- **Causal Mechanism$_4$** *– Precarious employment*. The creative-destructive character of the innovation process implies that innovation not only destroys existing jobs but also creates new ones (see also the *Amelioration* causal scenario below). However, as several studies have either shown or pointed out (especially in the Employment theme), innovation has, since the 1970s, replaced stable, middle-income (manufacturing) jobs with precarious and relatively lower paid (informal service) jobs (e.g., mini-jobs) (Attanasio et al., 2004, Frey and Osborne, 2017, Mehic, 2018). Structural change, unequal organisational struc-

tures and strategies, (de-)clining union membership, declining real minimum wages (Kristal and Cohen, 2017), high-tech employment and innovation policies (Cozzens et al., 2002), as well as rising international trade (Attanasio et al., 2004), seem to be some of the most relevant conditions that contribute to the emergence of the precarious employment causal mechanism.

- **Causal Mechanism$_5$** – *New-Position Closure*. Due to its creative-destructive nature, the innovation process is riddled with problems and tensions, hence requiring the development of new institutional arrangements, organisational models and employment positions (Freeman, 2001, Bodrožić and Adler, 2018). The emergence of the ICT paradigm in the 1970s has not only reinforced the significance of management positions over labour (Hanley, 2014, Pianta, 2018), but has also led to the emergence of a new employment position, that of the *programmer*. This employment position is, currently, of utmost significance to an increasingly-digitalising innovation process (Echeverri-Carroll et al., 2018, Chang et al., 2019). However, due to already pre-existing gendered organisational structures, strategies (e.g., human resource strategies) and institutional factors (e.g., innovation policies, gendered labour markets, education system and culture) (Cozzens et al., 2002, Mukhopadhyay and Nandi, 2007, Asplund and Lilja, 2014, Karataş-Özkan and Chell, 2015), the great majority of programmers, and ICT experts in general, are male (Thakur, 2012, Chang et al., 2019). Thus, the economic benefits (e.g., higher wages) derived from the emergence of this new employment position in the innovation process are 'horizontally closed'.

2.5.2 Causal Scenario II: Amelioration

As mentioned earlier, the work of notable scholars opines that, among other things, innovation exerts a significantly positive influence on the distribution of income. Similarly, a growing number of studies on innovation emphasise the inclusive abilities of

the innovation process in both developed and developing countries (see, for instance Heeks et al., 2014). This review has also identified several studies which confirm that innovation reduces inequality. Based on a synthesis of key theoretical assumptions and findings from the relevant studies, the following three causal mechanisms can be hypothesised as responsible for reducing inequality.

- **Causal Mechanism$_6$** – *Inclusive Competence-Building*. Innovation, by definition, requires the creation of new competencies — a process known as competence-building (Archibugi and Lundvall, 2001, Lundvall, 2002). When the competence-creation process is inclusive, innovation mitigates existing inequalities, especially horizontal ones. To do so, however, it presupposes the existence of favourable conditions. Based on the most relevant studies under review, such conditions can include the following (Freeman, 2001, Lundvall, 2002, Arndt et al., 2009, Cozzens, 2012): inclusive organisational structures, human resource strategies, well-designed inclusive education programmes, and innovation policies.

- **Causal Mechanism$_7$** – *Inclusive Employment*. As mentioned earlier, innovation is a creative-destructive process that, while substituting for existing jobs in one sector and place (e.g., city, region and nation), also creates new jobs in another sector and place (Schumpeter, 1944/2006*a*, Pianta, 2005, 2018). When new jobs are filled by socially marginalised actors, innovation reduces inequality, and especially horizontal inequality (Echeverri-Carroll et al., 2018). To do so, however, a set of relevant favourable conditions must be present in a given context. The latter can range from increasing demand for labour, to inclusive organisational strategies, institutional arrangements, cultural factors and inclusive innovation policies (Freeman, 2001, Arndt et al., 2009, Thakur, 2012, Antonelli and Gehringer, 2017, Bonjean, 2019).

- **Causal Mechanism$_8$** – *Schumpeterian Social Mobility*. Innovation is a risky and failure-prone activity (Kline and Rosenberg, 1986, Lazonick and Mazzu-

cato, 2013). Nonetheless, when successfully commercialised, innovation allows the innovator (not necessarily the original innovator) to reap significant economic benefits, such as increased salaries and profits (Teece, 1986, Archibugi and Lundvall, 2001). In doing so, it enables the innovator (especially if the latter comes from a disadvantaged social background) to climb higher up on the social ladder, i.e., social mobility (Schumpeter, 1934, Antonelli and Gehringer, 2017, Jung et al., 2018, Aghion et al., 2019, Nakara et al., 2019). Based on the most relevant studies under review, innovation is more likely to lead to social mobility when the following conditions are obtained (Hatipoglu, 2012, Jung et al., 2018, Aghion et al., 2019, Bonjean, 2019): inclusive innovation (and entrepreneurship) policies, inclusive organisational structures and processes, relevant education programmes, financial incentives and support for disadvantaged, women and ethnic minorities, appropriate market conditions (e.g., rising demand and absence of substantial barriers to market entry), and favourable social contexts (e.g., absence of lobbying activities).

2.5.3 Summary and Caveats

Table 2.4 groups the hypothesised causal mechanisms into two main causal scenarios: the *intensification* and *creation* causal scenarios. The first consists of five complementary causal mechanisms generating the same type of empirical outcome, i.e., rising inequality, whereas the second consists of three causal mechanisms shaping the distribution of income in a positive manner. While the causal powers of each causal mechanism derive from the (Schumpeterian) creative-destructive nature of the innovation process – i.e., the ability of innovation to create and destroy jobs, skills and competencies (Schumpeter, 1934, 1944/2006*a*) – the efficacy of each causal mechanism is emerging out of interactions among the causal powers of innovation and a set of relevant conditions. Therefore, the ability of each causal mechanism to bring about an empirical outcome is highly contingent upon a set of relevant conditions, and hence

it needs to be conceptualised and analysed accordingly.

Table 2.4: Typology – Causal Scenarios and Mechanisms

Causal scenario	Causal mechanisms (CM)		Causal power(s) of innovation	Relevant conditions	Possible empirical outcome(s)	Relevant theme	Relevant sources
Intensification, i.e., innovation intensifies existing socioeconomic inequalities	CM1	*Skill wage premiums*	Creative-destruction of skills	Pay-premium strategies, skill shortages, institutional rigidities, deregulated labour markets,declining union membership, lack of (re-)training options, innovation and other policies	Rising income inequality among skilled and non-skilled workers	Employment, geographical aspects, horizontal inequalities, innovation policy skills	\Colclough and Tolbert (1990), Acemoglu et al. (2001), Cozzens et al. (2002), Attanasio et al. (2004), Black et al. (2004), Handel and Gittleman (2004), Mukhopadhyay and Nandi (2007), Mosher (2007), Cozzi and Impullitti (2010), Hanley (2014), Martorano and Sanfilippo (2015), Kristal and Cohen (2017), Santos et al. (2017), Thewissen et al. (2018), Hope and Martelli (2019)
	CM2	*(Horizontal) Competence concentration*	Creative-destruction of competences	Hiring and firing practices, social norms, lack of educational options, bonding social capital, existing socio-economic inequalities, lack of support and incentives	Rising (gendered or racial) inequalities	Skills, geographical aspects, horizontal inequality, digital inequality, biderectionality	\Colclough and Tolbert (1990), Cozzens et al. (2002), Mukhopadhyay and Nandi (2007), Black et al. (2004), Commander and Kollo (2008), Scott (2011), Hyytinen and Toivanen (2011), Brouwer and Brito (2012), Thakur (2012), Mendonça et al. (2015), Santos et al. (2017), Echeverri-Carroll et al. (2018), Jung et al. (2018), Thewissen et al. (2018), Chang et al. (2019)
	CM3	*Technological unemployment*	Destruction of jobs	Cost-effective strategies, lack of demand, lack of institutional support	Rising poverty and inequality	Skills, employment	\Cozzens et al. (2002), Black et al. (2004), Hanley (2014), Frey and Osborne (2017), Mehic (2018)
	CM4	*Precarious employment*	Creative-destruction of jobs	Immigration, de-regulated labour markets, labour policies , flexible employment strategies, structural change, de-regulated labour markets, employees disempowerment, labour policies, Cost-effective strategies, lack of demand, lack of institutional support	Rising poverty and inequality	Skills, employment, innovation policy	\Colclough and Tolbert (1990), Mosher (2007), Commander and Kollo (2008), Thewissen et al. (2018), Kristal and Cohen (2017), Hope and Martelli (2019), Mehic (2018), Chang et al. (2019)
	CM5	*New positional closure*	Creation of competences and jobs	Gendered and racially-incentive institutions, labour market and organisational settings, policies	Rising horizontal inequalities	Horizontal inequality	\Mukhopadhyay and Nandi (2007), Asplund and Lilja (2014), Echeverri-Carroll et al. (2018), Chang et al. (2019)
Amelioration, i.e., innovation reduces existing socioeconomic inequalities	CM6	*inclusive competence-building*	Creative-destruction of competences	Inclusive policies, favourable institutional arrangements, social norms	Declining horizontal inequality	Horizontal inequality, skills	\Otsuka et al. (1990), Freeman (2001), Arndt et al. (2009), Thakur (2012), Antonelli and Gehringer (2017), Bonjean (2019)
	CM7	*Inclusive employment*	Creative-destruction of jobs	Employment strategies, education and innovation policies, workers empowerment	Declining horizontal inequality	Employment Changes, horizontal inequality	\Otsuka et al. (1990), Cozzens (2012), Black et al. (2004), Mosher (2007), Asplund and Lilja (2014), Martorano and Sanfilippo (2015), Kristal and Cohen (2017), Echeverri-Carroll et al. (2018), Thewissen et al. (2018)
	CM8	*Schumpeterian social mobility*	Creative-destruction of competences	Lower barriers to entry for marginalised actors, supportive institutional arrangements, rising market demand	Declining top-income inequality	Biderectionality, innovation policy	\Mukhopadhyay and Nandi (2007), Hatipoglu (2012), Antonelli and Gehringer (2017), Aghion et al. (2019), Bonjean (2019)

Two caveats need to be mentioned here, before the paper is brought to an end. First, since the raw materials of the proposed typology consists of the extant literature, the structure and content of the proposed typology are provisional – they are a 'product in process'; thus, they need to be revised accordingly in light of new theoretical lessons and evidence. This, in turn, justifies why the proposed typology is styled as 'typology', rather than as 'taxonomy'; the latter has a somewhat static connotation. Secondly, due to the above issues, the explanatory power of the proposed causal mechanisms needs to be corroborated through concrete research. In their current form, the proposed causal mechanisms constitute crude conceptual prototypes of possibly existing entities. Future research will be instrumental in clarifying the existence, composition and efficacy of the proposed causal mechanisms. Despite these two important caveats, the typology in question enables us, although provisionally, to comprehend the complexities that govern the relationship between innovation and inequality in a manner that is creative, holistic and consistent with the findings of several studies on innovation and inequality.

2.6 Concluding Remarks, Suggestions and Limitations

This paper has identified and reviewed the extant stock of knowledge on innovation and inequality in various social science fields. It did so by combining and synthesising key insights based on two different literature review methods, i.e., the bibliometric (quantitative) method and meta-synthesis (qualitative) method. An analysis of 166 studies confirmed that social scientists have, since the late 2000s, been increasingly interested in the relationship between innovation and inequality. This is reflected in the rapid expansion of published studies on innovation and inequality, and the multi-disciplinary character of key research themes in the literature. It was also found that, while the relationship between innovation and inequality is bi-directional, causally-complex and multi-faceted, the great majority of studies under review confirm that

innovation induces inequality.

This finding suggests that innovation studies researchers and policy-makers need to reconsider the long-held trickle-down assumption, whereby rising inequality constitutes a necessary, transitory evil that innovation-driven growth will alleviate in the most efficient and timely manner possible. Instead, as illustrated throughout this review, the pressing question is no longer that of trickle-down, but of inclusive growth, specifically 'what kind of innovation policies need to be in place to make innovation-driven growth more inclusive and equitable than hitherto?'. While each of the nine research themes offers some interesting insights into such a policy-relevant question, much of our knowledge on innovation and inequality is informed by the Skills research theme in general, and SBTC research in particular. As a result of this, the existing research is unable to provide a set of insightful, empirically-grounded policy suggestions, other than the main policy implications derived from the SBTC account, such as the following two: (a) addressing skilled labour shortages could reduce skill premiums; and (b) incentivise marginalised and low-skilled employees to invest in education and training. However, and as the findings of some studies (e.g., Attanasio et al., 2004, Martorano and Sanfilippo, 2015) under review imply, both (a) and (b) seem to require, among other things, the creation of synergies across various policy domains (e.g., education, labour and trade policy).

Furthermore, and as shown in Section 2.4 of this study, the prevailing view in the extant literature on innovation and inequality is, currently, that innovation is mainly a technological, linear, R&D-driven process. This view contradicts several key stylised facts regarding our knowledge of innovation, especially within the field of innovation studies. For instance, several decades of innovation studies research have, among other things, taught us that innovation is a highly-complex, multi-source, interactive learning process, differing "*in many respects according to the economic sector, field of knowledge, type of innovation, historical period and [the] country concerned*" (Pavitt, 2005, p.86). Future research needs to go beyond the traditional, narrow variables of

innovation to examine the impact that different types of innovation (e.g., product, incremental and organisational innovation) could have on the distribution of income by utilising a broader set of variables to gauge innovation better than hitherto. Future research also needs to investigate the highly-overlooked, yet highly-plausible, causal possibility that, since innovation emerges in collectivities of actors (e.g., clusters, networks, innovation systems), it may be the latter which enable innovation to induce inequality in contemporary societies.

Moreover, while the innovation process is a collective activity, often encompassing systematic interactions among a wide array of private and public actors (e.g., firms, suppliers, universities, government organisations, laboratory, banks, venture capitalists, etc.), the income that innovation generates is, primarily, distributed within the innovative firm (rather than in labour markets as the bulk of the extant literature implies). Future research needs to unpack the 'black box' of wage inequality within the innovation firm. Emphasis must also be placed on how actors obtain access to income flows that innovation produces within the firm. Research on this issue could also help us to better understand the significantly-overlooked relationship between innovation and top income inequality (Aghion et al., 2019); in particular, how a set of high-income organisational actors (e.g., top executives, venture capitalists) manage to convince other organisational actors (e.g., labour representatives, and shareholders) that they deserve a significant share of the value that innovation generates within the innovation firm; even though, and as Lazonick and Mazzucato (2013) have emphasised, high-income organisational actors do not necessarily bear the lion's share of the risks involved in the innovation process. Relatedly, more research needs to be dedicated to the distributional impact of innovation policies; in particular, how, and under what conditions, innovation policies reduce income differentials. These are some essential knowledge gaps which innovation studies research could address in the years to come.

This study has a few limitations. Since it has used the scholarly database with the

most entries (Scopus), the analysis may have overlooked a few studies which are not included in this database. Furthermore, the bibliometric analysis in this paper did not use advanced bibliometric methods. Due to the popularity of the Skills research theme, a bibliographical coupling and co-citation analysis (which were conducted in various stages of the review process by using the VOSviewer software, `https://www.vosviewer.com/`) produced very little knowledge that was new to the analysis. Nonetheless, and given the rapidly-growing cross-disciplinary interest in innovation and inequality, future studies could utilise advanced citation methods as a means by which to extend our understanding of the nine research themes that this study has identified.

Chapter 3

Case Study Research on Innovation Systems: Paradox, Dialectical Analysis and Resolution

Highlights

- The paper shows that, at the centre of the field of innovation systems studies, lies a methodological paradox
- The paper resolves the paradox in question through a dialectical analysis
- Several novel methodological lessons and implications emerge from the analysis in this paper

Abstract

This paper deals with a largely unnoticed methodological paradox concerning the scientific status of case study research on innovation systems (ISs). On the one hand, case study research has been instrumental in the genesis and establishment of the ISs approach as one of

the most widely-used theoretical and policy-relevant perspectives on innovation in the social sciences. On the other hand, however, ISs scholars have often argued that case study research is not able to study generality and causality. To heighten our understanding, as well as to resolve, such a methodological irony, this paper utilises the dialectical method, in particular the analytical scheme of thesis, antithesis and synthesis. The analysis shows that the paradox in question is attributable to (a) the prevalent belief that the hypothetico-deductive model of scientific explanation constitutes the most desirable way of studying the causal aspects of ISs (***deductive thesis***), while it is also attributable to (b) the absence of a well-articulated *antithesis* to the deductive thesis in the relevant literature. In line with a growing number of critical realist studies on innovation, the paper utilises the critical realist mode of scientific explanation (namely, retroduction) to articulate the ***retroductive antithesis***, whereby case study research on ISs is necessary to learn about the general aspects of causality, and especially causal mechanisms. Overall, the dialectical analysis in this paper demonstrates that the ability of case study research on ISs to produce generalisable, causal-explanatory knowledge depends, to a large extent, upon the model of explanation that inevitably informs our analysis, including the deeper (ontological and epistemological) assumptions associated with the model in question (***dependency synthesis***). The paper ends by discussing how the proposed synthesis enables ISs researchers to conduct case study research in a paradox-free, stand-alone and causal explanatory manner.

Keywords: Innovation systems, Case study research, Paradox, Dialectic, Deduction, Retroduction, Synthesis

3.1 Introduction

> "*A paradox is an idea involving two opposing thoughts or propositions which, however contradictory, are equally necessary to convey a more imposing, illuminating, life-related or provocative insight into truth than either fact can muster in its own right...What the mind seemingly cannot think, it must think.*"
>
> (Slatte, 1982, p.4, cited in Andriopoulos and Lewis, 2009)

Understood as the set of interacting private and public organisations that, under specific organisational and institutional arrangements, facilitate the generation, use, and dissemination of new knowledge, learning and innovation (Freeman, 1987, Edquist, 2005, Doloreux and Parto, 2005, Asheim et al., 2019), ISs constitute an essential structural condition for achieving and sustaining a high level of (Schumpeterian) growth and development in modern-day capitalist societies (Freeman, 2002, Bergek et al., 2008, Castellacci and Natera, 2013, Filippetti and Archibugi, 2011, Radosevic and Yoruk, 2013, Radosevic, 2022). Since the early 1990s, ISs have been the object of extensive research and policy action across the world (Sharif, 2006, Rakas and Hain, 2019). This, among other things, has led to the emergence of the ISs approach, which is – by now – one of the most widely-utilised theoretical perspectives on innovation in the social sciences (Carlsson, 2007, Doloreux and Porto Gomez, 2017, Rakas and Hain, 2019).

This paper is among the first to stop and think systematically about the *methodological assumptions* that inevitably underpin our research on ISs. As such, both the analysis and findings of this paper complement recent stock-taking contributions to ISs (Teixeira, 2014, Chaminade et al., 2018, Asheim et al., 2019, Rakas and Hain, 2019, Fernandes et al., 2020). However, unlike these very interesting and informative contributions, this paper is motivated by the existence of two largely unnoticed, yet contradictory, methodological developments in the literature, which – as is shown throughout this paper – raise a few 'fatal' questions about the scientific image and qualities – i.e., the *scientificity* – of the ISs approach.

On the one hand, the seminal work of the protagonists of the ISs approach – such as Christopher Freeman's (1987) analysis of the national innovation system (NIS) in Japan, Richard Nelson's (1993) collection of 14 case studies of various NISs across the world, as well as the edited volumes of Braczyk et al. (1998) and Malerba (2004) on regional innovation systems (RISs) and sectoral innovation systems (SISs) – clearly

demonstrates the methodological importance of case study research[1] for the field of ISs studies. On the other hand, however, a growing number of ISs scholars believe, either implicitly or explicitly, that case study research is not scientific enough. The underlying argument can be summarised in the following way: since the principal aim of scientific research is to produce generalisable causal knowledge (Chalmers, 2009), and case study research is – by definition – small-N research, it follows that case study research on ISs cannot study the general aspects of causality.

In propagating such a view (either explicitly or implicitly), ISs scholars have created several methodological ironies and impasses. For instance, if we provisionally accept the view that case study research is scientifically-circumscribed, how do we explain the fact that case study research is the most popular form of research within the field of ISs studies (Carlsson, 2007, Doloreux and Porto Gomez, 2017)? Since the current stock of knowledge on ISs is mainly based upon the findings of case study research, does this mean that the ISs approach – including the analytical and policy implications that emanate from it (Woolthuis et al., 2005) – are also not *that* scientific? It is such methodological contradictions and tensions that constitute the heart of the *case study paradox*[2] in the field of ISs studies.

The present paper utilises the philosophical dialectical method (also known as dialectics), and in particular the analytical 'dialectic triad' of thesis, antithesis, and synthesis (Popper, 1940, Bhaskar, 2008*a*, Hargrave and Van de Ven, 2017). By dialectically scrutinising the paradox in question, it is shown that the case study paradox is attributable to, first, the intellectual monopoly of ***deductive thesis***, whereby the hypothetico-deductive model of explanation constitutes the most scientifically legit-

[1]There are various definitions and perspectives on case study research in the literature (Eisenhardt, 1989, Verschuren, 2003, Yin, 2009, Tight, 2010). In this paper, case study research is understood as the research design (Yin, 2009) that investigates "*one or a small number of social entities or situations about which data are collected using multiple sources of data and developing a holistic description through an iterative research process*" (Easton, 2010, p. 119).

[2]It is interesting to draw a parallel between the case study paradox on ISs and the liar's paradox in philosophy (Honderich, 2005, pp. 678-680). The liar's paradox refers to Epimenides of Knossos (circa 600 B.C.), an ancient Cretan philosopher who repeatedly stated that 'All Cretans are liars'. The paradox is that Epimenides was a Cretan!

imate way of drawing generalisable knowledge about ISs, and socio-economic phenomena in general, as well as, second, drawing attention to the absence of a *well-articulated antithesis* to the deductive synthesis in the relevant literature. In line with a growing number of critical realist contributions on innovation (e.g., Castellacci, 2006, Koutsouris, 2012, Jackson et al., 2016, Adamides, 2018, Menzies, 2012, Sorrell, 2018), the present paper formulates the ***retroductive antithesis***, whereby case study research is not only able to study the general aspects of causality (especially *causal mechanisms*), but it is also essential to do so. To capture the dialectical tension between the two theses, the paper develops the ***dependency synthesis***. In a nutshell, the proposed synthesis states that, like any other type of research on ISs, case study research inherently possesses certain scientific qualities; however, the extent to which such qualities will be realised in a concrete project is subject to the model of explanation that informs the project in question.

This paper makes an essential contribution to the methodology of the field of ISs studies in general, and case study research on ISs in particular. By clarifying and resolving several methodological misconceptions and ironies, the paper not only clears the methodological ground, but also enables case study research on ISs to address, in a more productive (in terms of knowledge generation), yet methodologically-consistent, manner than hitherto, a few key research challenges which the field of ISs studies is currently facing. For instance, Chaminade et al. (2018) and Asheim et al. (2019, pp.111-119) identify three major research avenues for the field of ISs, namely (a) to study the creation of new, and the transformation of existing, ISs; (b) to broaden the scope of ISs research (e.g., digital innovation activities); and (c) to produce knowledge about grand societal challenges (e.g., environmental sustainability, inclusive growth, declining labour productivity growth, and rising income inequality). The dialectical analysis in this paper casts a fresh methodological perspective on how future case research on ISs could produce causal-explanatory knowledge about these research challenges in a manner that would have otherwise been methodologically impossible, given the prevalence of the deductive thesis in the relevant literature.

The remainder of this paper is organised as follows. Section 3.2 begins with a brief overview of the ISs approach, following which it proceeds by discussing the popularity and ironic state of the case study method within the field of ISs. Section 3.3 introduces the main features of the dialectical method, before Section 3.4 articulates, compares and contrasts the two main theses in this paper, i.e., the deductive thesis and the retroductive antithesis. The paper ends by advancing the dependency synthesis in the concluding section. Methodological implications, limitations and research avenues that emanate from the dialectical analysis are also discussed in the concluding section of this paper.

3.2 ISs Approach: Theory and Methodology

3.2.1 ISs Approach I: Theoretical Overview

Over the past four decades, numerous contributions have confirmed that innovation is by no means a single-actor, well-behaved, smooth, linear activity that begins with scientific research and development (R&D), before reaching the market through production, marketing and sales activities (Kline and Rosenberg, 1986, Lundvall, 2013). Central to such a 'non-linear' strand of innovation research is the work of Neoschumpeterian/evolutionary economists, in particular the work of Christopher Freeman, Ben-Akt Lundvall and Richard Nelson on NISs (Sharif, 2006, Fagerberg and Sapprasert, 2011). Freeman (1987), for instance, demonstrates that, behind the Japanese 'economic miracle' in the post-war period and the subsequent technological leadership in electronics in the 1970s and 1980s, was a well-functioning national innovation system (NIS), i.e., "*the networks of institutions in the public and private sectors whose activities and interactions initiate, modify and diffuse new technologies*" (Freeman, 1987, p.1).

Motivated by the findings of Freeman's study in Japan, as well as by the early re-

search on NISs in the 1990s (e.g., Nelson, 1993), and particularly by the observation that the national scale is often too broad to understand the complexities that characterise the systemic character of innovation, several contributions have attempted – since the late 1990s – to ascertain whether ISs exist at the other levels of socio-economic organisation, such as in cities, regions, sectors, technologies and firms (e.g., Braczyk et al., 1998, Malerba, 2004, Bergek et al., 2008, Granstrand and Holgersson, 2020). In its current form, the ISs approach constitutes a popular theoretical foundation for policy-relevant research on innovation (Rakas and Hain, 2019). Central to the ISs approach are, currently, the following four variants or specifications: a *geographical variant* that studies NISs and RISs (Asheim et al., 2011, Chaminade et al., 2018, Asheim et al., 2019); a *sectoral-technological* variant that looks at sectoral innovation systems (SISs) (Malerba, 2004) and technological innovation systems (TISs) (Bergek et al., 2008); a *configurational* variant which seeks to identify configurations of SISs and TISs across the globe (Markard and Truffer, 2008, Binz and Truffer, 2017, Weber and Truffer, 2017); and lastly, the *innovation-ecosystem* variant, that deals with firm-based ISs (Suominen et al., 2019, Granstrand and Holgersson, 2020).

Despite their analytical differences, especially with regard to the primary unit of analysis (e.g., nation, region, sector, technology, and firm), all variants of the ISs approach share the same semantic core, i.e., they all theorise and analyse systemic interactions among the *production* base (i.e., innovating firms) and the *institutional support* base (i.e., universities, research institutes, government organisations, suppliers, consultants, etc.). They also assess how such a dynamic ensemble of interacting actors facilitates – under specific favourable institutional arrangements (e.g., formal and informal rules, norms and regulation) (Nielsen and Johnson, 1998) – the creation and exchange of relational resources (e.g., financial and social capital, knowledge) and processes (e.g., interactive learning) necessary for the successful development and commercialisation of innovative activities in contemporary capitalist societies (Radosevic, 1998, Nielsen, 2003, Malerba, 2004, Bergek et al., 2008, Fragkandreas, 2012, Chaminade et al., 2018, Asheim et al., 2019). Correspondingly, all variants of the ISs

approach underline that innovation policy is more effective when it seeks to address a variety of *system-specific failures* (e.g., interaction failures, infrastructural failures, institutional failures, lock-in and capability failures) that hinder the development of promising innovative activities and paths of growth, rather than when it is exclusively designed to address market failures (Tödtling and Trippl, 2005, Woolthuis et al., 2005, Bergek et al., 2008, Chaminade et al., 2018, Asheim et al., 2019).

3.2.2 ISs Approach II: Methodological Overview

In line with Joseph Schumpeter's (1954/2006*b*) methodologically-eclectic approach to socio-economic research (Shionoya, 2004), ISs researchers have utilised several research designs and methods to study the 'empirically rich' (Asheim and Gertler, 2005, p.300) and 'institutionally diverse' (Radosevic, 1998) nature of the systemic roots of innovation, namely the stylised fact that each IS has a unique social division of labour[3]. In alphabetical order, the following research designs are, currently, the most popular: *case study research* (Doloreux, 2004, Asheim and Coenen, 2005, Storz, 2008, Lawton Smith et al., 2014), *econometric and advanced statistical analysis* (Buesa et al., 2006, Vilanova and Leydesdorff, 2001, Belussi et al., 2010, Hermann and Peine, 2011, Filippetti and Archibugi, 2011, Castellacci and Natera, 2013, Ivanova and Leydesdorff, 2015), *historical research* (Fagerberg et al., 2009, Negro and Hekkert, 2008), *grounded theory* (Abolhasani et al., 2014), *network analysis* (Belussi et al., 2010, Kauffeld-Monz and Fritsch, 2013), and *simulation research* (Samara et al., 2012).

Despite such a rich 'methodological menu', it is the case study method that lies at the centre of research on ISs. Bibliometric analyses confirm that the vast majority of ISs studies are either single or multiple case studies (Suominen et al., 2019, Carlsson, 2007, Doloreux and Porto Gomez, 2017, Teixeira, 2014). For instance, Doloreux and

[3]For instance, culturally-similar countries (e.g., Denmark and Sweden), neighbouring cities and regions within the same nation exhibit significant structural differences in terms of how ISs are organised (Nelson, 1993, Braczyk et al., 1998, Doloreux, 2004)

Gomez (2017) find in their systematic review of two decades of research on RISs that 61% (182 studies) of all published studies are case studies (n=292).

Table 3.1 lists some of the most often cited case studies on ISs. In a nutshell, the table in question confirms that case study research has made a significant contribution to the process of conceptual enrichment and development of the ISs approach. This is also reflected in the total number of citations, which stood at 37,627 citations in early 2020, corresponding to 1,636 citations per case study, with the 'classics' of Freeman (1987) and Nelson (1993) being the most cited contributions. Thanks to its inherent ability to generate new knowledge, concepts and theories about real-word phenomena where statistical data is lacking (Eisenhardt, 1989), case study research has acted as a vehicle to introduce the ISs approach to new scientific fields such as agricultural (Klerkx et al., 2010), energy (Foxon et al., 2005) and tourism studies (Mattsson et al., 2005).

Considering the above, it seems reasonable to expect that ISs scholars would be among the most ardent supporters of case study research in the social sciences. In fact, one would have expected that, for many social scientists, the literature on ISs would provide a wealth of methodological inspiration and instruction on how to conduct highly influential, yet policy-relevant, case studies. However, and as will be shown shortly, ISs scholars seem to have accepted the conventional, yet highly misguided, view that, regardless of its aims (i.e., exploratory or explanatory), case study research produces findings that are causally circumscribed and not applicable beyond the case study context. Before the discussion focuses more closely on the paradoxical status of case study research on ISs, a few words need to be said about the case study research design, and, in particular, about the question of *popularity*, i.e., why case study research is a popular choice among ISs researchers. This section approaches the popularity question by summarising key stylised aspects of the vast literature on case study research in the social sciences.

Table 3.1: A List of Well-Cited Case studies on ISs

	Author	Year	Title	Type of case Study	Unit of analysis	Data collection and analysis	Book/article	Journal/publisher	Citations(*)
1	Nelson R.	1993	National Innovation Systems: A Comparative Analysis	Multiple case studies	National systems of innovation in 12 countries	Different sources of evidence	Book	Oxford University Press	12,119
2	Freeman, C.	1987	Technology, Policy, and economic performance: lessons from Japan	Single case study	Japan's national system of innovation	Different sources of evidence	Book	Pinter	8,699
3	Braczyk, H. J., Cooke, P. N., & Heidenreich, M.	1998	Regional innovation systems: the role of governance in a globalized world	Multiple case studies	14 case studies on different regional innovation systems	Different sources of evidence	Book	Routledge	3,858
4	Asheim B.T., Isaksen A.	2002	Regional innovation systems: The integration of local 'sticky' and global 'ubiquitous' knowledge	Multiple case studies	3 regional clusters of firms in Norway	Different sources of evidence	Article	Journal of Technology Transfer	1,915
5	Asheim B.T., Coenen L.	2005	Knowledge bases and regional innovation systems: Comparing Nordic clusters	Multiple case studies	Case studies of five different industries and their corresponding RISs in Denmark, Norway and Sweden	Different sources of evidence	Article	Research Policy	1,750
6	Malerba, F	2004	Sectoral systems of innovation: concepts, issues and analyses of six major sectors in Europe	Multiple case studies	Case study analysis of six sectoral innovation systems (e.g., pharmaceuticals, chemicals, software, machinery, serveices, and internet and communication)	Different sources of evidence	Book	Cambridge University Press	1,720
7	Muller, E; Zenker, A	2001	Business services as actors of knowledge transformation: the role of KIBS in regional and national innovation systems	Multiple case studies	5 regions in France and Germany	Firm surveys of manufacturing and knowledge intensive firms	Article	Research Policy	1,250
8	Asheim B.T., Isaksen A.	1997	Location, agglomeration and innovation: Towards regional innovation systems in Norway?	Multiple case studies	2 industrial agglomerations of innovating firms in Norway	Interviews with managers	Article	European Planning Studies	1,009
9	Liu, XL; White, S	2001	Comparing innovation systems: a framework and application to China's transitional context	Single case study	An analysis of different ISs in China	Descriptive statics and narrative	Article	Research Policy	940
10	Foxon, T., et al.,	2005	UK innovation systems for new and renewable energy technologies: drivers, barriers and systems failures	Single case study	An analysis of different TISs in the UK	Multiple sources of evidence	Article	Energy Policy	617
11	Klerkx et al.	2010	Adaptive management in agricultural innovation systems: The interactions between innovation networks and their environment	Multiple case studies	Analysis of two cases in the Dutch agri-food sector	Multiple sources of evidence	Article	Agricultural Systems	556
12	Hekkert, Marko P.; Negro, Simona O.	2009	Functions of innovation systems as a framework to understand sustainable technological change: Empirical evidence for earlier claims	Multiple case studies	5 case studies	Process analysis based on documents	Article	Technological Forecasting and Social Change	511
13	Gilsing, V; Nooteboom, B	2006	Exploration and exploitation in innovation systems: The case of pharmaceutical biotechnology	Single case study	Pharmaceutical biotechnology in the Netherlands	Narative analysis of key facts and developments	Article	Research Policy	462
14	Intarakumnerd P., Chairatana P.-A., Tangchitpiboon T.	2002	National innovation system in less successful developing countries: The case of Thailand	Single case study	A single case study analysis of the Thai NIS	Narative analysis of key facts and developments	Article	Research Policy	429
15	Doloreux D.	2004	Regional innovation systems in Canada: A comparative study	Multiple case studies	A comparative analysis of two RISs in Canada	Multiple sources of evidence	Article	Regional studies	311
16	Belussi, Fiorenza et al.	2010	Learning at the boundaries in an Open Regional Innovation System: A focus on firms' innovation strategies in the Emilia Romagna life science industry	Single case study	Analysis of life science firms in the region of Emilia Romagna in Itally	Survey of firms	Article	Research Policy	288
17	Doloreux D.	2003	Regional innovation systems in the periphery: The case of the Beauce in Québec (Canada)	Single case study	A single case study of Beauce RIS	Multiple sources of evidence	Article	International Journal of innovation management	264
18	Surrs, Roald A. A.; Hekkert, Marko P.	2009	Cumulative causation in the formation of a technological innovation system: The case of biofuels in the Netherlands		Analysis of the biofuels TIS in the Netherlands	Multiple sources of evidence	Article	Technological Forecasting and Social Change	260
19	Edquist, C; Hommen, L	2009	Small country innovation systems: globalization, change and policy in Asia and Europe	Multiple case studies	Case studies of 10 national innovation system in different countries across the world	Multiple sources of evidence	Book	Edward Elgar	236
20	Binz, Christian et al.	2014	Why space matters in technological innovation systems-Mapping global knowledge dynamics of membrane bioreactor technology	Multiple case studies	Analysis of the membrane bioreactor TIS	Network analysis	Article	Research Policy	227
21	Doloreux D. Dionne, S.	2008	Is regional innovation system development possible in peripheral regions? Some evidence from the case of La Pocatière, Canada	Single case study	A single case study of the La Pocatière region in Canada	Interviews, documents and secondary statistics	Article	Entrepreneurship and Regional Developmen	206

* Source: own elaboration, Google Scholar, February 2020

Average citation	1,636
Total	37,627

3.2.3 Case Study Research: A Brief Methodological Overview

Case study research is one of the oldest and most popular designs of the social sciences. Currently, it occupies a prominent place in most methodological social sciences textbooks (e.g., Blaikie, 2000, Bryman, 2004, Frenz et al., 2011, Myers, 2019). However, this was not always the case. For instance, case study research was mostly absent from the methodological curriculum (although not from the research practice) in the postwar period (Platt, 1992, Blaikie, 2000, p.213-215). During the period in question, the vast majority of social scientists believed that case study research is a purely descriptive and subjective form of research (Flyvbjerg, 2006, Yin, 2009); hence, it needs to be avoided at all costs.

Traditionally, this view has been associated with the emergence of the (standard) positivist philosophy of science[4] (Tsoukas, 1989, Benton and Craib, 2001). Positivism argues that scientific research proceeds by identifying objective (i.e., value-free) large-scale empirical observations such as constant-conjunctions among empirical events, also known as empirical (law-like) regularities (Blaikie, 2000, Benton and Craib, 2001). Correspondingly, small-N research that deals primarily with words (qualities), instead of numbers (quantities) is, by definition, incompatible (although not entirely) with the positivist model of social sciences (Benton and Craib, 2001, Gibbert et al., 2008). Thus, from the standpoint of positivism, case study research is not ideal to a social science that seeks to emulate the methods of natural science (i.e., methodological naturalism), especially the methodological apparatus of the 19th century physics (Bhaskar, 1979, Lawson, 1997, Smith, 1998).

Thanks to the work of philosophers of social sciences which has, in one way or another, made it evident that positivism fundamentally misconstrues not only the interpretive nature of social phenomena (including the volitional character of social be-

[4]It is important to note here that the philosophical opponent to positivism in the social sciences, namely interpretivism (Benton and Craib, 2001), also implies – although for different reasons – that case study research is a descriptive and exploratory form of research. For an overview on this, see Tsang(2014).

haviour), but also the aims and scope of scientific research in general (Bhaskar, 1979, Benton and Craib, 2001), social scientists have gradually realised that Joseph Schumpeter[5] was, among others, right to believe that case study research is ideal for studying the highly-complex character of socio-economic phenomena (Swedberg, 1991, Reinert, 2002). Case study experts confirm that case study research is one of the few, if not the only, research design(s) that allows us to study the dynamic, historically-contingent and context-specific nature of important socio-economic phenomena by utilising different forms of triangulation (i.e., data triangulation, investigator triangulation, methodological triangulation, theoretical triangulation) within the same research project (Eisenhardt, 1989, Flyvbjerg, 2006, Yin, 2009, Easton, 2010).

In addition to methodological flexibility, case study research is flexible in regard to how the primary unit of the primary unit(s) of analysis (i.e., cases) is (are) conceptualised and analysed. Yin (2009), for instance, distinguishes between holistic and embedded (nested) case study research: the first analyses the unitary character of the case under consideration (e.g., the overall structure of ISs); the second focuses on the interaction between the whole and its parts, including their attributes (e.g., interactions among firms and universities in an IS). Like Yin (2009), Easton (2010) points out that flexibility and triangulation are two strengths unique to case study research. Furthermore, case study research can be used to describe, explore and explain social phenomena (Yin, 2009). It can also be utilised in 'intrinsic' and 'instrumental' ways (Stake, 2005), namely to generate new concepts and theories (Eisenhardt, 1989) or to test an existing theory (Flyvbjerg, 2006, Yin, 2009). Moreover, case study research is also ideal for research seeking to evaluate innovation policies (Pawson and Tilley, 1997, Pawson, 2006, Brown et al., 2016). Lastly, it is compatible with research which endeavours to initiate positive social change (action research) (Ollila and Yström, 2020).

[5]Reinert (2002), for instance, attributes the emergence of the Harvard Business School approach to case study research to the emigration of Joseph Schumpeter and other German historical economists to the US.

Considering the above, it appears that it is its theoretically-flexible, methodological pluralist and open-ended nature that makes case study research ideal for analysing the highly-idiosyncratic nature and capabilities of interacting innovating actors, including the highly-heterogeneous structural anatomy of ISs, especially when the availability of sophisticated quantitative data is limited.

3.2.4 Case Research on ISs: A Riddle?

Having discussed the key aspects of the ISs approach, and having confirmed the methodological significance of case study research for the field of ISs studies, it is now pertinent to introduce the paradoxical status of case study research.

Dodgson et al. (2008) emphasise in their explanatory case study on Taiwan's NIS that while their study examines "*the process and mechanisms by which new biotechnology innovation networks are being created...[g]eneralizations from case studies are, of course, unadvisable*" (p.442). Similarly, Dodgson (2009) points out that, while case studies are "*well suited to studying emerging phenomena and behaviour*...[and] *how things evolve over time and why they evolve in that way*" (ibid.), the findings "*cannot, of course, be generalised*" (Dodgson, 2009, p.605). Like Oliveria and Natrio (2016), whose case study analysis focuses on the agro-food IS in the Tagus Valley, Trippl (2011) states that her case study findings regarding the Vienna food IS "*cannot and should not be generalised*" (p.1606). Smith and Estibals (2011) emphasise, in a policy report on ISs and growth, that "[c]*ase studies have the advantage of being able to explore the complexity of the innovation process...in a depth that is not otherwise possible*" (p.115). However, "*the disadvantage [is] that [the] results lack generality*" (ibid.).

While the above confirms that regardless of being exploratory or explanatory, case study research on ISs fails to meet the *external validity criterion*[6]. Harris (2011) re-

[6]i.e., the extent to which the findings "*account for phenomena not only in the setting in which they*

lates the fact that "[m]*ost of the evidence supporting the existence and importance of such systems is case-study based*" (p.933) to the scientificity of the ISs approach. To illustrate his point, he refers to the seminal paper by Bergek et al. (2008) on the functions of ISs. As he puts it, "*the approach taken by Bergek and her collaborators is not about modelling (and therefore testing any hypotheses for)...rather the approach remains descriptive and subjective*" (Harris, 2011, p.933). Harris' (2011) view reflects a broader perception in the literature that the ISs approach is a descriptive, analytical framework (Lundvall, 1992, Jenson et al., 2016, Weber and Truffer, 2017); hence, unlike formal (economic) theories, it is 'under-theorised' (Edquist, 2005) in the sense that it does not provide "*clear propositions regarding causal relations among variables*" (Uyarra and Flanagan, 2010, p.682). To improve the scientificity of the IS approach, a growing number of IS researchers are either suggesting or adopting a methodologically-rigorous approach based on hypotheses-testing and large-scale quantitative analysis (e.g., econometrics) (e.g., Edquist, 2005, Sharif, 2006, Teixeira, 2014, Chaminade et al., 2018).

The above-mentioned questions raise a largely overlooked, within the field of ISs studies, question of *methodological naturalism* (Bhaskar, 1979, Beed and Beed, 2000): do the methods of the natural sciences, such as physics, that have long been regarded by positivist social scientists (including neoclassical economists[7]) ideal for studying social phenomena (Smith, 1998, Benton and Craib, 2001) are a feasible methodological option for ISs research? Put it differently, if we accept the premise that reality is an open system, constituted by different strata with each stratum holding its own unique constellation of emergent powers (Benton and Craib, 2001, Bhaskar, 2008*a*), *why should an IS scholar regard as ideal the methods of lower strata (e.g., physics, biology, chemistry, physiology) for studying the causal powers of upper strata (e.g., human beings and society)*? If one accepts the thesis in question, it follows that

are studied, but also in other settings" (Gibbert et al., 2008, p.1468)

[7]Louçã (2007), for instance, shows that the work of neoclassical economists betrays, in one way or another, the belief that mathematical formalism and econometrics will turn economics into a pure science of the social world, a sort of 'social physics' (see, also Mirowski, 1991, Lawson, 1997).

ISs research is explanatorily successful only when it attributes the existence and causal abilities of ISs to lower strata (e.g., geology, biology and so on). Otherwise, what is the point of using the methods of lower strata sciences (e.g., experimental methods, hypothesis testing, mathematical formalism, and so on) to study the upper strata, given the fact that both innovating actors and ISs are, by definition, fundamentally different from physical phenomena[8]?

These kinds of concerns are not only in line with Schumpeter's overall methodological outlook[9]. The above-mentioned concerns also touch upon a few critical problems that quantitative studies regarding ISs often face. Crescenzi (2005), for instance, builds a formal (production function) model to study the relationship between RISs and regional growth in European regions. However, as the aforementioned author acknowledges, this type of analysis needs to make "*some simplistic assumptions*" (Crescenzi, 2005, p.477) in order to be able to "*reveal a few regularities*" (ibid.) regarding the "*complexity of the underlying mechanism*[s]"(ibid.). Additionally, due to a significant dearth of quantitative data[10], and large-scale quantitative studies often analyse ISs in a 'narrow' way, i.e., focusing exclusively on science and technology indicators, even though these studies explicitly understand the systemic character of innovation in a 'broad' way, for instance, as an interactive learning process, embedded in a specific institutional context (Lundvall, 1992). This, among other things, implies that a purely quantitative analysis of ISs may often fail to meet the *construct validity* criterion, i.e., "*the extent to which a study investigates what it claims to investigate*"(Gibbert et al., 2008, p.1466).

[8]Inspired by the work of Thomas Kuhn (1962/2012) on scientific paradigms, one could add that it is the methods of the upper strata sciences that significantly enhance our understanding of the lower strata of reality. The same holds for phenomena such as environmental pollution, the underlying causes of which originate and act in a top-down manner (i.e., downward causation) in the upper strata (e.g., society and economy) (Elder-Vass, 2010).

[9]Swedberg (1991), for instance, points out that Paul Samuelson and Richard Goodwin (both of whom were Schumpeter's students) were surprised by the fact that "*in the very last paper he* [Schumpeter] *ever wrote...said that the future of research lay in the study of the records of great business enterprises – no mention of Econometric model building and testing!*" (p.176).

[10]Howells (2006, p.720) rightly reminds us that government or statistical bodies do not formally recognise innovation intermediaries.

Furthermore, McCloskey (1998, pp.115-119) points out that econometric studies are, by design, liable to conflate statistical significance with scientific relevance; for instance, when the absence of statistically significant relationships is interpreted as conclusive evidence for absent causality. This, among other things, confirms that it is not mathematical modelling and statistical significance that generates and tests theory but the researcher's interpretation of the data (Sutton and Staw, 1995, McCloskey, 1998). Pearl and Mackenzie (2018), for instance, observe that "*data do not understand causes and effects; humans do*" (p.21). Thus, as is the case with case study research on ISs, a formal, statistical research on them is, after all, a rhetorical/narrative analysis.

Pearl and Mackenzie (2018) emphasise in their seminal book on causality that a sophisticated advanced statistical analysis, is, by design, bias-prone. By introducing new confounders to the analysis, the statistical scholar also introduces new biases to a statistical model. It is such inherent methodological weaknesses that, according to some scholars (Sørensen et al., 2010, Boudreau and Lakhani, 2015, Engel and Kleine, 2015), justify the use of experimental methods on innovation. However, as is the case with formal quantitative studies, experimental studies seek to eliminate at all costs the influence of contextual factors ('context is noise') by engineering an artificially (statistical) closed system. This methodological practice makes one seriously wonder whether this type of research can produce useful knowledge about an inherently, qualitative context-specific (open system) phenomenon such as the systemic, and constantly evolving character of innovation.

Given that a formal-quantitative approach is also fraught with some severe methodological limitations, the question must be asked, why do a growing number of ISs researchers believe that a 'quantitative turn' (Chaminade et al., 2018, pp.54-67) is necessary to make the ISs approach more scientific[11] (Sharif, 2006, pp.757-760)? In other words, why does a formal methodological approach provide a reliable yardstick

[11]To avoid misunderstandings, including unnecessary critique, this paper does not oppose the use and relevance of formal and advanced statistical analyses on ISs. Instead, it questions the view that quantification and mathematical formalisation is necessary to study the general aspects of causality and generality.

to judge the scientificity of case study research on ISs, including the scientific qualities of the ISs approach in general? Given that more than half of the total number of ISs studies are case studies (Carlsson, 2007, Doloreux and Porto Gomez, 2017), how many more case studies do ISs scholars need to conduct until the findings of case studies are regarded as scientifically legitimate? Is there a threshold which, once met, will mean that case study research on ISs offers a legitimate basis for a scientific explanation and generalisation? Does the same threshold apply to large-scale quantitative studies on ISs? If no, why is this? It is these largely overlooked methodological questions that the dialectical analysis in this paper seeks to address.

3.3 Dialectical Method: An Overview

In his seminal book on the history of economic theory, Schumpeter (1954/2006*b*) shows, among other things, that philosophy, economic theory and research are intertwined (Shionoya, 2004, Lewis et al., 2020). However, innovation studies researchers seem to have endorsed, either implicitly or explicitly, the *scientism* thesis that philosophical analysis and scientific research are not only fundamentally incompatible (Benton and Craib, 2001), but also that innovation research constitutes the most legitimate means of acquiring knowledge about innovation. Since the late 2000s, an explicit philosophical concern with innovation has increasingly been seen as somewhat necessary to clarify, deepen and expand our understanding, including our methods, of studying innovation (e.g., Arthur, 2009, Jackson et al., 2016, Moussavi and Kermanshah, 2018, Adamides, 2018, Blok, 2018, Sorrell, 2018). In line with this philosophically-minded line of research, the present paper embraces the (Lockean[12]) thesis that, while philosophical inquiry can never replace scientific research on innovation, it can occasionally be utilised as an under-labourer to resolve concrete scientific problems, especially chronic methodological problems (Popper, 1940, Bhaskar, 1979,

[12]John Locke (1632-1704) argues in his book *An Essay Concerning Human Understanding* that philosophy can "*act as the under-labourer, and occasionally as the mid-wife, of science*" (Bhaskar, 2008*b*, xxxi).

Lawson, 1997). As Harré (2002) nicely puts it, '[i]*n studying a scientific project philosophically, we bring out taken-for-granted presuppositions and subject them to critical scrutiny*' (Harré, 2002, p.2). Similarly, this paper utilises the dialectical method as the under-labouring methodological foundation to identify and critique the deeper and taken-for-granted methodological assumptions that sustain the case study paradox on ISs.

The dialectical method constitutes an interesting way of thinking, analysing and resolving conflicts and contradictions, including paradoxes, in the domains of both matter and intellect (Popper, 1940, Slaatte, 1982, Hargrave and Van de Ven, 2017, Smith et al., 2017). It originates in the work of Ancient Greek philosophers (e.g., Socrates, Plato and Aristotle), and was developed further in the work of notable philosophers during and after the Enlightenment-era (e.g., Immanuel Kant, Friedrich Hegel, Karl Marx). Today, the dialectical method encompasses several varieties and forms. Nonetheless, common to all variants of the method in question is the interplay between mutually-opposing elements (i.e., thesis and antithesis) and the qualitative change (i.e., synthesis) that emanates from it (Honderich, 2005, Hargrave and Van de Ven, 2017, pp.212-213).

Karl Popper (1940) summarises the key components of the dialectical method in the following way.

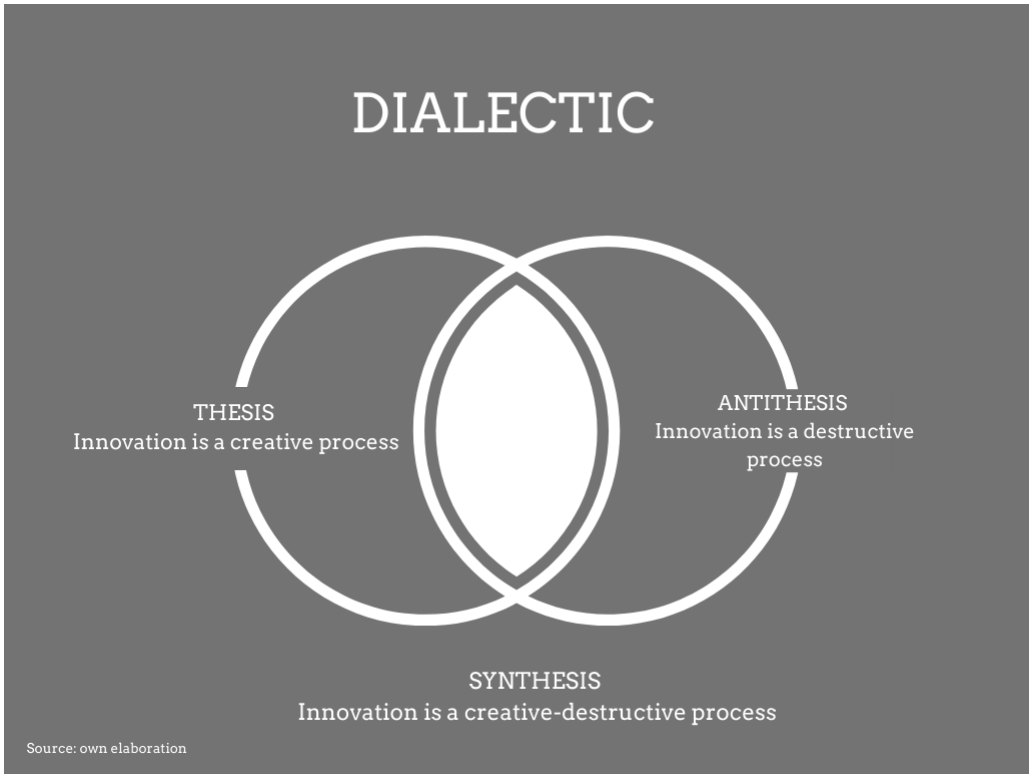
> "*First, some idea or theory or movement is given, which may be called '**thesis**'. Such a thesis will often produce opposition, because probably it will be, like most things in this world, of limited value – it will have its weak spots. This opposing idea or movement is called '**antithesis**', because it is directed against the first, the thesis. The struggle between the thesis and the antithesis goes on until some solution develops which will, in a certain sense, go beyond thesis and antithesis by recognising the relative value of both, i.e., by trying to preserve the merits and to avoid*

> *the limitations of both. This solution, which is the third step, is called '**synthesis**'. Once attained, the synthesis may in turn become the first step of a new dialectic triad, and it will, if the development does not stop with the particular synthesis reached.*"
>
> (Popper, 1940, p.325, emphasis added)

To illustrate briefly how the dialectical method works in practice, the following utilises Schumpeter's (1944/2006*a*) famous (Nietzschian) conceptualisation of innovation as a 'creative-destructive' process (Reinert and Reinert, 2006). The *thesis* is that innovation is a creative activity, adding new skills, competencies, jobs, knowledge, new products and services into the economic system; the *antithesis* is that innovation destroys existing skills, jobs, competencies and knowledge; and the *synthesis* is that innovation does both simultaneously: it is a creative-destructive socio-economic process. As Schumpeter (1944/2006*a*) famously puts it, innovation is the "*entrepreneurial function*" (Schumpeter, 1934, p.59) that "*incessantly revolutionises the economic structure from within, incessantly destroying the old one, and incessantly creating a new one*" (Schumpeter, 1944/2006*a*, p.83). Figure 3.1 provides a schematic representation of the dialectical method as applied to Schumpeter's synthesis of innovation as a creative-destructive process.

This study utilises the basic analytical scheme of thesis, antithesis, synthesis. However, it does so in a somewhat different and novel manner which is, nonetheless, consistent with the key principles of the dialectical method. In particular, the dialectical analysis in this paper is informed by the work of the realist philosopher of science, Roy Bhaskar (2008*a*). Although not easy to comprehend, Bhaskar's overall approach to the dialectical method is original in the sense that it makes it possible to analyse not only the presence of a thesis but also the absence of an antithesis (Norrie, 2009).

Figure 3.1: Schumpeter's (1944/2006*a*) conception of innovation as a creative-destruction process



> "*Absence is a hugely valuable diagnostic category. Looking at what is missing in a social context/situation or entity/institution/organization will often give a clue as to how that situation and so on is going to, or needs to change.*"
>
> (Bhaskar, 2014, xii).

Bhaskar's approach is of significance to this methodological study as it implies that the absence of an antithesis can be as significant as the presence of a thesis.

The remainder of this paper uses Bhaskar's overall thesis on the dialectical method. It does so, first, by identifying the deeper methodological assumptions that lie beneath the deductive thesis that case study research on ISs cannot study causality and generality. Second, it shows that once a sound antithesis has been advanced, the case study paradox appears to be a special case of the deductive thesis rather than a general weakness of case study research on ISs.

3.4 Case Study Research on ISs: A Dialectical Analysis

This section provides a dialectical analysis of case study research on ISs. It begins with the deductive thesis and then proceeds to formulate the retroductive antithesis in the second part of this section. The outcome of the dialectical tension between the two theses is discussed in the last section of the present paper.

3.4.1 Deductive Thesis: Case Study Research Cannot Study Causality and Generality

Deduction refers to the inferential process through which knowledge about a phenomenon of interest is obtained via deductive syllogisms and reasoning; in particular, by deducing knowledge about the particular from the general (Benton and Craib, 2001, Chalmers, 2009). The hypothetico-deductive model of explanation (HDME) has long been regarded as the most representative form of deductive reasoning and analysis in both natural and social sciences (Smith, 1998, Chalmers, 2009). Methodologically, this model encompasses a three-stage, formal (often mathematically-traceable), inferential process (Lawson, 1997, Chalmers, 2009). Firstly, an interesting empirical phenomenon is identified (i.e., explanandum); secondly, based on the current stock of knowledge (initial conditions), the researcher deduces a set of formal hypotheses in the form of 'if event X is present, event Y (or tends to) follow(s)' in order to account for the explanandum (i.e., explanans); thirdly, the validity of the explanans is verified (or falsified) through the identification of constant sequences or successions of empirical events (i.e., empirical regularities), ideally through the identification of statistically significant associations between variables.

However, as practised today in the social sciences, the HDME is not as homogeneous as is often portrayed in the relevant literature. In fact, it encompasses four main

variants, each of which has several crucial implications for case study research on ISs.

1. **Deductive verification** refers to the standard version of HDME (Eidlin, 2010, Chalmers, 2009). According to the verification variant, scientific research proceeds by verifying theoretical statements (e.g., hypotheses) through the identification of large-scale empirical (law-like) regularities (Smith, 1998, Fleetwood, 2001, Lawson, 1997, Eidlin, 2010). Despite the stance of Karl Hempel (1905-1997), who was one of the leading figures of HDME, and who was fully aware of the flaws of this model (Gorski, 2004), social scientists – most notably neoclassical economists – have long regarded deductive verification as ideal to a 'hard' social science, i.e., a social science that seeks to imitate the methods of the natural sciences (Smith, 1998, Lawson, 1997, Gorski, 2004, Bhaskar, 2008*b*). By placing significant emphasis upon the identification of law-like empirical regularities as the most reliable criterion to judge the analytical ability of case study research on ISs, the verification variants of the HDME make it impossible to see how an in-depth analysis of one or a few ISs allows us to obtain a sophisticated understanding of the population of ISs.

2. **Deductive falsification** is the second main variant of the HDME. It emanates from the work of Karl Popper (2014). The latter has famously argued that what distinguishes a scientific theory from a non-scientific one lies in its ability to be falsified – the falsification criterion. According to the deductive falsification variant, case study research offers an opportunity to conduct a 'critical test' of an established assumption, preposition or hypothesis (Flyvbjerg, 2006, pp.224-228). However, even in this case, the findings of case study research are treated with severe methodological suspicion. For instance, Cooke et al. (2000) find in their study of 11 European regions that only two regions (i.e., Baden-Württemberg and North Brabant) had a well-functioning RIS. Does this finding falsify the hypothesis that "*all regions have some kind of a regional innovation system*" (Doloreux and Parto, 2005, p.142)? Since case study research investigates

a very small number of cases, one or even a few falsifying cases are not enough to reject a widely-accepted theory or hypothesis unless the scientific community is willing to accept the results of falsified case studies as reliable and generalisable. To paraphrase Karl Popper's famous example of swans, the observation that one or a few swans are black does not falsify the generic view that the vast majority of swans are white.

3. **Deductive corroboration** is the third main variant of the HDME. According to Popper (2014), scientific research proceeds by corroborating theoretical statements rather than by verifying their truthfulness. Since case study research mainly utilises qualitative data, it can only corroborate a theory in qualitative terms (Mattsson et al., 2005, Gilsing and Nooteboom, 2006). For instance, Mattsson et al. (2005) mention in their study of eight ISs in the tourism sector that "*it is very difficult to ascertain 'hard facts'...Only general perceptions and proxy estimations of respondents have been available in the case studies*"(Mattsson et al., 2005, p.378). Furthermore, case study research is an in-depth, time-consuming and methodologically-challenging form of research[13], its feasibility to corroborate a theory lies in keeping the number of cases as small as possible. In this regard, the ability of case study research to corroborate a theory in a generalisable manner lies in studying the most representative (average) case(s) in a population of cases (Yin, 2009, p. 41). However, since each IS has its own unique structure and properties (Nelson, 1993, Braczyk et al., 1998, Malerba, 2004), the ability of case study research on ISs to corroborate a theoretical proposition in a manner that is perfectly compatible with the corroborative variant of the HDME is, certainly, limited.

4. **Inductive deduction** is the last and the most recent variant of the HDME in the

[13]For instance, unlike a statistically-advanced analysis of ISs which – in principle – seeks to utilise only a very small number of variables, case study research deals with a "*technically distinctive situation*" (Yin, 2009, p.22), i.e., there are more variables of interest than data points. Although for the deductivist scholar, this implies that case study research is unable to produce generalisable findings, for the retroductive researcher – as will be discussed below – the number of cases under investigation and the generalisability of findings are two completely different issues.

social sciences. Although it may sound like an oxymoron, as induction (which moves from the particular to the general) and deduction have traditionally been regarded as two antagonistic modes of scientific analysis and inference (Blaikie, 2000, Chalmers, 2009), the inductive variant is the most case study-friendly of all four variants of the HDME. According to inductive deduction, case study research on ISs is an exploratory type of analysis, ideal for developing new concepts and testable theoretical propositions (Eisenhardt, 1989, Yin, 2009). As Moussavi and Kermanshah (2018) put it,

> "*[t]he first function of cases [on ISs] is...[to] feed induction processes: instances in this research tradition help to form empirical generalizations in the form of propositions. They also support the evolution of new empirical concepts*"(p.62).

Implicit in this passage is that, unlike other quantitative and more rigorous research designs, case study research on ISs is unable, on its own, to study what is general about causality, unless its inductively-developed concepts and theoretical statements are corroborated by the findings of a large-scale quantitative analysis. To a large extent, this methodological view is, currently, prevalent in the literature on NISs. While the early research was undertaken as inductive grounded theory (Lundvall, 2007, p.98), the more recent research on NISs proceeds by testing theoretical propositions and hypotheses based on statistically significant empirical associations among variables (see, for instance, Herrmann and Peine, 2011, Castellacci and Natera, 2013).

All in all, the HDME underlines that, since causality occurs in the form of law-like empirical regularities, case study research on ISs cannot provide a reliable methodological basis to infer the general aspects of causality. To put it differently, the acceptance of the HDME as the primary methodological foundation in ISs research inevitably leads to the conclusion that deductive theorising (hypothesis testing) and

large-scale quantitative research will make the ISs approach more 'scientific'. In contrast, case studies are highly unlikely to do so.

3.4.2 Retroductive Antithesis: Case Study on ISs Can Study Causality and Generality

The retroductive model of explanation (RME) constitutes the principal antagonist to the HDME in both the natural and social sciences (Harre and Madden, 1979, Lawson, 1997, Danermark et al., 2002, Bhaskar, 2008*b*). Although a vital part of scientific thought and research (e.g., the methodological process behind Darwin's theory of evolution), the RME was, explicitly, discussed in the work of realist philosophers in the 1970s (e.g., Bhaskar, 2008*b*). At the core of the RME lies the causal inferential strategy of retroduction (Downward and Mearman, 2007). Retroduction refers to the process of postulating (in theory) and identifying (empirically) a set of ***causal mechanisms*** (i.e., dynamic combinations of causal powers of structures and relevant contextual factors) capable of producing the empirical phenomena under consideration (Lawson, 1997, Danermark et al., 2002, Bhaskar, 2008*b*). In short, retroduction is ultimately a search for causal mechanisms rather than empirical regularities. As Sayer (2000) puts it,

> "*What causes something to happen has nothing to do with the number of times we have observed it happening...Explanation depends instead on identifying causal mechanisms and how they work, and discovering if they have been activated and under what conditions*."
>
> (Sayer, 2000, p.14)

Why do we need to study causal mechanisms rather than empirical regularities? Why do causal powers of structures matter, and not constant conjunctions of empirical events? And, how do all these relate to case study research on ISs? The afore-

mentioned are some important questions that the deductively-minded ISs scholar may rightly think of. Since the RME has only recently been introduced to the study of ISs (Castellacci, 2006, Koutsouris, 2012, Jackson et al., 2016, Adamides, 2018), the best way to approach these questions is by discussing the key philosophical assumptions that underpin the RME, namely the philosophical core of the critical realist philosophy of science.

RME: A Critical Realist Perspective

Critical realism (CR) is a realist philosophy of science, thus – and as is the case with all the other realist philosophies of science – it endorses the realist thesis, whereby the objects of scientific research exist, at least for the most part, independently of our knowledge (Sayer, 2000, Danermark et al., 2002, Bhaskar, 2008*b*). However, and as argued by its progenitor – i.e., Roy Bhaskar (1998) – CR is the only realist philosophy in the social sciences that manages to combine and reconcile several crucial dichotomies that none of the traditional philosophies of social sciences (i.e., positivism and interpretivism) are able to overcome.

More technically, the philosophical core of CR consists of a synthesis of the following three philosophical principles: *ontological realism, epistemological relativism, judgemental rationality* (Danermark et al., 2002, Bhaskar, 2008*a*, Norrie, 2009). The principle of *ontological realism* states that, for scientific research to be possible, the world must be fundamentally complex and irreducible to the means (e.g., empirical observation, concepts, discourses and experiences) through which it becomes intelligible; otherwise, and if the objects of science were transparent and immediately accessible through empirical observation (as the positivist philosophy of science has long argued), there will be very little need to conduct scientific research. Like the philosophy of interpretivism in the social sciences, and the philosophy of conventionalism in the natural sciences, CR endorses the *epistemological relativist* thesis, whereby scientific research is always concept-laden as well as theory-informed, and thus also

subjective and fallible (Benton and Craib, 2001, Bhaskar, 2008*b*). However, against both interpretivism and conventionalism, CR argues that, while our knowledge of the objects we study is fallible, this does not necessarily mean that our research, including its ultimate product (i.e., knowledge), is entirely fallible. By endorsing the principle of *judgemental rationality*, CR stresses that, since there is always an external dimension to research (i.e., an objectively existing reality), the latter provides a benchmark to identify the least fallible aspects in the current stock of knowledge (Bhaskar, 1998, Danermark et al., 2002, Bhaskar, 2014).

According to critical realists, the RME provides an ideal way of identifying the least fallible aspects in the current stock of knowledge (Danermark et al., 2002, Bhaskar, 2008*b*). In particular, like the HDME, the RME is a causal explanatory model of science, meaning that it provides a stylised way of inferring causality in the objects we study. However, unlike the HDME, which rests upon a purely empirical perspective on causal explanation, the RME is grounded in a deep perspective on causality based on structures and causal powers (Harre and Madden, 1979, Fleetwood, 2001, Bhaskar, 2008*b*, Elder-Vass, 2010). More specifically, the RME distinguishes between three ontologically-distinct (i.e., irreducible to each other), and organically-related (i.e., non-linearly-related) dimensions of causality (Fleetwood, 2001, Bhaskar, 2008*b*): the *empirical dimension* of causality which consists of experiences (e.g., statistically-significant associations, concepts, ideas and discourses); the *actual dimension* of causality which consists of events and which occurs regardless of being identified at the empirical level; and the *real dimension* of causality which consists of structures and their causal powers (see Table 3.2).

Table 3.2: Key Dimensions of Causality

Causality		**Mode of causal explanation**	
Dimension	**Entity**	**HDME**	**RME**
Empirical	Experiences, perceptions	+	+
Actual	Events and actions	+	+
Real	Structures and causal powers		+

Source: Inspired by Fleetwood (2001), Bhaskar (2008*b*)

Unlike the HDME, which implies that causality is a purely empirical phenomenon

(empirical and actual dimensions of causality), the RME attributes causality to the real dimension, i.e., to the underlying structures of entities and their causal powers (e.g., due to its chemical composition, dynamite is capable of explosion), which can be active but, due to countervailing factors (e.g., dynamite is damp), generate no change at the empirical level (e.g., damp dynamite is brought into contact with fire but no explosion is observed). From the standpoint of RME, the HDME forces explanatory research to commit the *epistemic fallacy* (Bhaskar, 2008*b*), i.e., the reduction of the existence of causality to the means through which it becomes empirically identifiable (e.g., empirical observation); in short, the reduction of the empirical dimension of causality to the real one. Critical realist economists (e.g., Lawson, 1997, Fleetwood, 2001) emphasise that, for the HDME to be the principal mode of causal explanation in economic research, not only must the economic system be structured and operating as a (quasi-)closed system, but also economic agents (e.g., entrepreneurs and managers) must lack the ability to be creative and volitional; otherwise, and if the economic system is an open system, and agents are creative, then the best one should expect to find in terms of pure empirical regularities is *demi-regularities*.

> "*A demi-regularity, or demi-reg for short, is precisely a partial event regularity which prima facie indicates the occasional, but less than universal, actualization of a mechanism or tendency, over a definite region of time-space*"
>
> (Lawson, 1997, p.199)

Furthermore, and unlike the HDME which regards causality as occurring in the exact same way in both natural and social systems (Bhaskar, 1979, Chalmers, 2009), the RME stresses that, in contrast with natural structures and causal mechanisms (e.g., magnetic fields, law of gravity), the existence of social structures (e.g., firms, ISs, etc.) and causal mechanisms always depends upon the activities of human agents

(Bhaskar, 1979, Lawson, 1997, Svensson and Nikoleris, 2018). For instance, inspired by Bhaskar (1979), Lawson (1997) attributes the causal powers of economic agents to the interplay between economic agency and social structures. Thus, unlike deductive explanatory research which – in principle – needs to eliminate the significance of both social structures and contextual factors ('context is noise'), the RME sees context as an opportunity to study the causal powers of structures, in particular the dynamic configurations among causal powers and contextual factors capable of generating important empirical events such as the presence or absence of demi-regs in the socio-economic world.

RME: An Operational Overview

Having discussed the philosophical aspects of the RME, the following provides an operational overview of the RME. More specifically, the RME encompasses a three-step[14] process (Wynn and Williams, 2012, Jackson et al., 2016, Papachristos and Adamides, 2016, Hu, 2018, Hu et al., 2020).

- **Step 1 – Identification of events**. Like the HDME, the RME begins with the identification of an empirical phenomenon or a set of phenomena (Jackson et al., 2016, Papachristos and Adamides, 2016, Sorrell, 2018). However, unlike the HDME, which regards the identification of empirical regularities as the end product of a causal explanatory analysis, the RME regards readily-identifiable empirical patterns, including the absence of them, as the starting point of such an analysis. Furthermore, and in contrast with the HDME, which treats the absence of (demi-) regularities as the absence of genuine causality, the RME takes an eclectic view on empirical observation. Not only the presence, but also the absence, of an expected demi-reg constitutes a reliable entry point (Lawson,

[14]This section discusses a condensed, idealised version of the two main approaches to retroductive analysis: the Describe-Retroduce-Eliminate-Identify (DREI) analysis and the Resolve-Redescribe-Retrodict-Eliminate-Identify (RRREI) analysis. For an overview of these approaches to retroduction, see Mingers and Standing (2017).

1997, Norrie, 2009, Bhaskar, 2014). In addition to demi-regs, personal experiences, prominent discourses and single events could also provide valid entry points in retroductive analysis (Jackson et al., 2016, Papachristos and Adamides, 2016, Belfrage and Hauf, 2017). For instance, in their retroductive study, Jackson et al. (2016) analyse data from statistical databases and reports (e.g., Cornell University and OECD) to verify their initial hint that the Australian NIS fails to translate innovation inputs into outputs. The aim of the above-mentioned study is "*to find out whether the empirical data in these reports support this observation*" (Jackson et al., 2016).

From the standpoint of HDME, the existence of demi-regs (including the absence of them) does not constitute a reliable basis to infer the existence (or absence) of genuine causality. However, from the standpoint of the RME, not only the presence of demi-regs but also their absence is the product of genuine causality, i.e., the outcome of active structures and causal mechanisms: "*where demi-regs are observed*"(Lawson, 1997, p.199), they are often the product of "*relatively enduring and identifiable [causal] tendencies*" (ibid.), and thus also of generative structures which, in turn, need to be studied.

- **Step 2 – Conceptual abstraction**. The second step in the RME is that of conceptual abstraction (Lawson, 1997, Yeung, 1997, Danermark et al., 2002). The latter is a creative, rather than a formal (mathematical), process. The underlying aim is to develop a provisional *conceptual model* of (known or unknown[15]) causal mechanisms. This is achieved by means of creative (re-)conceptualisation of the current stock of knowledge. To develop retroductive conceptual models, abstraction poses certain types of ontological (rather than

[15]Tsang (2014, p.181) discusses four types of retroductive theorising: overcoded, undercoded, creative, and meta retroduction. *Overcoded retroduction* (also known as retrodiction) refers to the cases where the causal mechanism that explains a phenomenon is already known. *Undercoded retroduction* is when the current body of knowledge suggests a number of potential mechanisms but identifying which is the most plausible needs to be achieved empirically. *Creative retroduction* requires the researcher to invent the causal mechanism because no sufficient understanding of the causal mechanisms can be drawn from the literature. Finally, *meta-retroduction* refers to the situation where our observations do not fit our theories, thus requiring us to rethink afresh.

empirical) questions, such as 'what must be the case for ISs to be able to boost the innovative capability of firms?', rather than 'what is the impact of ISs on the innovative capability of firms?'. By conceptually addressing such questions, abstraction helps the research process to hypothesise a set of possible causal powers regarding ISs that, if existing and acted out in the postulated manner, could account for the empirical events identified in Step 1. In summary, the second step in retroductive research seeks to conceptualise, as well as to clarify, the necessary (structural) preconditions that make possible the empirical phenomena under consideration in Step 1.

- **Step 3 – Empirical identification of causal mechanisms**. Unlike the HDME, which regards the identification of law-like empirical patterns as a necessary criterion to assess the explanatory ability of a set of theoretical statements, retroductive conceptual models are assessed according to their explanatory power (Lawson, 1997, pp.212-215), i.e., their ability to illuminate our understanding of a wide range of empirical phenomena (e.g., both presence and absence of demi-regs). To do so, retroductive research utilises the product of abstraction in Step 2 (i.e., a hypothetical conceptual model of structures and causal powers) as the theoretical lens through which to tease out and study operative causal mechanisms (Danermark et al., 2002, Elder-Vass, 2010, Papachristos and Adamides, 2016). Since causal mechanisms originate and reside in the form of (exercised or unexercised) causal powers in the real (non-empirical) domain (Bhaskar, 2008*b*, Elder-Vass, 2010), retroductive research infers the existence of operative causal mechanisms by systematically analysing their empirical effects at the actual and empirical domains (Danermark et al., 2002, Downward and Mearman, 2007, Jagosh, 2020). The inferential process is a methodologically eclectic, open-ended and highly-iterative (Lawson, 1997, Downward and Mearman, 2007, Jagosh, 2020). From the standpoint of RME, the pressing question is not which types of data (i.e., quantitative versus qualitative data) are more superior than the other, but how to employ "*the full spectrum of data*"

(Wynn and Williams, 2012, p.801) to reach the condition of *theoretical saturation*[16] regarding causal mechanisms. Furthermore, due to its commitment to an ontologically-deep perspective on causality, the RME implies that "[i]*is primarily the nature of the object under study which determines what research methods one may use*" (Danermark et al., 2002, p.11), not the other way around (as is often the case with deductive explanatory research). Lastly, unlike the last step in deductive research, which seeks to identify large-scale empirical regularities (***empirical necessity***) as the only logical basis to infer causality, retroductive analysis seeks to identify ***causal necessity*** (Runde, 1998, Wynn and Williams, 2012), i.e., the ability of a particular constellation of causal powers and contextual factors to produce the empirical event(s) in Step 1.

Overall, retroductive research proceeds by postulating conceptual models of structures, causal powers and relevant contextual factors, which, if existing and acted out in the hypothesised manner, are capable of producing the events under consideration.

3.4.3 RME and Case Study Research on ISs: Practical Implications

In general, the RME is compatible with a wide range of research designs and methods, meaning that there is a wide range of options to address Step 3 in retroductive analysis. For instance, agent-based modelling, case study research, econometrics, ethnography, discourse analysis, grounded theory, network analysis, simulation, and structural equation modelling have all been utilised, either on their own or in conjunction, in retroductive studies (see, for instance, Downward and Mearman, 2007, Olsen, 2010, Edwards et al., 2014, Papachristos and Adamides, 2016). However, and as is the case with research on ISs, it is the case study research that is the most popular research design in retroductive research (e.g., Tsoukas, 1989, Easton, 2010, Wynn

[16] "*Theoretical saturation is simply the point at which incremental learning is minimal because the researchers are observing phenomena seen before*"(Eisenhardt, 1989, p.545).

and Williams, 2012). From the standpoint of HDME, this constitutes a methodological puzzle, given that the RME regards causal explanation and generalisation as the defining features of scientific research (Danermark et al., 2002, Bhaskar, 2008*b*). The question must then be asked, *why does the RME assign methodological significance to case study research?* Should not, for instance, a 'hard' research design be the most popular in retroductive research? The best way to illustrate the underlying differences between the two models of explanation is by discussing their practical methodological implications for case study practice on ISs. Following the work of Yin (2009) and other notable case study experts (Eisenhardt, 1989, Flyvbjerg, 2006), the discussion centres upon six key methodological implications.

1. **Use – why case study?** According to HDME, case study research on ISs is, in principle, a descriptive-exploratory research design; hence, it is only appropriate in the initial stages of scientific inquiry rather than in the later (more mature) stages which, according to the HDME, deal with what is causal and general. On the other hand, the RME underlines that case study research on ISs is, by default, a causal-explanatory research design, ideal for identifying and teasing out a complex of causal mechanisms through which the 'overall function' (Edquist, 2005) in ISs leads to specific theory-relevant empirical outcomes. As (mainly) an intensive form of analysis, case study research is not only necessary to identify causal mechanisms, but also ideal for uncovering relations that are substantial and causal in ISs. Moreover, by providing an in-depth analysis of the underlying structure and causal powers of ISs, case study research eliminates the possibility of mis-inferring causality, such as when a set of antagonistic causal mechanisms produce the same empirical (statistical) outcome(s). Therefore, from the standpoint of RME, case study research is, by default, a causal-explanatory form of analysis.

2. **Theoretical purpose**. According to the HDME in general, and its three case study-friendly variants (i.e., deductive falsification, deductive corroboration and

inductive deduction), case study analysis on ISs is best conducted as either a concept or theory-building (inductive) exercise, as well as – and where possible – a theory-testing (falsificationist or corroborationist) form of research. The HDME also understands scientific theory to consist of a set of deductively-formulated theoretical statements (Danermark et al., 2002, Chalmers, 2009)[17]. From the standpoint of RME, explanatory analysis consists of a ceaseless process of re-conceptualisation (Sayer, 2000, Easton, 2010, Tsang, 2014): "*What concepts do I need to understand and explore more fully the causal mechanisms under investigation?*"(Edwards et al., 2014, p.22). In this regard, the RME sees theory building and testing as two methodological steps that must always go hand in hand in explanatory research (Easton, 2010, Tsang, 2014). Due to its inherent ability to facilitate an iterative process of theory building, falsification and corroboration within the same research project, case study research is indispensable to retroductive, but not to deductive explanatory, research on ISs.

3. **Case selection**. In general, case study research follows a strategic approach to sampling that differs in fundamental respects from the logic of sampling in survey research. Yin (2009), for instance, discusses five sampling strategies for case study research (i.e., average, critical, extreme, longitudinal and revelatory), one of which (i.e., the average case) would be regarded as the most reliable in survey research. Unlike the HDME which, in principle, sees the average case as the most appropriate sampling strategy, the RME implies that case study research needs to assign methodological importance to the extreme, deviant, critical and comparative cases (Danermark et al., 2002, Flyvbjerg, 2006). Due to the fundamentally complex, messy and open system character of causality in ISs (and socio-economic reality in general), extreme, deviant and critical cases offer an ideal (longitudinal) setting to theorise and identify generative structures and their causal mechanisms (Danermark et al., 2002, p.103). Unlike the HDME,

[17] Kathleen Eisenhardt, who is regarded as one of the leading (theory-building) case study experts in (innovation) management studies, has recently confessed that "*my deductive editors often like propositions, and if so, I usually provide them*" (Gehman et al., 2018, p.296).

the RME regards contrasting cases (i.e., cases exhibiting contradictory empirical outcomes) as ideal for explanatory research that seeks to ascertain why the same causal power(s) of ISs produce(s) differential empirical outcomes in one case but not in the other(s).

4. **Data triangulation**. One of the distinguishing strengths of case study research lies in its ability to utilise multiple sources of evidence, i.e., data triangulation (Eisenhardt, 1989, Yin, 2009). Although data triangulation is recognised by the case study-friendly variants of the HDME as an important methodological process, it is still not enough to increase the scientific quality of the findings. This, among other things, is due to the fact that, at the centre of the HDME, including case study research informed by this model, lies the belief that it is the identification of empirical regularities which constitutes the most reliable indicator of a causal relationship. In this regard, using one or more data collection sources to establish data convergence does not mitigate the problem of *external validity*, unless advanced statistical methods are used to establish the 'nomothetic' properties of the findings (Eisenhardt, 1989). On the contrary, the RME regards data triangulation as a necessary and mandatory methodological procedure with which to study causality and generality (Downward and Mearman, 2007, Wynn and Williams, 2012). Combining multiple sources of evidence allows the retroductive ISs researcher(s) to tease out causal mechanisms in concrete contexts. In this regard, the RME concurs with the view that "[m]*ost interesting [causal explanatory] studies on...innovation systems combine quantitative and qualitative methods*" (Chaminade et al., 2018, p.43).

5. **Quality criteria**. According to the HDME, the quality of case study research on ISs needs to be assessed by following the standard (positivist) quality criteria (i.e., internal, construct, external validity and reliability), which are also used to assess the findings of quantitative studies on ISs (Gibbert et al., 2008, Yin, 2009). However, according to the RME, such criteria are, on their own, not only inadequate but also misleading, especially when it comes to judging

the quality of retroductive case study research. Healy and Perry (2000) develop six (realist) quality criteria that can be used to judge the quality of retroductive case study research on ISs. These are as follows: two ontological criteria (ontological appropriateness and contingent validity); one epistemological criterion (multiple perceptions); and three methodological criteria (methodological trustworthiness, generalisation and construct validity).

The first ontological criterion – i.e., *ontological appropriateness* – refers to whether the choice of research problem and methods is in line with the structurally-heterogeneous, open system and fuzzy (in terms of boundaries) nature of ISs, including the deep nature of causality. Similarly, the second ontological criterion – i.e., *contingent validity* – assesses whether case study research on ISs has identified the contextual factors that either impede or facilitate the causal abilities of ISs. Furthermore, and unlike the HDME, which implies that causal explanatory research on ISs needs to be detached from actors' views, retroductive research sees in actors' views an invaluable window through which ISs researchers can learn a great deal about the systemic character of the innovation process. Although imperfect, actors' perceptions provide valuable insights which can subsequently be "*triangulated with other perceptions*" (Healy and Perry, 2000, p.123) to establish 'facts' based on data convergence (Downward and Mearman, 2007). Thus, while the lack of interview data does not hamper the explanatory ability of deductive research on ISs, from the standpoint of the RME, it is regarded as a significant methodological limitation that significantly endangers the epistemological credibility of the findings. For instance, Jackson et al. (2016) consider the lack of interview data in their retroductive study on the Australian NIS as a significant drawback. According to the RME, gathering and analysing multiple perceptions (including multiple data sources) regarding the underlying problem, not only enhances the *construct validity* of retroductive case study analysis on ISs, but also increases its *methodological trustworthiness* (Healy and Perry, 2000).

The last quality criterion is that of *generalisation*. However, given its significance for our understanding of the scientificity of case study research on ISs, it is discussed separately.

6. **Generalisation**. The question of 'how many cases' has often been regarded as identical to the question of external validity or generalisation, i.e., "*the problem of knowledge whether a study's findings are generalizable beyond the immediate case study*"(Yin, 2009, p.49). According to the key variants of the HDME, it is extremely difficult, if not impossible, to draw reliable general knowledge from small-N research, especially single-case research, on ISs: "*What can one case tell you?...The answer is very clear: very little indeed*" (Easton, 2010, p.213). However, from the standpoint of the RME, the findings of single case studies on ISs are as reliable as the findings of multiple case studies, including those produced by large-scale quantitative studies. Unlike the HDME, which implies that generalisable knowledge is obtained only through empirical observation (empirical generalisation), the RME adopts an ontological perspective on generalisation, best known among critical realists as *transfactual generalisation* (Danermark et al., 2002, Morais, 2011, Tsang, 2014).

   Specifically, according to this perspective, generalisable knowledge about ISs lies in the deeper (less empirical) aspects of such system-like entities, and particularly in the causal powers of ISs which often act but, due to counteracting factors (e.g., blocking causal mechanisms), produce no statistically-significant observations. As Bhaskar (2008*b*) puts it, "[s]*cientifically significant generality does not lie on the face of the world, but in the hidden essences of things*" (p.217). From the standpoint of RME, the findings of deductive studies on ISs are not externally valid nor they are explanatorily informative: the identification of constant conjunctions of events (e.g., empirical level) is *not* the same as having causal knowledge of deeper levels of causality (e.g., real level). Thus, from the RME, it is fundamentally misleading to believe that knowledge of the empirical stratum offers a reliable basis for developing generalisable insights about

ISs. Otherwise, and if one adopts the empirical (statistical) view on generalisation, thus also on causality, he or she commits the *epistemic fallacy* (Bhaskar, 2008*b*), namely the reduction of our knowledge of the causal capabilities of ISs to what can be counted or be associated with recurrent empirical patterns and events.

Finally, the RME implies that, once a causal explanation about the causal powers of ISs has been developed in one or more ISs, "*the constituents of that explanation provide a basis for making [transfactual] theoretical propositions beyond the case under investigation*" Easton (2010, p.127). In this regard, the RME not only significantly extends and deepens Yin's (2009) popular approach to 'analytic generalisation[18])' by, for instance, adding an ontological dimension to it; indeed, this model also makes it possible to acquire generalisable knowledge about the deeper aspects of causality ISs in a manner that is impossible to achieve with the empirical approach to generalisation.

Summary Table 3.3 summarises a set of key practical implications that both models have for case study research on ISs. In a nutshell, the table in question confirms that the deductive thesis and retroductive antithesis have fundamentally different implications in all the key methodological dimensions of case study research on ISs. Nonetheless, such differences have the same intellectual denominator, i.e., they stem from the deeper (ontological and epistemological) presuppositions that both models rest upon. For instance, while the HDME sees causality as a purely empirical phenomenon, the RME understands causality to be a fundamentally deep (non-empirical) process. Furthermore, common to all variants of the HDME is the presupposition that explanatory research on ISs deals, in principle, with empirical events in general, and constant conjunctions of empirical objects in particular. Correspondingly, the most desirable form of theorising is hypothesis development and testing. On the contrary,

[18]Analytical generalisation refers to the process of comparing the findings of case study research with a previously developed theory. For instance, when "*two or more cases are shown to support the same theory, replication may be claimed*"(Yin, 2009, p.57).

the RME implies that the primary objects of causal analysis are the interactive nature of ISs, their causal powers, and contextual factors that generate empirical outcomes. Therefore, and unlike the HDME, which implies that the analytical flexibility which characterises the ISs approach significantly restricts causal-explanatory research, for the RME, it is the flexible nature of the ISs approach that makes it ideal for conceptualising and studying causal mechanisms.

Table 3.3: HDME and RME: Key Methodological Implications for Case Study Research on ISs

	Deductive (HDME) thesis				Retroductive (RME) antithesis	Further information
	Deductive Verification	**Deductive Falsification**	**Deductive Corroboration**	**Inductive Deduction**		
Implications						
Overall purpose	Description	Explanation	Exploration	Exploration	'Thick' explanation	Yin (2009), Easton (2010)
Theoretical purpose	-	Theory testing	Theory testing	Theory building	Theory building and testing	Yin (2009), Eisenhardt (1989), Tsang (2014)
Number of cases	One case	One or multiple cases	One or multiple cases	Multiple cases	One or multiple cases cases	Eisenhardt (1989), Yin (2009), Easton (2010)
Sampling strategy	Representative case(s)	Critical case(s)	Representative case(s)	Multiple cases	Extreme, critical and comparative cases	Danermark et al. (2002), Yin (2009)
Data triangulation	Relevant but not necessary	Relevant but not necessary	Relevant but not necessary	Relevant but not necessary	Necessary	Danermark et al., (2002)Yin (2009), Easton (2010), Morais (2011)
Generalisation	Empirical generalisation	Analytical generalisation	Empirical and analytical generalisation	Empirical and analytical generalisation	Transfactual generalisation	Danermark et al., (2002), Yin (2009), Morais (2011), Tsang (2014)
Quality criteria	Construct, internal and external validity and reliability	Construct, internal and external validity and reliability	Construct, internal and external validity and reliability	Construct, internal and external validity and reliability	More than validity and reliability: realist (ontological, epistemological and methodological) criteria	Healy and Perry (2000), Gibbert et al., (2008)
Presuppositions						
Primary object(s) of analysis	Empirical events	Empirical events	Empirical events	Empirical events	Structures, causal powers and contingent factors	Tsoukas (1989), Tsang (2014)
Form of causality	Constant successions of empirical events	Constant successions of empirical events	Constant successions of empirical events	Constant successions of empirical events	Causal mechanisms	Tsoukas (1989), Danermark et al., (2002)
Causal inference	Deduction	Deduction	Deduction	Induction and deduction	Retroduction	Blaikie (2000, pp.85-127), Danermark et al. (2002, pp. 73-114)

Source: own elaboration

3.5 Concluding Discussion, Synthesis and Implications

This paper identified and analysed, in a dialectical manner, the paradoxical status of case study research on ISs. The analysis in the previous section shows, among other things, that the paradox in question stems from the belief that the HDME constitutes the most reliable yardstick with which to judge the scientific qualities and abilities of case study research on ISs, and the ISs approach in general. Such a widespread methodological practice is erroneous, as it conflates the key aspects of the HDME with the actual abilities of case study research, including the ISs approach. It is this methodological error which has, inevitably, led many ISs scholars to the conclusion that case study research is, in principle, not a causal-explanatory form of scientific research, even though, and as illustrated by the articulation of the retroductive thesis in this paper, case study research is ideal for studying causality (in the form of causal mechanisms), as well as for acquiring (transfactual) general knowledge about the causal powers of ISs. In this regard, the dialectical analysis in the present paper has not only resolved the case study paradox, but has also made it possible for ISs scholars to construe, undertake and defend case study research as a purely causal-explanatory effort.

Since this paper has resolved the case study paradox in a methodologically-consistent manner, it can, indeed, claim that because the retroductive antithesis is, currently, not as popular as the deductive thesis in the relevant literature, the development of a sophisticated synthesis has to wait for a little while until a considerable number of ISs studies have used the RME.

However, this may entail a significant methodological danger. Spurred on by the increasing digital availability of large chunks of quantitative data ('big data'), as well as by the need (especially on the part of young researchers) to publish as many papers as possible in high-ranked journals, the 'quantitative turn' in the literature on NISs (Chaminade et al., 2018, pp.54-67) places a significant methodological pre-

mium on a large-scale quantitative analysis of ISs rather than to time-consuming and methodologically-challenging case studies. In such a 'quantitatively inclined' landscape, a sort of a methodological battle (*methodenstreit*) is likely to erupt between the proponents of the deductive thesis and of the retroductive antithesis. To prevent such an unnecessary methodological tension from occurring, the rest of the paper proposes a synthesis that is consistent with, yet fundamentally different from, the deductive thesis, and which allows us to practise case study research in a manner stipulated by the retroductive antithesis.

In line with the underlying logic of the dialectical method, the paper proposes the following dialectic synthesis as a possible methodological foundation for future case study research on ISs.

> ***Dependency synthesis****: like any type of research, case study research on ISs has certain qualities, abilities and weaknesses; however, the extent to which such properties will materialise in a research project is dependent upon the model of scientific explanation that, either implicitly or explicitly, informs the analysis.*

The dependency synthesis acknowledges that, while case study research cannot identify large-scale empirical regularities (deductive thesis), this does not mean that it cannot study causality and generality (retroductive antithesis). Thus, one of the key advantages of the dependency synthesis is that it allows us to undertake case study research on ISs in a manner that is consistent with, yet fundamentally different from, the deductive thesis.

More importantly, the proposed synthesis directs our attention to several methodological inconsistencies and ironies that accrue from the deductive thesis, such as the increasingly-held view that the hypothetico-deductive approach to causal explanation offers the most reliable basis to acquire generalisable knowledge on ISs, and innovation in general. In fact, the dependency synthesis turns the deductive thesis on its

head[19].

Specifically, and while the retroductive scholar holds a deep view on the ontology of ISs, including a context-sensitive theory of causality (i.e., causal mechanisms), both of which are, largely, consistent with stylised facts of three decades of research on ISs (Castellacci, 2006, Adamides, 2018, Chaminade et al., 2018), the deductive scholar faces several challenges here. For instance, for the deductive thesis to be the methodological norm in the field, the deductive scholar must, from now onwards, justify the empiricist view on ISs (i.e., the most scientifically interesting aspects of ISs lie in the empirical and actual domains rather than in the real domain), including the view that causality on ISs occurs in the form of regular successions of events (i.e., the regularity theory of causality) at the empirical and actual domains rather than at the real domain. Put it differently, the deductively-minded scholar needs to convince us that, given that innovative actors such as entrepreneurs, managers and policy-makers are creative and volitional, and that ISs are structurally heterogeneous and open system collectivities of heterogeneous actors (Lundvall, 1992, Bergek et al., 2008, Chaminade et al., 2018), hence having differentiated causal powers and liabilities, *why should we expect empirical regularities to be stable and ubiquitous across (nearly) all ISs?* Otherwise, if empirical regularities are by no means enduring and ubiquitous (as the extant literature on ISs shows), *why should empirical regularities constitute the primary methodological criterion to judge the explanatory capacity of case study research on ISs*?

In addition to the above, and unlike the retroductive scholar, the deductive scholar needs to address the following conundrum: since innovative behaviour is always institutionally embedded and conditioned (Lundvall, 1992, Nielsen and Johnson, 1998, Edquist, 2005), and that scientific research is, by design, theory-laden and context-sensitive (Flyvbjerg, 2001, Bhaskar, 2008*b*), *why should one defend the deductive view that developing context-independent causal knowledge is possible and beneficial to the scientificity of the IS approach*? It is, among other issues, these questions that

[19] As Martin (2016) observes "*an increasing proportion of [innovation studies]...are quantitative, even econometric, often exhibiting a naive positivism*"(p.440).

the dependency thesis brings to the fore.

Furthermore, the proposed synthesis implies that the scientificity of case study research is not a matter of crafting our case study analysis in a certain way, as the work of case experts stresses (Eisenhardt, 1989, Yin, 2009); instead, it is mainly a matter of the model of explanation that, unavoidably, informs the analysis. As a result of this, categorising case study research as a purely exploratory (qualitative) method is highly misleading because it fails to explicitly acknowledge that it is the model of scientific explanation which, in principle, shapes the epistemological aims (exploratory or explanatory) and methodological scope (qualitative and/or quantitative methods) of case study research. This also means that a proper assessment of both scientific qualities and findings of case study research on ISs requires case study researchers and journal reviewers to be more methodologically-transparent than hitherto, especially regarding the model of scientific explanation that informs their views. In this regard, one of the key strengths of the dependency synthesis is that it forces us to lay our 'methodological cards' on the table before assessing the scientific quality of case study research on ISs, and in doing so it encourages methodological reflexivity, transparency and constructive critique.

Lastly, and as is the case with every study, this methodological study has some limitations. In the process of dialectically analysing the case study paradox on ISs, the analysis may have either superficially covered or overlooked key developments in the literature on both ISs and the case study method in the social sciences. However, to the best of my knowledge, the analysis in this paper has either referred to, or touched upon, several key methodological developments in the literature on both ISs and case study research. Despite this possible limitation, the present paper has debunked several methodological misconceptions about one of the most popular types of research within the field of ISs, namely case study research; especially to young researchers convinced by Schumpeter (1954/2006*b*) overall methodological outlook that socio-economic research is, by definition, an eclectic, yet systematic, process of studying

the most fundamental (qualitative) features and dynamic effects of the perennial gales of creative destruction in capitalist societies.

Chapter 4

When an Innovation System Generates Income (In)equality – Conceptual Model and Causal Mechanisms

Highlights

- Extremely little is, currently, known about the relationship between innovation systems and income inequality
- A conceptual model is developed and applied in a regional innovation system in Germany
- It is shown that, contingent upon focal actors' strategies, the innovation system under consideration gives rise to seven causal mechanisms of (in)equality
- Tackling rising income inequality in innovative place requires 'strategy synergies' among focal actors in innovation systems

Abstract

How does innovation as a collective (multi-actor) activity shape the distribution of income in contemporary societies? To address this largely under-researched, and thus also under-theorised, question, the present paper develops a novel conceptual model based on a synthesis of the literature on innovation systems, relational inequality theory, and critical realist causal mechanisms theory. Drawing upon an in-depth, mixed-method case study analysis, this paper demonstrates how the strategies of focal actors (e.g., firms, universities, research institutes, policy organisations) combine with the causal abilities of the innovation system under investigation to form seven causal mechanisms of (in)equality: ***five inequality-inducing causal mechanisms*** (competence concentration, concentrated-income hoarding, skill premiums, precarious employment, and old-age technological unemployment) and ***two inequality-reducing causal mechanisms*** (gender-inclusive competence-building and employment). The findings contribute to, among other issues, a rapidly-growing concern with the question of rising inequality within the field of innovation studies, while also having an important policy implication: achieving inclusive growth in an innovative place requires the formation of 'strategy synergies' among focal (triple-helix) actors in regional innovation systems.

Keywords: Innovation systems, income inequality, relational inequality theory, causal mechanisms, critical realism, Germany

JEL Classification: O30, D30

4.1 Introduction

One of the most paradoxical and worrisome features of economic development in modern-day societies is that the more innovative and affluent the modern-day economic system becomes, the more unequal the distribution of income (i.e., income inequality) tends to be, especially in advanced economies (Acemoglu, 2002, Brynjolfsson and McAfee, 2012, Lazonick and Mazzucato, 2013, Breau et al., 2014, Piketty,

2014, OECD, 2015, Frey and Osborne, 2017). For instance, echoing Thomas Piketty's (2014) bestselling book on inequality, the Organisation of Economic Co-operation and Development (OECD) states in one of its reports on income inequality that "*the gap between rich and poor is at its highest level since 30 years*" (OECD, 2015, p.15) in its 37 member countries. Illustrative of this trend is the 'the Silicon Valley paradox'(Simmonds, 2017): namely, despite being one of the most important engines of innovation and wealth creation in the United States (US), and a major source of inspiration for policy action worldwide (Casper, 2007), the distribution of income in the region is not only highly uneven (Gray et al., 1998, Florida, 2007, p.186), but also – and most importantly – 25% of the inhabitants in the region experienced food insecurity and hunger in 2017.

Why do the economic gains of technological innovation no longer 'trickle-down' as suggested, for instance, by Kuznets (1955) in his seminal paper? According to the skill-biased technological (SBTC) account, which is currently the most popular theoretical perspective on inequality, technological innovation – especially in the form of general-purpose technologies (GPTs) such as computers, robots, and artificial intelligence – induces inequality through two main mechanisms: first, it increases the *skill premium* (Krusell et al., 2000), i.e., the wage gap among skilled and unskilled employees; and second, it leads to *technological unemployment* by replacing routinised job tasks (task-biased technological change) with computers and robots (Autor et al., 2008, Acemoglu and Autor, 2011, Van Reenen, 2011, Brynjolfsson and McAfee, 2012). Sociological studies criticise SBTC research for failing to see that GPTs are neither skilled-biased nor purely market-driven; instead, they are power-infused and class-biased, benefiting mainly the economic interests of certain organisational actors (e.g., management and shareholders) (e.g., Hanley, 2014, Kristal and Cohen, 2017, Kristal, 2019). Lastly, the findings of another (mainly geographical) line of research suggest that the traditional measures of innovation – such as research and development (R&D) expenditure and patenting intensity – are positively associated with different measures of inequality (e.g., Gini, Theil's index, Atkinson's index and percentiles) in

cities and regions of Canada (Breau et al., 2014), China (Guo, 2019), Europe (Lee, 2011), and the US (Donegan and Lowe, 2008, Florida and Mellander, 2016).

Despite being rapidly growing and cross-disciplinary, the extant literature on innovation and inequality has, to date, failed to incorporate several important stylised facts of innovation research (Lazonick and Mazzucato, 2013, p.1177). This is best reflected in the very fact that, while we know a great deal (in terms of statistical associations) about the skill and task bias of GPTs (Van Reenen, 2011), we know very little about how interactions among actors in the innovation process shape the distribution of income through, for instance, the skill and task-bias mechanisms. This is a significant omission, which has several crucial theoretical and policy implications. For instance, if we explicitly acknowledge that continuous innovative activity emerges in enduring collectivities of innovating actors – such as clusters, ecosystems, networks and systems of innovation – it follows that it is the latter which shape the inequality-inducing abilities of GPTs in contemporary societies. Similarly, innovation policy action, which has no knowledge of the causal mechanisms through which collectivities of innovating actors shape the distribution of income may, inadvertently, contribute to rising inequality (Cozzens et al., 2002, Zehavi and Breznitz, 2017, Echeverri-Carroll et al., 2018).

To investigate how innovation as an interactive, multi-actor process affects inequality, this paper develops an original conceptual model based on a synthesis of key concepts and insights from three largely compatible – yet to date unconnected – kinds of literature, namely the literature on *innovation systems* (Chaminade et al., 2018, Asheim et al., 2019), *relational inequality theory* (Tomaskovic-Devey and Avent-Holt, 2019), and *causal mechanisms* due to the critical realist philosophy of science (e.g., Bhaskar, 2008*b*, Sorrell, 2018). The explanatory power of the proposed model is illustrated by means of an in-depth, mixed-method case study analysis of a regional innovation system in Germany. The analysis unearths the following seven causal mechanisms: ***five inequality causal mechanisms*** (competence concentration, income

hoarding, skill premiums, precarious employment and old-age technological unemployment) and ***two equality causal mechanisms*** (gender-inclusive employment and competence-building).

This study's findings make several novel contributions to our understanding of how innovation shapes the distribution of income in contemporary societies, especially within the field of innovation studies itself, where our knowledge on the relationship between innovation and inequality is in the early stages (Lazonick and Mazzucato, 2013, Martin, 2016, Zehavi and Breznitz, 2017, Chaminade et al., 2018, Biggi and Giuliani, 2021). First, by being the first to identify an amalgam of complementary and competing causal mechanisms, as well as by opening up the 'black box' of each mechanism, this study shows that there is much more to the relationship between innovation and inequality than the skill and task-biased studies have let us believe. Second, this study casts a fresh perspective on the debate between markets, institutions and organisations, in particular between scholars attributing rising inequality to market forces (e.g., skill shortages and polarising labour markets) (Autor et al., 2008, Acemoglu and Autor, 2011, Brynjolfsson and McAfee, 2012), those arguing that institutional forces play the most significant role (e.g., global trade, deunionisation, declining minimum wages, welfare state retrenchment) (Kristal and Cohen, 2017, Kristal, 2019), and yet others (Cobb, 2016, Tomaskovic-Devey and Avent-Holt, 2019) who place organisational factors at the centre of analysis. To this debate, the present study contributes, by showing that it is the *mix of organisational strategies* that focal actors in ISs devise and adopt as a means of addressing key challenges that they encounter in the various stages of the innovation process which, in the end, shapes the direction, scope and strength of causality in the relationship between innovation and inequality in contemporary societies. Finally, this study speaks to the current debate on innovation policy theory (e.g., Schot and Steinmueller, 2018, Asheim et al., 2020), in particular the question of whether the innovation systems approach provides an appropriate theoretical framework to design transformative innovation policies. It does so by illustrating that the innovation systems approach constitutes a prolific theoretical basis for research

aimed at producing policy-relevant knowledge about the grand societal challenge of rising inequality.

The remainder of this paper consists of four sections. Section 4.2 provides an overview of the relevant literature on innovation systems, relational inequality theory and critical realist causal mechanisms theory, whereas a subsequent part in the section in question develops a conceptual model capable of guiding the messy and quite challenging process of unearthing causal mechanisms in highly-complex (i.e., open system) settings. Section 4.3 introduces the case study region of Braunschweig in Germany. It also discusses the data collection techniques and analysis that this study has used to extract empirical material from the region of Braunschweig. Section 4.4 discusses the relevant evidence, illustrating the existence of seven operative causal mechanisms. Section 4.5 concludes this paper by discussing findings and limitations, as well as analytical and policy implications.

4.2 Innovation Systems and Inequality: Theoretical Framework and Conceptual Model

The point of departure in this section lies in the assumption that a causal explanatory analysis of the relationship between innovation and inequality presupposes not only an appropriate theory of innovation (as a collective activity) and inequality but also a theory of causality. Correspondingly, this study conceptualises innovation from the standpoint of innovation systems theory, inequality from the standpoint of relational inequality theory, and causality from the standpoint of critical realism.

4.2.1 Innovation Systems Theory: An Overview

Since the emergence of the innovation systems (ISs) approach in the early 1990s (Sharif, 2006), ISs have been a popular object of scientific analysis and policy action across the world (Chaminade et al., 2018, Rakas and Hain, 2019, Asheim et al., 2019). Defined as *the set of bounded rational, highly-heterogeneous actors (e.g., entrepreneurs, suppliers, producers, users, universities, research institutes, government bodies, venture capitalists) whose interactions under a favourable institutional framework facilitate the successful (re-)development of innovation* (Malerba, 2002, Bergek et al., 2008, Chaminade et al., 2018, Asheim et al., 2019), ISs provide an enduring, yet dynamic, structural condition for achieving and maintaining high levels of innovation performance, competitiveness, employment, entrepreneurship, growth and quality of life in contemporary societies (Freeman, 1987, Lundvall, 2002, Pianta, 2005, Fagerberg and Srholec, 2008, Storz, 2008, Radosevic and Yoruk, 2013).

Christopher Freeman (1987), for instance, shows in his seminal analysis of the Japanese national innovation system (NIS) that, thanks to the latter, Japan was able to catch-up (both in economic and technological terms) with the US in the post-war period. Furthermore, Freeman's analysis identifies a set of institutional, organisational and strategic factors (e.g., long-term innovation policies, integrative strategies of large firms [*keiretsu*], favourable financial and educational arrangements). These factors were instrumental in combining increasing product quality, shortenings in the innovation process, and the emergence of new sectors (e.g., robotics) with inclusive growth in post-war Japan. Thus, and in line with Lundvall's (2002) subsequent analysis of the Danish NIS, Freeman's analysis suggests that NISs have, historically, been a necessary structural precondition for achieving inclusive growth and social cohesion in capitalist societies.

Since the 1990s, ample research has confirmed that ISs are multi-level entities (Markard and Truffer, 2008); in particular, they exist at (in addition to the level of

nations) the level of cities and regions (local and regional innovation systems), sectors (sectoral innovation systems), technology (technological innovation systems), and firms (innovation eco-systems) (Malerba, 2002, Bergek et al., 2008, Chaminade et al., 2018, Asheim et al., 2019, Granstrand and Holgersson, 2020). Nonetheless, and despite offering a sophisticated multi-level framework to study the collective aspects of innovation, the IS approach has – to date – not been utilised in the study of innovation and inequality. This omission can, among other things, be attributed to two main factors. First, despite being able to address in a sophisticated manner the question of *inter-regional and national inequality* (i.e., why are some regions and nations more innovative and affluent than others?), the ISs approach is, at this juncture, unable to inform – and as is the case with all the other popular theoretical frameworks on innovation (e.g., clusters, industrial districts, networks, sociotechnical transitions) – research focused on the question of ***income distribution***, i.e., who gets what and how from the income that the innovation process generates in contemporary societies? Secondly, like the other theoretical perspectives on innovation, the ISs approach provides a 'heuristic framework' rather than a formal (mathematical) economic theory (Edquist, 2005, Sharif, 2006, Sorrell, 2018). The underlying methodological implication is that ISs research on inequality is mainly exploratory and descriptive, rather than causal-explanatory.

This study addresses these two issues in the following manner. First, by drawing insights from the *relational theory of inequality*, it equips the analysis with a sophisticated theory of income acquisition; and, second, by adopting the *critical realist approach to causal mechanisms*, it utilises the current stock of knowledge on ISs as the primary material to develop a conceptual model capable of analysing a set of causal mechanisms through which ISs shape the distribution of income in contemporary societies.

4.2.2 Relational Inequality Theory: An Overview

Where and how do actors acquire the income that innovation generates? Does the income acquisition process occur in *labour markets* (as economic studies on innovation and inequality argue)? Or, does it take place in *organisations* (as the work of organisational scholars and economic sociologists suggests)? In such an analytical dilemma, this study argues for the second. The underlying reason for choosing organisations over (labour) markets is based on the following fact: *it is the innovative firm that pays salaries and distributes profits (e.g., dividends) rather than (labour) markets*. Unfortunately, such an essential fact is overlooked. To compensate for this (somewhat scandalous) omission, this study draws insights from the 'categorical strand' of relational inequality theory (Vallas and Cummins, 2014, pp. 230-234).

Relational inequality theory (RIT) is an economic sociological theory of inequality (Vallas and Cummins, 2014); thus, and as is the case with the ISs approach, it assumes that economic behaviour is always embedded in a specific socioeconomic context (Lundvall et al., 2002, Tomaskovic-Devey, 2014, Vallas and Cummins, 2014). According to RIT, income acquisition occurs not in labour markets, but in organisations such as innovative firms (Lazonick and Mazzucato, 2013, Tomaskovic-Devey and Avent-Holt, 2019). Actors acquire income by making wage claims within the innovative firm – a process known as *claims-making* (Tomaskovic-Devey, 2014, pp. 56-58). This process refers to the strategies that organisational actors construct to convince other actors within the firm about the 'true value' and 'objectivity' of their income claims. This process can be *formal* (e.g., pay-rise stipulated by employment contract), *informal* (e.g., an irregular pay-rise request), *collective* (e.g., labour union agreements) and/or *individually-undertaken* (e.g., annual review). To make persuasive claims, actors create, utilise and mobilise a set of resources such as the following three types (Tilly, 1998, Avent-Holt and Tomaskovic-Devey, 2014): *individual* resources (e.g., experience, education, age, productivity, social capital), generally-accepted *social distinctions* (e.g., male/female, educated/non-educated, skilled/unskilled, black/white,

native/immigrant, etc.), and *external environmental resources* (e.g., product market conditions, labour market conditions, and national institution frameworks). Thus, from the standpoint of RIT, skills and labour market conditions provide one of the many resources in the claims-making process; however, they are neither the only ones nor by necessity the most influential ones (Avent-Holt and Tomaskovic-Devey, 2014, Tomaskovic-Devey and Avent-Holt, 2019).

Since the late 2000s, RIT has informed a rapidly-growing number of studies (Vallas and Cummins, 2014, Tomaskovic-Devey and Avent-Holt, 2019). One of the main findings of this line of research is that claims (whether successful or otherwise) are incorporated into the organisational hierarchy, culture, and structure of firms (Vallas and Cummins, 2014, Tomaskovic-Devey, 2014). To conceptualise the structural heterogeneity of firms, relational inequality scholars use the concept of *organisational inequality regimes* (Tomaskovic-Devey and Avent-Holt, 2019). The latter refers to a set of "*loosely interrelated practices, processes, actions, and meanings that result in and maintain...inequalities within particular organisations*" (Acker, 2006, p.443). RIT hypothesises that, when embedded in an organisational inequality regime, the claims-making process gives rise to the following two causal mechanisms of inequality (Tilly, 1998, Tomaskovic-Devey, 2014, Tomaskovic-Devey and Avent-Holt, 2019): the (Marxian) process of *exploitation* where one actor or set of organisational actors (not necessarily owners of capital) benefit at the expense of other organisational actors; and the (Weberian) process of *income hoarding* which occurs when significant flows of income (and job rewards in general) are attached to specific positions within the firm; hence, accesses to these benefits "*is reserved for incumbents and categorically similar actors*" (Tomaskovic-Devey, 2014, p.59).

Overall, RIT not only provides a (ontologically-compatible) theory of inequality to the ISs approach, but also directs our attention to the claims-making process within innovative focal firms in ISs, including the possibility that the latter may be operating as organisational inequality regimes.

4.2.3 Causal Mechanisms: A Critical Realist Approach

How do we know that one object/phenomenon (e.g., systems of innovation) induces a change in another object/phenomenon (e.g., distribution of income)? In a nutshell, this is the question of *causal inference*, and which has long been debated by philosophers of (social) science, as well as by natural and social scientists (e.g., Beebee et al., 2009, Ylikoski and Hedström, 2010). As a result of this, there are not only different theoretical perspectives on causality (Beebee et al., 2009), but also different modes to infer it (Danermark et al., 2002, pp. 73-104). In line with recent contributions within the field of innovation studies (e.g., Papachristos and Adamides, 2016, Svensson and Nikoleris, 2018, Sorrell, 2018), this study approaches the question of causal inference from the standpoint of the critical realist philosophy of science in general (Danermark et al., 2002), and the *critical realist* approach to causal mechanisms in particular (Mingers and Standing, 2017, Ylikoski and Hedström, 2010).

Critical realism (CR) is one of the main philosophies of social science[1]. One of the most distinctive features of CR lies its approach to causality and causal explanation (Danermark et al., 2002, Papachristos and Adamides, 2016). According to CR, causality originates in structured entities (i.e., a dynamic ensemble of related elements), and particularly in the *causal powers* of structures (Danermark et al., 2002, Bhaskar, 2008*b*, Mingers and Standing, 2017). Causal powers refer to the inherent capacities of structures to act in certain ways, enabling them to bring about certain events but not others (Bhaskar, 2008*b*, Sorrell, 2018). For instance, due to its chemical structure (H_2O), water is not only capable of putting out a fire (causal power), but is also liable to evaporate when exposed to very high temperature (causal liability). Similarly, due to their inherent cognitive, physiological and psychological structures, employees can be creative, productive and demotivated (causal powers and liabilities), even when they are unemployed, being on holidays, etc.

[1] Given the existence of a huge amount of (philosophical) literature on CR, this section touches only upon the elements of CR which are the most relevant to the present study. For an accessible overview of CR, see Section 1.3 in this thesis, and Danermark et al. (2002), Sorrell (2018, pp. 270-2073).

These two (pedagogical) examples demonstrate, among other things, that causal powers are not simple 'causal paths', connecting event X to event Y (Ylikoski and Hedström, 2010, Bhaskar, 2008*b*), nor they are purely interpretive (socially-constructed) and contextual processes (Mingers and Standing, 2017, Sorrell, 2018). Instead, they are real, enduring properties, acting as *causal tendencies* in specific contexts, and regardless of the empirical effects they generate (e.g., empirical regularities), including our knowledge and research on them (Fleetwood, 2001, Bhaskar, 2008*b*, Svensson and Nikoleris, 2018). Hence, when contextual factors are favourable, causal powers (including liabilities) emerge as ***causal mechanisms***, capable of bringing about concrete empirical events and outcomes (Fleetwood, 2001, Bhaskar, 2008*b*, Sorrell, 2018). Therefore, from the standpoint of CR, causal mechanisms consist of the following (schematic) composition of elements:

Causal Powers (CPs) + *Relevant Conditions (RCs)* = *Empirical Outcome (EO)*

The rest of this paper utilises the above formula as a source of inspiration to conceptualise and analyse a set of causal mechanisms through which ISs shape the distribution of income. It does so by, first, developing a conceptual model and by subsequently applying it in an IS in Germany.

4.2.4 Conceptual Model

What are the causal mechanisms through which ISs could affect the distribution of income? To address such a largely overlooked (and thus also significantly under-theorised) question, this study develops a conceptual model by means of a creative re-conceptualisation of the current stock of knowledge on ISs. In this process, the present section utilises a particular feature of the critical realist approach to causal explanation, namely *retroductive theorising* (Danermark et al., 2002, Bhaskar, 2008*b*). In a nutshell, retroductive theorising constitutes a "*thought operation*" (Danermark

et al., 2002, p.79), aimed at (re-)conceptualising, before and during the data analysis process, a set of basic preconditions (necessary circumstances) which must, at least in theory, exist for an IS to be able to shape the distribution of income. Thus, in line with the retroductive approach to theorising, the main building blocks in the proposed model consist of three basic theory-informed preconditions.

- **Precondition I: Agency-Structure Co-evolution in ISs**. As is the case with all social structures (e.g., firms, labour markets, welfare states), ISs can not reproduce their own structural anatomy (Carlsson et al., 2002, Svensson and Nikoleris, 2018, Chaminade et al., 2018); in short, they are not autopoietic systems. Surprisingly, accepting this (ontological) fact leads to the conclusion that ISs constitute a significant source of change in contemporary societies. By providing a unique set of 'system-level resources', ISs orientate, (de-)motivate and facilitate (as well as constrain), the activities of innovating actors (e.g., entrepreneurs, managers, and policy-makers) when it comes to developing new, or improving existing, innovative products and services (Nielsen and Johnson, 1998, Lundvall et al., 2002, Storz, 2008, Lawton Smith, 2018, Musiolik et al., 2020). Furthermore, since innovating actors barely create from scratch the structural components in ISs (e.g., knowledge bases, education systems, scientific systems, financial and regulatory systems) that enable them to innovate at a particular point in time (Asheim and Coenen, 2005, Lam and Lundvall, 2006, Sotarauta and Mustikkamäki, 2015, Lawton Smith, 2018, Grillitsch and Sotarauta, 2020, Musiolik et al., 2020), it follows that it is the dynamic, mutually-reinforcing (co-evolutionary) interplay between innovative agency and the structure of ISs that constitutes the underlying *causal agent* in the innovation process in contemporary societies.

- **Precondition II: Creative-Destruction of Jobs, Skills and Competencies**. Following Schumpeter's (1944/2006*a*) work, it has been common to define innovation as a creative-destructive process (e.g., Teece et al., 1997, Tripsas, 1997,

Fagerberg, 2003, Brynjolfsson and McAfee, 2012, Archibugi et al., 2013, Xing and Sharif, 2020). In this (Schumpeterian) regard, it is the co-evolutionary relationship between agency and structure in ISs that sustains and sets in motion the creative-destructive nature of innovation. In doing so, it accelerates the pace of change in the innovation process, thus constantly creating and raising the demand for new jobs, skills and competencies (Tripsas, 1997, Teece et al., 1997, Archibugi and Lundvall, 2001, Xing and Sharif, 2020). Simultaneously, and due to the destructive nature of innovation, the structure-agency interplay reduces in a gradual (path-dependent) manner the demand, and thus also the economic significance, of existing jobs, skills and competences; especially, those that are no longer needed in the innovation process (Archibugi and Lundvall, 2001, Pianta, 2005, Brynjolfsson and McAfee, 2012). This, among other things, implies that every time actors utilise parts of the structure of ISs in the innovation process, the 'overall function' (Edquist, 2005) of ISs simultaneously exercises two overarching causal tendencies to the distribution of income. On the one hand, it releases a positive ***inequality-ameliorating*** causal tendency to the distribution of income (e.g., creation of new skills, jobs and competencies); on the other hand, it induces a negative ***inequality-exacerbating*** causal tendency (e.g., destruction of skills, jobs and competencies). Although these two overarching causal tendencies are always exercised when actors innovate, the causal efficacy of these tendencies regarding the distribution of income is highly *contingent* upon the presence or absence of a set of favourable conditions in ISs.

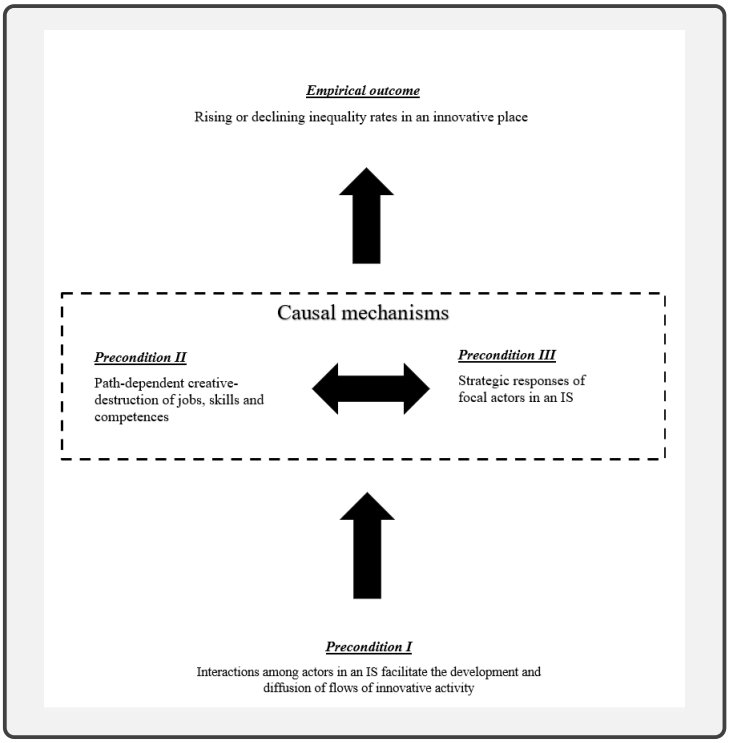
- **Precondition III: Strategic Responses**. In line with RIT, as well as with the 'actor turn' in IS studies (e.g., Hung and Whittington, 2011, Watkins et al., 2015, Lawton Smith, 2018, Grillitsch and Sotarauta, 2020, Musiolik et al., 2020), this study understands contingency as a set of relatively-enduring strategies that focal (triple-helix[2]) actors in ISs devise as a means of coping with key problems

[2]Such as firms (industry), educational and scientific institutes (academia), and policy organisations (the state) (Etzkowitz and Leydesdorff, 2000).

and challenges that emanate from the creative-destructive character of the innovation process. Such problems and challenges include, among others, shortenings in the product life-cycle, appropriability challenges, development of new competencies, changing technological and regulatory regimes, external shocks, unstable and changing patterns of demand (Teece et al., 1997, Archibugi and Lundvall, 2001, Archibugi et al., 2013, Lazonick and Mazzucato, 2013). To deal effectively (in terms of costs, time and social legitimacy) with these challenges, focal actors devise, either singularly or collectively, a set of relatively-enduring strategies. This is often achieved by utilising existing organisational resources (e.g., complementary assets) and system-level resources (e.g., institutional arrangements, knowledge bases, financial resources and social capital), as well as – when necessary – by importing successful institutional arrangements (e.g., technology transfer offices, vocational training, venture capital model of finance, etc.) from other ISs (Teece et al., 1997, Tripsas, 1997, Nielsen, 2003, Lam and Lundvall, 2006, Casper, 2007, Musiolik et al., 2020). In doing so, focal actors determine, although not always intentionally, the type of causal tendency (i.e., inequality-reducing or inequality-inducing) which will prevail in an IS at a particular point of time and in a specific place.

Figure 4.1 provides a graphic summary of the conceptual model that this research uses to study causal mechanisms. According to the proposed model, causal mechanisms emerge when the three preconditions interact, especially when Preconditions II and III are mutually reinforcing. For instance, the creative-destructive element of the employment causal tendency (Precondition II) in the innovation process is very likely to form the classic (Marxian) causal mechanism of *technological unemployment* (Pianta, 2005) when innovative focal firms adopt cost-intensive innovation strategies and short-term 'hiring and firing' strategies (Precondition III). Alternately, when employment strategies are medium-to-long-term and collectively shaped (Precondition III), the destruction of the employment causal tendency could be blocked (Precondition

Figure 4.1: Conceptual Model



II), thus having either a positive or insignificant impact on the distribution of income (Lundvall, 2002, Pianta, 2005, Lam and Lundvall, 2006).

Similarly, the strategic responses of the triple-helix actors to the challenge of skill shortages could either form the causal mechanism of *skill premiums* (for instance, when innovative firms pay higher salaries to skilled labour); or could lead to the emergence of the causal mechanism of *inclusive competence-building*, for instance, when focal actors devise training programmes that enable socially-marginalised low-skilled employees to cope with the destructive effects of rapid technological change (Precondition II)(Archibugi and Lundvall, 2001, Lundvall, 2002, Lam and Lundvall, 2006). In addition, the development of new or the upgrading of existing organisational competencies requires collective investments to be made by both profit and non-profit actors in an IS (Freeman, 1987, Lazonick and Mazzucato, 2013). Hence, when innovative focal firms in ISs operate as organisational inequality regimes (Tomaskovic-Devey and Avent-Holt, 2019), the overall function of ISs is likely to produce inequality by embedding unequal distributions of risks (costs) and rewards (benefits) in the innovation

process (Lazonick and Mazzucato, 2013).

These are just but a few examples of how the causal abilities of an IS could interact with the strategic choices of actors to form causal mechanisms capable of shaping the distribution of income in an innovative place. It is knowledge about the existence and underlying composition of such ***a largely unknown set of causal mechanisms*** that the empirical part generates.

4.3 Research Design, Setting and Data

4.3.1 Research Design

To identify, elucidate and shed light on the anatomy and efficacy of causal mechanisms through which ISs affect the distribution of income in contemporary societies, this study adopts the methodologically-open-ended, data-rich and explanatory-thick, embedded single-case study research design (Tsoukas, 1989, Yin, 2009). By allowing the research process to get as close as possible to the real-life context of innovative behaviour, as well as by sorting out systematically-contradictory facts during the data collection and analysis process, case study research provides a contextually-rich picture of the three preconditions in ISs. In doing so, it allows the research process to trace how the causal powers of ISs could combine with relevant contextual factors (i.e., strategic responses of focal actors) to form causal mechanisms of (in)equality. This is of utmost methodological significance to the present study, as the causal abilities of both actors and ISs are very likely to be "*affected by and affect, a multitude of other causal powers and conditions*" (Svensson and Nikoleris, 2018, p.468).

4.3.2 Research Case

This study investigates the relationship between ISs and income distribution on the regional (sub-national) scale. The choice of the regional scale is based on the following syllogism: since the systemic character of innovation has a territorial dimension (Braczyk et al., 1998, Asheim and Gertler, 2005), as well as that income inequality occurs in the place where people reside and work (Tilly, 1998, DeVerteuil, 2009), *some of the most operative causal mechanisms through which ISs shape the distribution of income are very likely to operate more freely at the regional level rather than at the other levels*. This is not to say that the other domains of socio-economic organisation (e.g., firms, sectors and nations) are not significant in our understanding of how innovation as a systemic activity shapes the distribution of income. On the contrary, the focus on the regional scale in this study underlines that, given that our knowledge of the causal mechanisms through which an IS could affect the distribution of income is significantly under-developed, the regional scale offers an ideal starting point to search for causal mechanisms.

The primary research setting in this study consists of the region of Braunschweig. It is a small (approximately 1.1 million inhabitants) peripheral region of Germany. The region is located in the Southeastern part of the Federal State of Lower Saxony (Figure 2). Formerly known as the administrative region of Braunschweig (*Regierungsbezirk Braunschweig*[3]), the area in question is an economic region. It consists of, and is also governed by, economic and policy networks between the three urban districts (*Kreisfreie Städte*) of Braunschweig, Salzgitter, and Wolfsburg, and five rural districts (*Landkreise*) of Goslar, Gifhorn, Helmstedt, Peine, Wolfenbüttel.

Largely unknown among the generic public, the region is one of the most R&D-intensive areas of Europe. In 2017, regional actors invested more than 8.5% of the

[3]The administrative region of Braunschweig was dissolved in 2005. It consisted of the existing 10 cities and districts, specifically four cities (Braunschweig, Göttingen, Salzgitter and Wolfsburg) and six districts (Gifhorn, Goslar, Göttingen, Helmstedt, Northeim, Osterode, Peine, and Wolfenbüttel). Currently, the former region of Braunschweig exists only as a statistical unit.

Figure 4.2: Map – Region of Braunschweig

regional gross domestic product (GDP) (5.9 billion EUR) in R&D activities, which is nearly three times higher than the R&D investment rate of Germany (3.07%) and four times that of the EU28 (2.04%)[4]. Similarly, the European regional innovation scoreboard, which uses several indicators to gauge regional innovation performance (e.g., scientific co-publications, public and private R&D, firms introducing a new product or service, patent applications, etc.), has – since the late 2000s – consistently ranked Braunschweig in the top 30 best-performing regions in Europe (n=256)[5] (Fragkandreas, 2013, European Commission, 2019). According to the same report, the innovative performance of the region of Braunschweig is significantly higher than that of first-tier global metropolitan regions such as London, Paris, and Amsterdam. Previous research (e.g., Krätke, 2010) has identified several regional knowledge networks, consisting of large innovating firms, small and medium-sized enterprises (SME), universities and world-class research institutions. As summed up on the official website of a regional economic organisation, "*it's difficult to imagine a better breeding ground for collaboration between research and industry [in Germany]*" (source: allianz-fuer-die-region.de). Therefore, it is the existence of a well-connected and functioning re-

[4]For a comparative overview of the R&D statistics for the region of Braunschweig, see Appendix B.

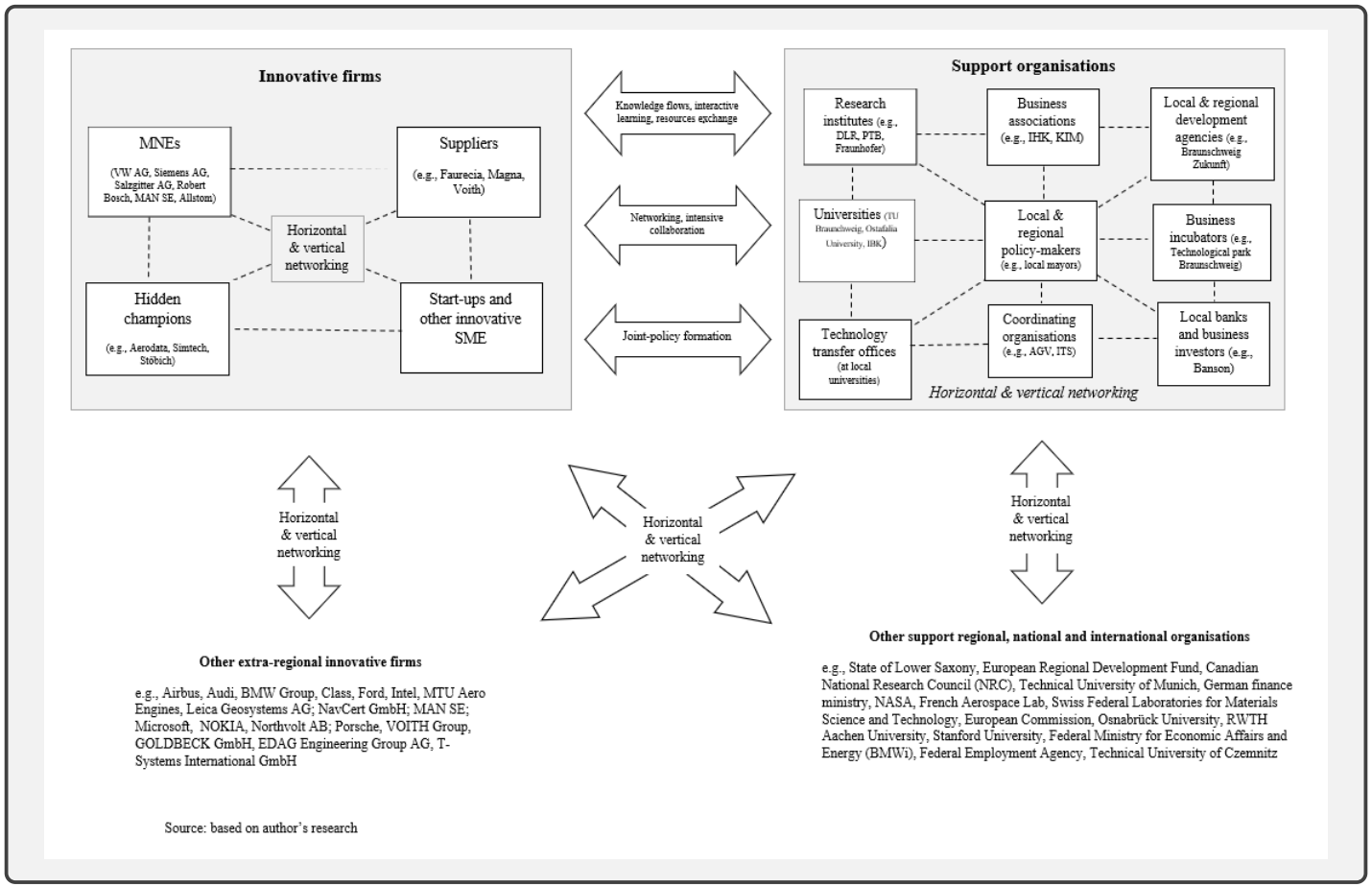
[5]For more information on the position of the region of Braunschweig in the Regional Innovation Scoreboard, see Appendix C.

gional innovation system (RIS) in the region of Braunschweig that makes the region in question ideal to search for causal mechanisms.

Figure 4.3 provides a graphical representation of the composition of the Braunschweig regional innovation systems (BRIS). In a nutshell, it is shown that there, indeed, exists a well-connected RIS, central to which are regional and extra-regional networks of four types of innovative firms (large innovative firms, innovative suppliers of large firms, hidden champions and other small innovative firms), as well as numerous support organisations, such as 27 research institutes[6], three research-active universities, several local development agencies and organisations, business associations, network organisations, technology transfer offices, business parks, incubators, and a few financial organisations. While such an 'organisationally thick' support system is typical of RISs in coordinated market economies such as Germany (Asheim et al., 2019), it is, certainly, impressive for a small region "*located in the middle of nowhere*" (Interview 2).

[6] Appendix D contains a list of research institutes in the region of Braunschweig.

Figure 4.3: BRIS – Structural Anatomy



4.3.3 Data Collection and Analysis

This study utilises the methodological strategy of *iterative abstraction* to identify causal mechanisms (Yeung, 1997, pp. 58-61). Iterative abstraction refers to the methodological process of going back and forth in the conceptual model (abstract) and research case (concrete) as much as is needed until a sound understanding (theoretical saturation) of causal mechanisms has been achieved. To access the 'concrete', the following five sources were used: (1) semi-structured interviews, (2) organisational documents, (3) organisational websites, (4) newspaper articles, and (5) secondary statistical data.

More specifically, 22 semi-structured interviews (each of which lasted approximately 45-80 minutes) were conducted in the region of Braunschweig with six focal actors[7] most of whom were male (approximately 80%) were conducted. A hybrid sampling strategy was used, combining theory-informed sampling (i.e., identifying focal actors based on the ISs concept) with snowball sampling. The interviews were conducted by using an interview protocol[8], consisting of four main parts: Part I (about you and your organisation), Part II (regional innovation activities), Part III (regional economic growth and development), and Part IV (closing part). When interviewees made a reference to relevant keywords (e.g., unemployment, employment, skills, inequality, poverty, competencies and so on), probing questions were posed. Since most interviewees granted permission to record the interviews, the interview data were transcribed and analysed by following the methodological procedures in the *template analysis* method (King and Brooks, 2017), in particular by using the key dimensions in the conceptual model to organise the codes into categories. Codes were either based on early versions of the proposed model (deductive coding) or emerged from the data analysis process (inductive coding)[9].

[7] These include top business executives, innovation project managers, consultants, business association representatives, policy-makers, technological transfer officers and labour union representatives.

[8] For more information about the interview protocol, see Appendix E.

[9] Appendix F provides an overview of the final template of codes, including representative interview passages.

In addition to primary qualitative data, secondary qualitative data were used to verify, extend and deepen key facts and patterns (e.g., strategies) in the interview data, as well as to gather relevant quantitative data, such as financial statistics and information regarding compensation of employees and top executives. These data sources consist of 50 organisational reports (approximately 9,000 pages), more than 100 carefully-selected economic and business news articles (e.g., Reuters, Deutsche Welle), and relevant material from the official websites of focal firms and support organisations[10]. Documentary data were analysed by using the coding template of interviews (see, Appendix F).

Secondary statistical data were also collected and analysed in a descriptive manner. These consist of data taken from the statistical databases of Eurostat, Destatis (regional database) and the regional innovation scoreboard (European Commission, 2019). Statistical data were used mainly to (a) verify key empirical patterns that emerged from interviews and documents, as well as (b) to gauge the level of income inequality in the region of Braunschweig[11]. With a very few minor discrepancies (which prompted further research), a systematic analysis of all data sources led to data convergence.

In addition to systematic data analysis, this study used the methodological criterion of *causal necessity* to infer causal mechanisms (Runde, 1998, Wynn and Williams, 2012). In a nutshell, causal necessity refers to the ability of a hypothesised configuration of causal tendencies and contextual factors to produce a given empirical outcome. The following "*causal test question*" (Wynn and Williams, 2012, p.801) was

[10]For more information on this data source, see Appendix G.

[11]There are significant data availability issues when it comes to calculating the standard measures of inequality (e.g., Gini coefficient and percentiles) for the region of Braunschweig, as well as for all regions and cities in both Germany and Europe. This data limitation is not unique to the present study, and is common within all studies on innovation and inequality at the sub-national level. One accessible income data source is the German Socioeconomic Panel data, which contain a sample of household data since the early 1980s. However, after careful consideration, this dataset was deemed inappropriate for the present study: first, the sample data are representative at the national and (in part) at the federal level, but not at the regional level; (b) there are important fluctuations in the number of observations. For instance, in 2000, the sample for the State of Lower Saxony (to which the region of Braunschweig belongs) was 2,831 households, whereas in 2017 the sample was 5,768. To compensate for the lack of detailed inequality statistics, this study used categorised income data (e.g., number of taxpayers having a certain amount of income, i.e., 0-10,000 EUR, 10,000-20,000 EUR, etc.) for two main periods: 1998-2004, and 2008-2015. These data are provided by the German statistical service (Destatis).

repeatedly posed: *To what extent could the proposed configuration of causal power (or liability) and relevant conditions produce the observed outcome?* When the answer to this question was largely affirmative (i.e., to a large extent), the hypothesised causal mechanism was regarded as explanatorily satisfactory. Lastly, a set of (realist) case study criteria was adopted to establish the quality of this study[12] (Healy and Perry, 2000). Particular attention was paid to the quality criterion of construct validity which, as suggested by Yin (2009, p.34), was addressed through the data triangulation process.

The next section discusses the relevant empirical material indicating the existence of seven active causal mechanisms in the region of Braunschweig. It draws heavily from a case study report (approximately 150 pages long) which, as suggested by Yin (2009, pp.141-166), was prepared in the form of notes during the various stages of the data analysis process.

4.4 Findings: Seven Causal Mechanisms

As mentioned, this section summarises the main findings indicating the existence of seven active causal mechanisms in the region of Braunschweig. The anatomy of causal mechanisms is spelt out by utilising the critical realist formula as discussed in Section 4.2, namely causal power or liability (i.e., creative-destruction of jobs, skills and competencies in the BRIS) + relevant conditions (i.e., strategic responses of focal actors in the BRIS) = empirical outcome (i.e., rising or declining inequality). The order in which the causal mechanisms are discussed reflects not causal significance, but rather how each mechanism emerged from the data analysis process.

[12] An overview on the quality criteria that this study has utilised is provided in Appendix H.

4.4.1 Regional Competence Building and Relevant Strategies

Mobility Competence Due to the existence of "*a mass variety of research institutes*" (Interview 3), three research active universities, and a strong economic specialisation in the automotive sector (e.g., Volkswagen AG), the knowledge expertise of the region of Braunschweig consists mainly of analytical and synthetic knowledge bases such as the following ones: aviation, aerospace, automotive, biotechnology, industrial design, information technologies, metal processing, precision mechanics, micro-assembly, micro-production, optical and meteorological technologies, traffic engineering, renewable energy, road and rail technology (Braunschweig Stadtmarketing GmbH, 2009*a*,*b*, Krätke, 2010, IHK Braunschweig, 2019). These regional knowledge bases are sustained and enhanced by "*close ties between universities, research institutes and private enterprises*" (Niedersachsen Global GmbH, 2013, p.14), thus allowing scientific findings to be "*integrated into the development of new products, processes and services*" (ibid.)[13].

However, from all the major regional knowledge bases, the most significant one lies in a fusion between the fields of automotive, aviation, traffic engineering, rail and road technologies. This fusion of knowledge is known among regional actors as the ***mobility competence***.

> "*Mobility is the core competence of our region; the mobility industry and research are key drivers of economic growth and employment.*"
>
> (source: allianz-fuer-die-region.de)

Core-Periphery Strategies Since the late 2000s, focal actors (especially the State of Lower Saxony, local policy-makers, large firms, universities and focal research institutes) have pursued a number of cluster-based initiatives: "*the region is getting more*

[13] Appendix H contains passages from interviews and documents illustrating the existence of close ties and networks among firms and support organisations.

and more towards, let's say, from a network to a mobility cluster" (Interview 19). These initiatives are often supported by strategic investments in the research infrastructure (e.g., new research campuses on mobility research, research projects), especially in the research airport of Braunschweig which, by now, formulates "*a hotbed of ideas and research in everything that pertains to mobility in the region*" (source: foschungesflughafen.de). Strategic investments in the mobility competence in general, and clustering initiatives around the research airport of Braunschweig in particular, are considered necessary by regional policy-makers, if the region is to "*continue to be among the leaders in the future*" (source: allianz-fuer-die-region.de). Attributable to its hybrid economic base[14], clustering initiatives are also seen by policy-makers as necessary to capture some value locally by participating in extra-regional knowledge and production networks.

> "*We develop very good product innovations for the market but is explored by companies having the headquarters anywhere else not here*."
>
> (Interview 18)

While the focal actors in the BRIS are working closely to improve the regional (hard and soft) infrastructure that underpins the mobility competence, "*regional innovation policies are not coordinated...There are small initiatives but not an integrated strategy on innovation policy*" (Interview 15). To address these issues (which were intensified by the dissolution of the former administrative region of Braunschweig in 2005), focal actors in the BRIS (especially the VW AG and the cities of Wolfsburg and Braunschweig) joined forces to create several project-based support organisations and think-tanks (e.g., Allianz-fuer-die-Region, Haus der Wissenschaft, projekt REGION BRAUNSCHWEIG, ForschungRegion Braunschweig, etc.). Despite that the more recent regional initiatives have ameliorated fragmentation issues among regional pol-

[14]The economic structure of the region of Braunschweig is hybrid in the sense that it hosts not only the headquarters of leading global firms such as VW AG, Salzgitter AG and innovative SMEs (hidden champions), but also several factories of firms in the manufacturing, engineering and automotive sectors (Appendix J).

Table 4.1: Regional GDP by City

Territory	Gross Domestic Product								
	2000			2017			Change %		
	Amount	Per employee	Per inhabitant	Amount (thousands)	Per employee	Per inhabitant	Amount	Per employee	Per inhabitant
Braunschweig region	31,912,048	55,832	27,939	54,371,439	81,926	48,627	70.38	46.74	74.05
Braunschweig, Kreisfreie Stadt	7,870,522	51,932	32,410	12,382,655	72,974	49,861	57.33	40.52	53.84
Salzgitter, Kreisfreie Stadt	3,640,845	62,712	32,788	5,620,493	98,476	53,987	54.37	57.03	64.65
Wolfsburg, Kreisfreie Stadt	9,818,707	102,265	81,111	21,366,978	163,592	172,437	117.61	59.97	112.59
Gifhorn, Landkreis	2,347,766	45,927	13,797	3,847,178	66,299	21,995	63.87	44.36	59.42
Goslar, Landkreis	3,014,333	43,899	19,399	4,060,817	65,669	29,475	34.72	49.59	51.94
Helmstedt, Landkreis	1,533,631	48,690	15,377	1,802,224	59,932	19,611	17.51	23.09	27.53
Peine, Landkreis	2,101,151	45,471	16,003	2,827,175	62,453	21,229	34.55	37.35	32.66
Wolfenbüttel, Landkreis	1,585,093	45,763	12,623	2,463,919	66,016	20,418	17.27	45.18	27.59
Min	1,533,631	43,899	12,623	1,802,224	59,932	19,611	17.51	36.52	55.36
Max	9,818,707	102,265	81,111	21,366,978	163,592	172,437	117.61	59.97	112.59
Average	3,989,006	55,832	27,939	6,796,430	81,926	48,627	70.38	46.74	74.05
Standard deviation	3,121,083	19,708	22,924	6,766,926	35,149	51,856	116.81	78.35	126.21
Germany	2,116,480,000	53,022	25,983	3,277,340,000	74,032	39,650	54.85	39.63	52.60

Source: own elaboration, data from regionalstatistik.de

icymakers, these activities seem, so far, to have been unable to counterbalance the excessive focus on the large cities: "*a lot of things are [still] a matter of how you define the region*" (Interview 3), and "*many people in the region focus on the large cities, and there are many people living in economically weak rural districts*" (Interviews 5 & 8).

Rising Income Gap In line with the underlying hypothesis in the IS approach, whereby systemic interactions among actors are key to sustaining high-levels of (regional) productivity and growth (Freeman, 1987, Lundvall, 2002), the region of Brunswick has one of the highest labour productivity and income per capita rates in Germany (see, Table 4.1). For instance, the average regional income per capita is 27% higher than the national average (48,627 EUR in 2017), and has increased by 74% since the early 2000s. Despite this, economic disparities have increased significantly in the region – a phenomenon known among regional actors as "*the regional income gap*" (Interviews 5, 8 & 18). For instance, the standard deviation of the regional income per inhabitant has risen by 126% since the early 2000s: from 22,924 EUR in 2000 to 51,856 EUR in 2017, with the highest regional income per capita being observed in the city of Wolfsburg (172,437 EUR per capita in 2017), and the lowest in the rural district of Helmstedt (almost 19,611 EUR in 2017). Similarly, the income per capita has risen by 112.59% in the first, and only by 27.53% in the second.

Causal Mechanism$_1$: Regional Competence Concentration Close collaboration among the focal actors in the BRIS has facilitated the emergence and enhancement of the mobility competence. However, due to both historic (path-dependency) and a set of core-periphery type of strategies, the competence-building process has mainly taken place in the most affluent cities of the region of Braunschweig. Hence, while this process has, on average, benefitted the economic potential of all cities and districts in the region, it has also intensified the income gap among the most affluent cities and the least affluent districts.

4.4.2 Competence Dependency and Claims-Making Strategies

Competence Dependencies The region of Braunschweig is home to numerous active innovative SMEs[15]. Despite this, it is the activities of large innovative firms which shape the co-evolutionary link between agency and structure in the BRIS.

> "*The answer lies in big companies...Innovation is always linked with these companies...who else? It is a need, otherwise, innovation will not come into any product*"
>
> (Interviews 18 & 19).

Seven multinational enterprises (MNEs) are based in the region. In alphabetical order, these are as follows: Alstom SE (located in Salzgitter), MAN SE (located in Salzgitter), Nordzucker AG (headquartered in Braunschweig city), Robert Bosch GmbH (located in Salzgitter), Salzgitter AG (headquartered in Salzgitter), and Volkswagen AG (headquartered in Wolfsburg). Among all of these firms, however, it is

[15] According to one source, there are at least 250 innovative SMEs in the region of Braunschweig (Braunschweig Stadtmarketing GmbH, 2009*a*). This is also reflected in the most recent version of the regional innovation scoreboard (European Commission, 2019), whereby the percentage of SME innovating in-house is one of the highest in Europe (ranked 16th in Europe).

the VW AG which is the most the significant actor in the BRIS: "*VW is the most important answer to the question of innovation in the region*" (Interview 18). The firm is not only the largest employer in the region[16], employing more than 100,000 employees (IHK Braunschweig, 2019, Volkswagen AG, 2019), but it is also one of the top 5 R&D investors by volume in the world, as well as "*one of the biggest patent earners*"[17] (Interview 9).

Income Hoarding Strategies in Focal Firms The revenue of VW AG grew by 60%, from 50 billion EUR in 2005 to 80 billion EUR in 2019 (Volkswagen AG, 2005, 2019). Similarly, the net income has risen by 570%, from 741 million in 2005 to 5 billion Euros in 2019 (ibid.). Given such a robust financial performance, it is hardly surprising that top management executives' total compensation – such as chief executive officers (CEOs) and the board of directors (BoD) – has risen considerably in the period under consideration. For instance, the current CEO of VW AG (Dr Herbert Diess) earns 2.5 times more (nearly 10 million EUR) than his predecessor (Bernd Pischetsrieder) in 2005; the latter's total compensation was 2.8 million EUR in 2005 (ibid.). Similarly, the total compensation for the average member of the board of directors was 1.9 million EUR in 2005, rising to 5.7 million EUR in 2019.

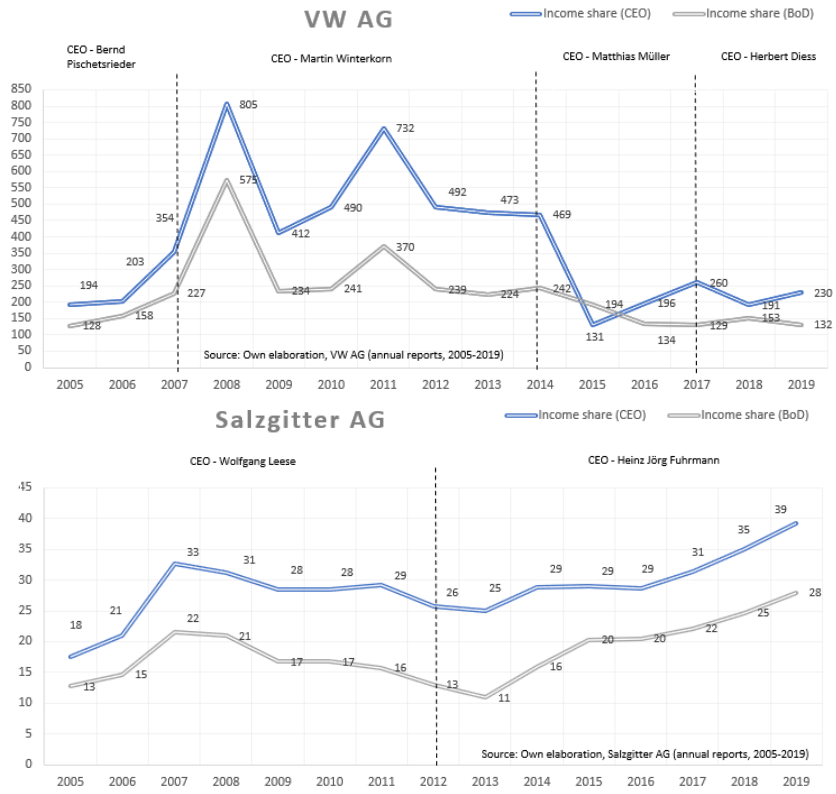
Rising income gains at the top of the organisational hierarchy are certainly not unique to VW AG. For instance, the CEO's total compensation at Salzgitter AG (which is the second-largest employer in the region, with approximately 8,000 employees) (IHK Braunschweig, 2019) was 1 million EUR in 2005, rising to 2.8 million in 2019 (Salzgitter AG, 2005, 2019). However, what is interesting in both firms is that, when a new CEO arrives, a new 'inequality regime' seems to emerge (see, for instance, Figure 4.4). For instance, during the tenure of Bernd Pischetsrieder at VW AG, the total compensation of BoD was, on average, 128 higher than the average annual salary (as measured by the annual average personnel costs) in the firm, jumping

[16]For an overview of the largest employers in the region of Braunschweig, see Appendix J.

[17]For instance, in 2019, the firm filed "*7,614 patent applications worldwide for employee inventions, the majority of them in Germany*" (Volkswagen AG, 2019, p.140).

to 575 times in 2008 (Dr Martin Winterkorn's tenure), and subsequently falling to 230 times in 2019 (Dr Hebert Diess' tenure)[18].

Figure 4.4: Top Executive Compensation Relative to Average Personnel Cost



From the standpoint of RIT (Tomaskovic-Devey and Avent-Holt, 2019), significant changes in the compensation of top executives are attributable to the dynamic nature of organisational inequality regimes in each firm, as well as to the ability of top executives to construct persuasive income claims on an annual basis, given the provision of certain favourable organisational resources and conditions (e.g., revenue, profitability, acquisitions, international expansion). Age (in the 50s-60s range), high-level education (e.g., postgraduate and a doctorate degree in Physics or Engineering), and prior experience on the board of directors of the same firm are common among most CEOs in the innovative focal firms of the BRIS (especially VW AG and Salzgitter AG). In addition, the fact that all CEOs, including the great majority of board

[18]For more information on the top management compensation at VW AG and Salzgitter AG, see Appendix K.

members, are native, white, and male, suggests that social distinctions – such as gender (male/female), race (white/black) and citizenship (native/immigrant) – seem to be essential credentials for someone to reach the top of the managerial hierarchy in innovative focal firms. Lastly, a comparison of the opening statements of CEOs in the annual reports of focal firms reveals that CEOs often emphasise how well the firm is positioned, in terms of both financial performance and strategy, to face the following challenges: increasing technological competition, unstable demand (e.g., global financial crisis, Brexit, protectionism), new entrants to the industry, and increasing regulatory pressure (e.g., environmental law protection).

Rising Number of High Income Earners Since the late 1990s, the number of taxpayers earning more than 125,000 EUR has increased on average at a higher pace in the region of Braunschweig than in Germany (Table 4.2). For instance, the percentage of high-income taxpayers in the region of Braunschweig rose by 222% in 1998-2015, whereas in Germany it increased by 140%. In 1998, 1% of taxpayers in the region (6,340 taxpayers) earned more than 125,000 EUR. In 2015, this ratio was at 3.43% (19,275 taxpayers). However, the average income in this income category fell by 27% to 208,894 EUR per taxpayer in 2015. This implies that the rise in the number of high-income taxpayers has mainly occurred in the income range of 125,000-208,984 EUR. Interestingly, the highest rise in the percentage of high-income earners in the region is observed in the city of Wolfsburg (370% increase) and the district of Gifhorn (346% increase) where several automotive suppliers (e.g., Continental Teves AG) of the VW AG are located. From the standpoint of RIT (Tomaskovic-Devey and Avent-Holt, 2019), this implies that middle- and top-management employees in local firms seem to emulate successful income hoarding strategies from their counterparts in the local automotive cluster.

> **Causal Mechanism$_2$: Concentrated income hoarding** – The underlying composition of the BRIS favours, and is favoured by, the innovative activ-

Table 4.2: Taxpayers with Income over 125.000 Euros by City and Year

Territory	% of Taxpayers		
	1998	2015	Change (%)
Braunschweig city	1.26	3.72	194.85
Salzgitter	0.79	1.73	118.87
Wolfsburg	0.93	4.39	370.47
Gifhorn	1.03	4.60	346.83
Goslar	1.10	2.13	93.60
Helmstedt	0.87	3.18	265.46
Peine	0.94	2.73	192.21
Wolfenbüttel	1.33	3.68	176.51
Region of Braunschweig	1.06	3.43	222.18
Germany	1.36	3.26	140.16

Source: own elaboration, regionalstatistik.de

ities of large innovative firms. Due to their economic success, these firms provide a fertile ground for top management teams to successfully devise persuasive income hoarding strategies. This, in turn, reinforces the significance of organisational inequality regimes as an income distribution arrangement in local innovative firms, contributing to an above-average increase in the percentage of high-income earners.

4.4.3 Creative-Destruction of Employment and Relevant Strategies

Technological Unemployment Since the late 1980s, technological unemployment has been a recurrent challenge for the region of Braunschweig. Traditionally, technological unemployment was induced by sectoral change: "*the money-making industries*" (Interview 2) – such as packaging, caning, machine building, precision and optical engineering – "*either closed down or moved away*" (ibid.). As a result of this, "*fewer people work for these industries in the region than twenty and thirty years ago*"(ibid.). However, technological unemployment has, more recently (circa the late 2000s), been afflicting employment in the sectors that traditionally helped the region cope with technological unemployment. "*The automotive industry is in the midst of a*

rapid structural upheaval" (Volkswagen AG, 2010, p.18), stated the former CEO of VW AG in 2010. More recently, the current CEO of the firm, Dr Herbert Diess, has added that,

> "*We have to invest billions of euros in new cars and services while new rivals will attack us – the transformation will surely be more radical than everything we have experienced to date*"
>
> (Cremer and Schwartz, 2016).

To overcome these technological challenges, and to recover from the diesel gate scandal (which has cost the firm billions of euros, including 30,000 job cuts), VW AG has announced its strategic plan "*to invest more than 30 billion EUR by 2025...in the digitisation of vehicles and plants as well as in CO2-neutral production right through to its suppliers*"(Welle, 2019*b*, wv.com). To economise resources, the firm replaced 4,000 jobs in non-production units with 2,000 jobs in digital activities, leading to a net loss of 2,000 jobs (ibid.). Although labour union representatives of the firm claim that there will be no further lay-offs until 2029 (Welle, 2019*b*,*a*), it is the restructuring in the production plants of the regional automotive supply chain (and manufacturing in general) that makes technological unemployment inevitable. For instance, the production of different parts of electric vehicles requires 25% less manual labour than the production of combustion engine vehicles (Welle, 2019*b*,*a*). This intensifies further the use of robots in the automotive plants in the region.

> "*Many robots are coming into the production, and now many people are getting unemployed. That's really a big problem for us*" [as policy-makers]
>
> (Interviews 8 & 9).

Flexible, Service-Orientated, Gender-Inclusive Employment Strategies Regional firms have utilised an extremely diverse (firm-specific) mix of employment strategies.

For instance, some large firms (e.g., Alstom SE, Robert Bosch GmbH), which are headquartered outside the region, have reduced employment in the region (IHK Braunschweig, 2008, 2019). Other large firms (e.g., MAN SE) have moved parts of their production lines to Eastern Europe, while, at the same time, "*creating logistics centres for spare parts in the region*" (Interview 17). Other firms (e.g., automotive suppliers, manufacturing SME) seek to "*reach more and more turnover with fewer employees*" (ibid.) by introducing flexible employment arrangements (part-time jobs), although, according to local labour union representatives, most of these jobs are not well-paid, and as a result of this, "*employees are often forced to apply for social benefits, in addition*" (Interview 18).

However, from all regional firms, it is the 'deeply-embedded' largest firms (i.e., firms that are born and bred in the region) which have handled the question of technological unemployment in a 'regionally-cautious' manner. Illustrative is the case of VW AG, which initially (circa the early 2000s) introduced flexible employment arrangements to combine cost-competitive (low labour costs) optimisation processes with flexible employment arrangements (Volkswagen AG, 2005). Subsequently (circa the early 2010s), VW experimented in its local factories with different innovative projects (e.g., co-generation gas home power plants) as a means to either create new jobs or avoid job redundancies. As a top management employee of VW's R&D department put it:

> "*The question is, if you want to do business employ people and* ***keep the region alive****, then you've got to consider how this can be done. You can do this by developing brand new things but that cost you a great deal of money and take a lot of time or you can produce new things by simply combining existing technologies*"
>
> (Interview with Deutsche Well News, bold emphasis added).

More recently, and due to a strong opposition from its labour union[19], which has caused serious trouble for the top management of the firm, and under the pressure of the State of Lower Saxony[20], VW AG has announced that it will spend more than 900 million EUR to set up a new battery cell production through a joint venture Swedish battery producer Northvolt AB, including the development of "*the first plant for recycling used electric car batteries*" (source wv.com) in the city of Salzgitter[21]. This investment will not only create hundreds of jobs in a city with one of the highest unemployment rates in the region, but it will also enable the firm to proceed in the least (regionally) controversial manner with its new strategic plan (TOGETHER 2025+), namely "*Shaping mobility for generations to come*"(source: vw.com).

Unlike VW AG, which is somewhat forced to tackle technological unemployment as a regional matter, regional policy-makers have treated the challenge of technological unemployment as a local (city-based) matter. A common policy response in all cities is to boost employment in the service sectors as a means to eliminate the effects of technological unemployment: "*to find more service industries is one of the main efforts that we are conducting here*" (Interview 19). Among the sectors that have been at the centre of local policy action are knowledge-intensive services (e.g., industrial design, software solutions), logistics, tourism, hospitality and the third sector (social services) (Interviews 2, 7, 8, 9, & 16; see also allianz-fuer-die-region.de). Increasing the number of service jobs is also seen as necessary to reduce the gender employment gap.

> "*The concentration of employment in our economy is mainly in the production of goods. In this production area, the share of male employees is*

[19] According to a local labour union representative, 95% of all employees in the three main factories (Wolfsburg, Braunschweig and Salzgitter) of VW are union members.

[20] The State of Lower Saxony is the fourth-largest shareholder, owning 11.8% of shares in the firm (source: `https://www.volkswagenag.com/en/InvestorRelations/shares/shareholder-structure.html`)

[21] The idea for this plant was developed 12 years ago by a doctoral student, Stella Konietzko, a geologist at the Technical University (TU) of Braunschweig (source vw.com).

high, and the one for female employees is quite low...That results is higher unemployment rate for women"

(Interviews 8, 9 &17).

While seeking to increase service employment as a response to technological unemployment, regional policy-makers are, at the same time, concerned about the fact that service jobs are often precarious and relatively not well-paid.

"*The region of Braunschweig includes a large service sector with an income structure which is below average...When you have low growth in Germany, they [service employees] are unemployed*"

(Interviews 5 &9).

Relevant Empirical Outcomes Reflecting a broader shift in employment in advanced economies towards service sectors, employment in the manufacturing sector in the region of Braunschweig has declined steadily since the early 2000s (source: regionalstatistik.de). For instance, while employment in industrial sectors fell to 24% in 2017%, from 29% in 2000, employment in service sectors (e.g., financial, insurance and business service providers, and real estate) increased by 16%, with the public, education, and health service sectors being the largest service employers (30% of regional employment in 2017). The rise in service employment jobs has contributed to a significant drop in the unemployment rate: from 10.45% in 2001 (58,854 registered unemployed) to 5.34% (31,411 registered unemployed) in 2019 (source: regionalstatistik.de). Compared to 1999, when 20% of the regional workforce held a part-time job, this jumped to 29% in 2018, increasing by 41% (source: Eurostat). In 2018, female part-time employment dropped by 8.57%, whereas male part-time employment rose by 52%, although the great majority of part-time employees were still female (78.6%).

Despite these positive developments in regional employment, also on the rise has been the rate of population living at-risk-of-poverty[22]. As calculated by the German statistical agency (Destatis), the risk of poverty rate was 15% in 2005 and 16.9% in 2017 in the region (source: regionalstatistik.de). The rise in relative poverty coincides with a considerable increase in the number of taxpayers reporting no income (absolute poverty) in the region (see Table 4.3). In 2007, the percentage of taxpayers with no income was 0.13%, whereas in 2015 it was 3.3%, which corresponds to an increase of 2,438%. Similarly, the absolute number of old age unemployed (55-65 years old) has increased by 17.2% since the mid-2000s: there were 5,950 unemployed in 2007 and 6,971 in 2015. This, among other things, suggests that technological unemployment affects mainly older, rather than young, employees in the region of Braunschweig.

Table 4.3: Taxpayers with No Income

	2007	**2015**	**Change (%)**
Region of Braunschweig	0.13	3.3	2,438.5
By city			
Braunschweig, Kreisfreie Stadt	0.18	3.33	1,782.6
Salzgitter, Kreisfreie Stadt	0.09	3.33	3,514.0
Wolfsburg, Kreisfreie Stadt	0.09	1.87	1,982.4
Gifhorn, Landkreis	0.13	2.24	1,623.3
Goslar, Landkreis	0.13	4.16	3,096.9
Helmstedt, Landkreis	0.16	2.44	1,423.6
Peine, Landkreis	0.13	4.32	3,220.3
Wolfenbüttel, Landkreis	0.12	2.90	2,316.7

Source: own elaboration, Regional Datenbank

Causal Mechanism$_3$: Precarious employment – Since the early 2000s, the overall functioning of the BRIS has facilitated the net creation of 24,773 new jobs (regionalstatistik.de), leading to a significant drop in the regional unemployment rate. However, due to a rise in precarious (part-time), relatively lower-paid jobs in both the manufacturing and services

[22] At risk-of-poverty are persons with an equivalised disposable income below the risk-of-poverty threshold, which is set at 60% of the national median equivalised disposable income (after social transfers) (source: Eurostat).

sectors, the relative poverty rate has also increased in the region of Braunschweig.

Causal Mechanism$_4$: Old-Age Technological Unemployment – Although the unemployment rate in the region has dropped, the unemployment rate among older people (55-65 years old) has been on the rise since the late 2000s. Due to the absence of an explicit strategic response on the part of focal actors in the BRIS, the increasing adoption of robots and digital technology in the regional production base has negatively affected the employment potential of older (male, less-skilled) employees. This has led to rising levels of (absolute and relative) poverty.

Causal Mechanism$_5$: Gender Inclusive Employment – Facilitated by a mix of gender-inclusive strategies of focal actors in the BRIS, the creative-destruction of regional employment has, since the mid-2000s, led to a gradual improvement in the rate of (full-time) female employment in the region of Braunschweig. This has narrowed down the gender (employment and income) gap in the region.

4.4.4 Skill Premiums and Gender-Inclusive Competence-Building

Skill Shortages The region of Braunschweig has one of "*the highest rates of employment in the field of R&D in Germany*"(Interview 8), as well as one of the highest rates of employment in medium and high-tech manufacturing and knowledge-intensive services in Europe (European Commission, 2019). On the one hand, the high concentration of research-intensive employment is attributable to the fact that innovative focal firms conduct a significant portion of their R&D activities in the region. For instance, VW employs more than 54,947 people group-wide (8.2% of the total workforce) in R&D, with more than 20% of these (over 10,000 employees in 2019)

being based in its R&D facilities at its headquarters in the city of Wolfsburg (Volkswagen AG, 2019, p.171). Similarly, 762 employees work in its R&D department of the Salzgitter AG (Salzgitter AG, 2019, p.33). Other large firms (e.g., Nordzucker AG and Siemens Mobility) have long been conducting R&D in the region, although the number of R&D workers is significantly lower than the absolute number people working in the R&D facilities of both Salzgitter AG and WV AG (IHK Braunschweig, 2019).

In addition, the region of Braunschweig has a vibrant scientific base which, according to both regional policy-makers and research organisations, "*is second to none in Germany*"(source: forschungregion.de) (see, also Braunschweig Stadtmarketing GmbH, 2009*b*). More than 16,000 people work in 27 research institutes in the region, especially in the city of Braunschweig (source: forschungregion.de). For instance, two of these institutes – i.e., the German Aerospace Center (DLR) and the National Metrology Institute (PTB) – employ nearly 3,000 thousand researchers at their research sites in the city of Braunschweig (source: dlr.de & ptb.de). The region has three research-intense universities, one of which (i.e., the Technical University of Braunschweig) has a long history of producing world-acclaimed research (e.g., Nobel prize winners in physics and chemistry) (Braunschweig Stadtmarketing GmbH, 2009*a*). In 2016, 33,611 students were enrolled in the three universities: Technical University of Braunschweig (19,514 students), Ostafalia University of Applied Sciences (13,104 students), and Braunschweig University of Art (HBK) (993 students) (source: niedersachsen.de/statistik). While the research expertise of the first two universities lies in analytical and synthetic knowledge themes (e.g., aeronautics, automotive, mechanical engineering, meteorology, physics, biology, etc.), HBK's expertise lies in industrial design: "*Braunschweig has a lot of designers, both graphic and industrial; hence, creativity is one of the assets in the region*" (Interview 2).

However, despite the availability of many researchers and students, one of the most significant challenges that innovative firms have been facing since the late 2000s

concerns the lack of skilled labour.

> "*The main difficulty for us as a company is to find and to keep high-qualified personnel such as programmers and that is the main challenge for every company in the region*"
>
> (Interview 10).

> "*There is already a shortage of well-trained workers in individual professions...while at the same time the demand for qualified personnel continues to rise*"
>
> (source: allianz-fuer-die-region.de).

Pay Premium, Talent Attraction, Retention and Gender-Inclusive Strategies

As is the case with the challenge of technological unemployment, innovative firms have responded to skill shortages in a highly differentiated manner. Start-up, small high-tech and knowledge-intensive firms have followed a 'geographical proximity' strategy, in particular seeking to be located near to campuses of universities: "*being near the local university...enables us to contact early-stage computer science students*"(Interview 10). Other science-based firms (e.g., biotechnology and IT) invest in research projects, including funding research professorships, at local universities, to either access scientific knowledge or be part of local research networks, which allows them to hire promising students and researchers. Additional firms (especially mechanical engineering firms) have created cooperative networks (e.g., KIM e.V., TELIAISON e.V.). One of the primary purposes of these cooperatives is to ensure full-time long-term employment for skilled labour. Through this association, firms "*exchange skilled labour based on their production needs*" (source: kim-braunschweig.de). In addition, these associations offer, together with local universities, dual (vocational) training (*Ausbilding*) in several subjects (e.g., plant mechanics, machine and system operators, information technology, logistics, precision mechanics, etc.). This not only

helps regional manufacturing SMEs to cope with skill shortages, but also leads to secure (medium to long-term) employment for skilled labour.

However, as is the case with the challenge of technological unemployment, it is the strategies of very large firms – especially VW AG and Salzgitter AG – in the region which have so far had the most significant impact in regional employment. Although these firms rely heavily upon the institution of vocational training as a means to attract and retain skilled labour (Salzgitter AG, 2019, Volkswagen AG, 2019), the need for high-skilled labour is such that "*VW AG and Salzgitter AG pay 70.000 EUR or 80.000 EUR a year to get young high-skilled professionals into the company*" (Interview 16). For instance, a recent organisational report of the WV AG states that:

> "*The ability to recruit top talent is of decisive importance, particularly in view of the company's transformation into a world-leading provider of sustainable mobility solutions and the associated development of new business fields*"
>
> (Volkswagen AG, 2018, p.150).

In addition to improving its "*external employer attractiveness*"(ibid.), VW AG seeks to create "*an exemplary leadership and corporate culture*" (ibid.) by, among others things, increasing the number of women in its workforce, including "*the proportion of women in management*" (ibid.), from 13.8% in 2018 to 20.2% in 2025 (ibid.).

Unlike the question of technological unemployment, regional policy-makers have approached the question of skill shortages as a major regional challenge, affecting in fundamental respects the competitiveness of regional firms. For instance, "*because VW pays such good salaries, many people go to VW*" (Interview 8). As a consequence of this,

> "*SMEs cannot pay the same salaries as VW does, and many people leave*

the companies to go to VW.....and their innovative potential is not used for other things in the region...that's a big problem"

(Interview 7 & 8).

In addition, an ageing and declining regional population, especially in the periphery of the region, shrinks the regional labour market: "*we have a sinking population, and that is a real problem*" (Interview 17). Hence, one of the major areas of regional policy action is to "*promote the recruitment, development and retention of skilled workers in the region*" (source: allianz-fur-die-Region.de). To this end, several initiatives have been launched by regional organisations as a means to tackle the lack of skilled labour. Among them is establishing a welcome centre for international researchers, managers and skilled workers (source: source: allianz-fur-die-Region.de). Another initiative is to improve the cultural activities in the large cities of the region so that students choose to stay in the region after completing their studies. However, and despite the fact that "*there is employment in the region*" (Interviews 2 & 4), most students prefer to move to the large metropolitan cities of Berlin, Munich and Hamburg.

"*Talent is attracted to big cities such as Berlin, Hamburg etc., and the rural areas have problems finding these younger people*"

(Interview 18).

Another strategy that some cities have sought is to create smaller departments of local universities in the periphery of the region as a means to revive the local economy and to increase the number of students in these places: "*what we tried to do is to get some units out of the university...because it does not make sense certainly to build up a new university*"(Interview 17). Finally, the increasing number of gender-sensitive employment initiatives in the region are seen as central to attracting and retaining skilled labour in the region: "*women prefer to live in big cities such as Hamburg*

and Munich" (Interview 17) rather than in peripheral regions, cities and rural districts which are considered somewhat "*too industrial and boring*" (Interview 2 & 18).

Relevant Empirical Outcomes Since the early 2000s, the number of inhabitants holding a university degree has increased by 55.1% in the region of Braunschweig (source: Eurostat). It was 18.7% in 2002, rising to 29% in 2019. Similarly, the percentage of persons with tertiary education who are also employed in science and technology activities has increased by nearly 20.15%: it was 40.2% in 2008, and rose to 48.3% in 2019 (source: Eurostat). The percentage of women with tertiary education has also increased by 70.63%, from 14.3% to 24.4% in 2019, although the percentage of males in tertiary education was much higher in the same period (33.7%).

Furthermore, as measured by the Eurostat, the rate of participation in ongoing training and education (life-long learning) has increased by 36.78%, from 6.8% in 2002 to 9.3% in 2019. Even though men were the most active life-long learners in 2019 (10.1%), the male/female life-long learning gap has narrowed significantly. For instance, 5.4% of women were engaged in life-long learning activities in 2002, increasing to 8.6% in 2019. Finally, more than 13,321 female students were enrolled for a university degree in the three universities in 2016; however, the percentage of female university students has remained relatively constant (nearly 40%) since 2004 (source: niedersachsen.de/statistik/).

From the standpoint of the SBTC account, a significant increase in the supply of skilled labour implies a downward pressure on skill premiums, and thus also on the wages of skilled labour (Acemoglu, 2002). However, as is shown in Table 4.4, the percentage of taxpayers earning 50,000-125.000 EUR in the region has increased considerably since the late 1990s. In 1998, 14,10% of taxpayers in the region of Braunschweig belonged to this income category, which was just below the national average (14,20%) for the same year. In 2015, this percentage rose to 22.53% – an increase of 59.78% since 1998. The highest percentage of taxpayers earning 55,000-

125,000 EUR per year was observed in the cities of Wolfsburg (26.80%) and Gifhorn (26.56%), followed by the district of Helmstedt (23.88%). Although the first two observations are attributable to the location of VW AG and its suppliers, the third is puzzling, given that the district of Helmstedt has one of the lowest income per capita in the region. One possible explanation for this is that the residence of taxpayers differs from the location of their workplaces (Interviews 2, 8, &18); hence, the most reliable way to look at these trends is by looking at the region of Braunschweig as a whole.

Table 4.4: Taxpayers with Income 55,000-125,000 EUR

Territory	% of taxpayers		
	1998	2015	Change (%)
Braunschweig city	13.93	21.61	55.07
Salzgitter	11.74	18.38	56.55
Wolfsburg	15.21	26.80	76.15
Gifhorn	16.74	26.56	58.70
Goslar	10.70	16.39	53.18
Helmstedt	14.26	23.88	67.40
Peine	14.03	22.23	58.47
Wolfenbüttel	15.92	23.06	44.85
Region of Braunschweig	14.10	22.53	59.78
Germany	14.20	19.54	37.67

Source: own elaboration, regionalstatistik.de

Causal Mechanism$_6$: Gender-Inclusive Competence-Building – Since the mid-2000s, the productive base of the BRIS has, gradually, been undergoing technological transformation (e.g., digitalisation, autonomous driving, green mobility, and environmental sustainability). This has significantly increased the demand for highly-skilled labour in the region. To address skill shortages, focal actors in the BRIS have, among others, actively pursued gender-inclusive skill-building and employment strategies as a means to attract and retain highly-skilled labour in the region. This has, among other things, contributed to narrowing down the gender income gap in the region of Braunschweig.

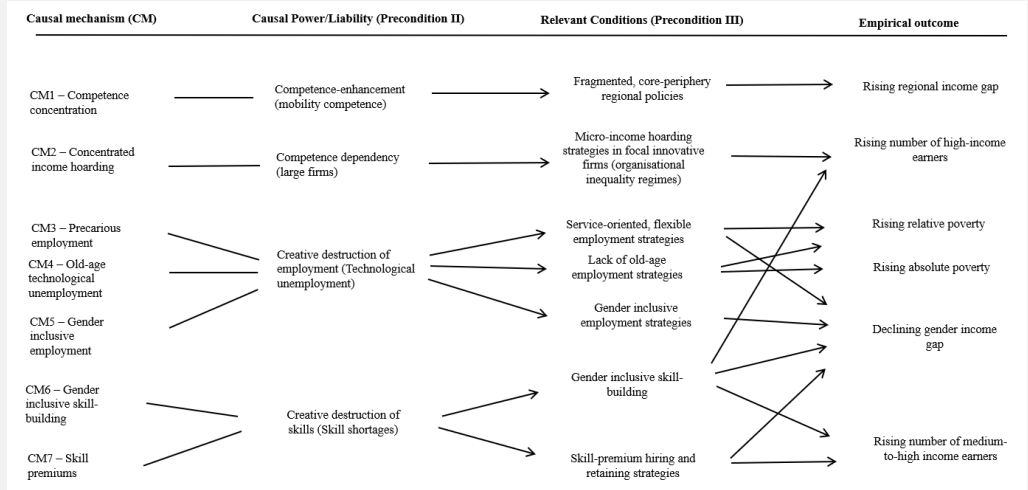
Causal Mechanism$_7$: Skill Premiums – Although focal actors in the BRIS have collectively devised strategies (e.g., vocational training, attention and retention strategies) to address the rising demand for skilled labour, there is still a significant shortage of skilled labour in the region. To cope with this issue in a timely manner, innovative firms pay higher salaries to attract highly-skilled labour. This, among other things, has contributed to an increase in the percentage of medium-to-high income earners in the region of Braunschweig (empirical outcome).

4.5 Concluding Discussion, Implications, Limitations and Suggestions

4.5.1 Causal Mechanisms and Theoretical Relevance

This study was among the first to systematically investigate how an IS shapes the distribution of income. Specifically, based on a causal-explanatory case study analysis of one of Germany's most innovative regions, the analysis has identified seven operative causal mechanisms, five of which induce inequality, while two mechanisms reduce inequality. Figure 4.5 provides a schematic overview of each causal mechanism's underlying composition. In a nutshell, the figure in question confirms that each causal mechanism exercises a differential impact on the distribution of income. For instance, while the causal mechanisms of precarious employment (CM3) and old-age technological unemployment (CM4) increase the relative poverty ratio, the causal mechanisms of concentrated-income hoarding (CM2) and skill premiums (CM7) increase the percentage of medium-to-high and higher-income earners. When combined, these four causal mechanisms exercise a polarising impact on the distribution of income in the region of Braunschweig. Thus, while the analysis has unpacked the composition of

Figure 4.5: Causal Mechanisms



two well-known causal mechanisms (CM3 and CM7) (Acemoglu, 2002, Van Reenen, 2011, Frey and Osborne, 2017), and some relatively lesser-known (CM2 and CM5) (Lazonick and Mazzucato, 2013, Echeverri-Carroll et al., 2018, Tomaskovic-Devey and Avent-Holt, 2019), it has also identified three new causal mechanisms, namely competence concentration (CM1), old-age technological unemployment (CM4), and gender-inclusive competence-building (CM6). In this regard, the present study has not only confirmed that ISs are of significance when it comes to our understanding of how innovation produces inequality, but has also deepened our understanding of the underlying composition of four relatively well-known causal mechanisms, whilst producing knowledge about three largely-unknown causal mechanisms.

Furthermore, and as illustrated in Figure 4.5, the fact that it is the strategies of focal actors that give rise to a set of causal mechanisms, which – in turn – could produce the same empirical outcome (i.e., rising or declining inequality) suggests that seeking to identify the 'overarching cause(s)' in the relationship between innovation and inequality is not only counterproductive to knowledge acquisition, but also contradicts the context-specific nature of causality in general, and causal mechanisms in particular. In fact, the same causal tendency (e.g., technological unemployment and skill shortages) can produce a radically different causal effect on the distribution of

income, once combined with a corresponding strategic response on the part of focal actors. This finding is in contrast with previous research on innovation and inequality which, in addition to remaining oblivious to the systemic character of innovation, sees rising inequality as the primary outcome of technological change responding to either/both market signals and/or institutional changes (e.g., Acemoglu, 2002, Autor et al., 2008, Kristal, 2019). This research reveals that, despite facing similar market challenges and operating under a common (national and regional) institutional framework, focal actors utilise a highly-heterogeneous mix of organisational strategies to deal with key challenges in the innovation process. As a result of this, they exercise a highly-complex causal impact on the distribution of income.

An important question that arises from the analysis in the region of Braunschweig concerns the question of *intentionality*. In other words, are the organisational strategies pursued by focal actors in the region of Braunschweig intentionally designed to induce or reduce inequality? This study shows that whilst most of the organisational strategies that focal actors construct as a means to address key challenges in the innovation process are not intentionally pursued to increase inequality, they – nonetheless – lead to inequality. For instance, while regional innovation policy initiatives are *intentionally* designed to boost the innovative capability and competitiveness of the region of Braunschweig, they have *unintentionally* increased inequality by intensifying the regional income gap among the constituent cities. Other strategies, however, are intentionally pursued to exacerbate inequality such as when certain organisational actors, top managers and business executives, construct narrative strategies to justify excessive pay raises and bonuses. However, what is evident from the analysis, in particular by the identification of two causal mechanisms that reduce gender inequality (i.e., CM6 and CM7), is that ameliorating inequality through the innovation process is a collective, intentional achievement in the sense that it requires the alignment of organisational strategies of focal (triple-helix) actors.

4.5.2 Analytical and Policy Implications

An important question that arises from the analysis in this study is that of *external validity*, namely to what extent are the identified causal mechanisms active in other innovative places across the world (Lee, 2011, Breau et al., 2014)? This question attains further significance if we consider that, like all ISs, RISs are structurally heterogeneous (Braczyk et al., 1998) and that the strategies of focal actors are extremely unlikely to be identical. However, the underlying composition in each causal mechanism (i.e., combinations of causal powers and relevant conditions) allows us to develop two generalisable theoretical propositions about the relationship between RISs and inequality.

> ***Theoretical proposition I****: RISs* ***exacerbate*** *inequality when focal actors, either intentionally or unintentionally, devise and adopt a mix of inequality-friendly and tolerant strategies as a means to address key problems and challenges that they encounter during the various stages of the innovation process.*

> ***Theoretical proposition II****: RISs* ***ameliorate*** *inequality when focal actors intentionally devise a mix of inclusive strategies as a means to address key problems and challenges that they encounter during the various stages of the innovation process.*

These two theoretical propositions have two interesting policy implications. First, the fact that it is the organisational strategies of focal actors in RISs that shape the causal aspects in the innovation-inequality nexus underlines that rising inequality is not necessarily an unavoidable, negative externality of innovation-driven growth in an increasingly globalising world, but rather it seems to be the outcome of strategic choices; hence, innovation policies can make a difference in this regard. Second, while RISs can, indeed, constitute a structural determinant of unequal growth, the

solution also lies within them: As the case of the region of Brunswick illustrates, RISs offer a ready-made, yet largely-underutilised, platform (or arena) to establish 'strategic coalitions' among focal actors which are favourable to inclusive growth in innovative regions.

4.5.3 Limitations and Suggestions

This study has a few limitations which, despite some intense efforts, could not be addressed. Although the primary purpose of this study was not to gauge income inequality in the most precise way possible but to identify active causal mechanisms through which innovation shapes the distribution of income, the data analysis process could have greatly benefited from the availability of demographic data (i.e., age and gender) about the population of taxpayers in the region of Braunschweig. Similarly, due to the lack of wealth data, this study could not investigate or trace causal mechanisms through which innovation affects alternative forms of economic inequality such as wealth inequalities (Piketty, 2014). Besides such common data limitations, future research could utilise the proposed conceptual model to search for an amalgam of (competing and complementary) causal mechanisms through which innovation as a collective activity shapes income distribution in contemporary societies. This is a promising research effort which, as shown throughout the present study, deserves the attention of innovation (system) researchers.

Chapter 5

Conclusion: Findings, Contribution, Implications and Limitations

5.1 Introduction

This thesis sought to investigate how innovation affects the distribution of income. It began by outlining the research background, motivation, problem and research questions (Chapter 1), before providing a systematic review of three decades of research on innovation and inequality (Chapter 2). Subsequently, it addressed the case study paradox in the field of innovation studies (Chapter 3) through a dialectical methodological analysis. Finally, it developed a conceptual model and identified, via an in-depth case study analysis, seven causal mechanisms through which a RIS in Germany shapes the distribution of income (Chapter 4).

This chapter weaves together the main findings of the three previous chapters. The remainder of the present chapter consists of four main sections. Section 5.2 responds to the research problem by reiterating each chapter's main findings, and by responding to each research question, as well as by relating the main findings of each chapter to the overall research problem in this thesis. Section 5.3 discusses the contribution

and implications of this thesis, whereas Section 5.4 discusses limitations and makes suggestions for future research. Lastly, Section 5.5 concludes this chapter, and thus also this thesis, with a summary.

5.2 Revisiting RQs and Research Problem

5.2.1 RQI – Innovation, Inequality and Causal Mechanisms

The first research question in this thesis was motivated by the issue of causal mechanisms, particularly whether the extant research on innovation and inequality investigates causal mechanisms.

> *Research Question I* - ***Does the extant research on innovation and inequality identify causal mechanisms? If yes, which ones? If no, how could a set of possible causal mechanisms be conceptualised before a fully-fledged empirical study has been conducted?***

To address this research question, Chapter 2 reviewed, in a systematic manner, the existing empirical literature (n = 166 studies) on innovation and inequality. One of the main findings of Chapter 2 is that, despite sustained cross-disciplinary research on innovation and inequality (e.g., nine research themes), the great majority of studies apprehend causality in the form of empirical regularities; hence the fact there is no study that has explicitly looked at the question of causal mechanisms. To address this omission, Chapter 2 utilised the critical realist approach to causal mechanisms as the theoretical foundation to hypothesise and conceptualise eight possible causal mechanisms. In this process, key elements from the most relevant contributions in the literature were integrated to conceptualise hypothetical, yet idealised, prototypes of the following eight causal mechanisms: (1) skill premiums, (2) competence concentration, (3) technological unemployment, (4) precarious employment, (5) new po-

sition closure, (7) inclusive competence-building, (7) inclusive employment, and (8) (Schumpeterian) social mobility.

5.2.2 RQII – Case Study Research on Innovation and Inequality

As shown in Chapter 2, the great majority of studies on innovation and inequality adopt an advanced 'hard' quantitative research design (e.g., regression analysis, econometrics), whereas only a very small fraction of studies (less than 10%) use 'soft' research designs such as case study. This, among other things, confirms the prevalence of the deductive thesis in the relevant literature, whereby case study research on innovation and inequality cannot ascertain the general aspects of causality; despite this, however, and as shown in Chapters 3 and 4, case study research is capable of addressing the questions of causality and generality. It was such contradictory methodological implications that, in the first instance, motivated the second research question in this thesis.

> *Research Question II* - ***Is a case study analysis on innovation and inequality capable of identifying a set of causal mechanisms through which innovation affects the distribution of income in contemporary capitalist societies? If yes, to what extent are the findings of such a type of analysis generalisable?***

Based on a dialectical analysis of the case study paradox in the field of IS studies, it was shown in Chapter 3 of this thesis that case study research is not only capable of teasing out and analysing active causal mechanisms in real-life, dynamic and causally-complex settings, but also necessary to do so. In this regard, the methodological significance of case study research lies in its ability to discern the existence of countervailing causal mechanisms, whilst unpacking their underlying composition (i.e., dynamic configurations of causal powers and relevant conditions). It seems that,

and as illustrated in Chapter 4, an advanced statistical analysis of causality is, *especially on its own*, unable to capture the operation of mutually reinforcing and competing for causal mechanisms, including the highly heterogeneous mix of organisational strategies that actors in ISs devise as a means to tackle key challenges in the innovation process. Thus, from the standpoint of causal mechanisms theory, the thorny question of scientific generalisation is neither a purely empirical issue (statistical generalisation) nor a theoretical one (analytical generalisation), but – and as stipulated by the retroductive antithesis in Chapter 3 – it is primarily an *ontological question* concerning the underlying causal properties of ISs.

5.2.3 RQIII – ISs and Inequality

As mentioned throughout this thesis, the IS approach is the most popular theoretical perspective on innovation in the social science (Rakas and Hain, 2019). Despite this, there is a significant lack of studies on ISs and inequality. This neglect seems quite surprising, given that, as several studies have shown, inequality has risen at a higher pace in innovative places – such as cities, regions and nations – than in less innovative ones (e.g., Van Reenen, 2011, Breau et al., 2014, OECD, 2015, Florida and Mellander, 2016). It was such a research omission which led to the formation of the third research question in this thesis.

Research Question III - ***What are the causal mechanisms through which ISs shape the distribution of income in contemporary societies? Is the overall causal impact of ISs on inequality positive or negative?***

Chapter 4 provided one of the first in-depth, causal-explanatory case study analyses of one of Germany's most innovative regions. The analysis unearthed two sets of causal mechanisms: two causal mechanisms which reduce inequality (i.e., gender-inclusive competence-building and employment) and five causal mechanisms inducing

inequality (i.e., competence concentration, concentrated-income hoarding, precarious employment, old-age technological unemployment, and skill premiums). While the identification of these causal mechanisms enhances our understanding of the typology of causal mechanisms, which was developed in Chapter 2, it also suggests that, from the standpoint of the proposed typology, the intensification, rather than the amelioration, causal scenario seems to prevail in the region of Braunschweig. This is also consistent with the key findings in Chapter 2, whereby most studies on innovation and inequality confirm that innovation induces inequality.

5.2.4 Research Problem

What do the main findings of each chapter tell us about the overarching problem in this thesis; namely, ***how does innovation as a collective activity shape the distribution of income?*** The analysis in this thesis leads to the following response to the research problem: *(a) innovation as a collective activity simultaneously affects the distribution of income both positively and negatively; (b) it does so by encompassing a set of inequality-inducing and reducing causal mechanisms; and (c) causal mechanisms emerge when focal (for-profit and non-profit) innovating actors design and utilise, either intentionally or unintentionally, a mix of strategies to confront key challenges in the innovation process*.

5.3 Contribution and Implications

5.3.1 Contribution

The analysis in this thesis contributes to two main kinds of literature: the literature on innovation and inequality, and the literature on ISs. Specifically, by systematically reviewing the extant literature on innovation and inequality, as well as by identify-

ing nine research themes, this thesis converts a highly-fragmented body of research into an explanatory typology of eight causal mechanisms, the explanatory power of which was also illustrated through a concrete case study analysis. In doing so, this research shows that there is much more to the relationship between innovation and inequality than research informed by the SBTC account, including its principal antagonist, namely the RRN framework, have let us believe. For instance, while the SBTC account assigns causality to two causal mechanisms, and the RRN framework to the distributions of risks and rewards in the innovation process, this study attributes the relationship between innovation and inequality to an amalgam of antagonistic and mutually-reinforcing causal mechanisms. Similarly, and unlike both SBTC and RRN accounts, which take an'either-or' perspective on the direction of causality (i.e., innovation either reinforces or lessens inequality), this thesis demonstrates that, depending upon the focal actors' strategies, innovation simultaneously induces and reduces inequality through seven causal mechanisms. Lastly, in contrast with existing research on innovation and inequality, which has – to date – paid very little attention to actors' strategies, this work not only unraveled the black box of organizational strategies, but also showed how these strategies are causally related to rising or falling inequality. This finding is of significance to both future studies and, as will be discussed below, policy action.

Furthermore, and unlike both SBTC and RRN accounts, which take an'either-or' perspective on the direction of causality (i.e., innovation either reinforces or lessens inequality), this thesis demonstrates that, depending upon the focal actors' strategies, innovation simultaneously induces and reduces inequality through seven causal mechanisms. Similarly, this thesis underlines that the SBTC, and in part the RRN, take a methodological individualist perspective on how innovation affects inequality (Hodgson, 2007); thus not only neglecting the co-evolutionary nature of 'agency-structure' interactions in ISs, but also the latter's multi-level and nested hierrarchy (Markard and Truffer, 2008, Weber and Truffer, 2017, Asheim et al., 2020, Radosevic, 2022). Lastly, in contrast with existing research on innovation and inequality, which has –

to date – paid very little attention to actors' strategies, this work not only unravelled the black box of organizational strategies, but also showed how these strategies are causally related to rising or falling inequality. This finding is of significance to both future studies and, as will be discussed below, policy action.

In addition, by being the very first to dialectically interrogate the paradoxical status of case study research on ISs, this thesis has debunked a number of chronic methodological inaccuracies and misconceptions, whilst also clearing the methodological ground for a new type of causal explanatory analysis based on the RME. In doing so, this thesis provides a new methodological understanding (i.e., the dependency synthesis), enabling future explanatory case studies on ISs to articulate their epistemological significance and relevance in a manner that otherwise would have been difficult, if not impossible.

Finally, this thesis makes a few interesting practical methodological contributions to a growing concern with CR within the field of innovation ISs (Castellacci, 2006, Koutsouris, 2012, Adamides, 2018), and innovation studies in general (Papachristos and Adamides, 2016, Sorrell, 2018, Svensson and Nikoleris, 2018). First, by explicitly articulating the retroductive antithesis, and systematically applying it in the RIS of Braunschweig region, this thesis demonstrates how the RME can be utilised as the methodological foundation in case study research on ISs. Second, by utilising key aspects of the critical realist approach (e.g., retroductive theorising), and by developing a critical realist-informed conceptual model based on a creative conceptualisation of the current stock of knowledge on ISs, this study provides a critical realist-informed, yet actionable approach for, case study research which seeks to study the causal mechanisms through which ISs can affect the distribution of income. Lastly, by teasing out seven causal mechanisms in a real-life context, this thesis illustrates how a fully-fledged, mixed-method critical realist-informed case study analysis on ISs looks, and what it can achieve in terms of causal explanation.

5.3.2 Analytical and Policy Implications

Several interesting analytical and policy implications emanate from this thesis.

First, in contrast with the increasingly held, yet implicit, belief among innovation researchers that mathematical modelling, hypothesis-testing, and advanced statistical analysis are necessary ingredients of causal-explanatory research (Martin, 2016, p.440), this thesis shows that, in the end, it is through well-crafted case studies that we can learn the most about the causal mechanisms through which innovative activities induce or reduce inequality. This, in turn, underlines that the quantitative turn in the field of ISs (Chaminade et al., 2018) may, after all, be based on the misleading, yet detrimental to knowledge progress, belief that identifying statistically significant associations among variables is equivalent to knowing the causal mechanisms under which the systemic character of innovation produces the flux of economic events in the world.

Second, and as shown in the core chapters of this thesis, various causal mechanisms of innovation can produce the same empirical outcome (i.e., rising or declining inequality). This, among other things, suggests that a purely statistical analysis of the relationship between innovation and inequality is very likely to fail, *especially on its own* [1], to enhance our knowledge of the myriad of causal possibilities through which the causal powers and liabilities of the innovation process combine with the strategies of focal actors to form causal mechanisms that could either induce or reduce inequality. However, it also implies that such a type of analysis may, after all, not be that helpful when it comes to informing a new type of inequality-sensitive innovation

[1] An interesting methodological possibility is to use (fuzzy-set) qualitative comparative analysis (QCA) to study causal mechanisms (Ragin, 2008, Marx et al., 2014). By combining elements from comparative case-oriented research, set theory and Boolean algebra (Marx et al., 2014), the QCA is believed to enjoy some of the strengths of qualitative and quantitative research methods (Ragin, 2008, Greckhamer et al., 2018). While this method has, to date, not been utilised to study causal mechanisms in the relationship between innovation and inequality, future research could use the method in question to explore possible causal configurations by using a relatively small number of qualitatively (theory-informed) chosen statistical variables. This could potentially be a useful complement to retroductive case study research on ISs and inequality.

policy (Zehavi and Breznitz, 2017, Schot and Steinmueller, 2018).

Third, and as shown in Chapter 4, it is the strategies of focal actors in RISs that give rise to a number of important causal mechanisms. This finding confirms that the strategies of innovating firms and support organisations are not only vital to our understanding of the uneven geography of innovation (Asheim and Gertler, 2005, Feldman and Kogler, 2010) but also – as far as the relationship between innovation and inequality is concerned – significant causality occurs in the intersection between organisational strategies and regional context. This analytical implication casts some fresh light on regional innovation policy action.

Specifically, and as illustrated by the case study region of Braunschweig, particularly by the identification of two causal mechanisms that lessen inequality (i.e., gender-inclusive employment and skill-building), the alignment of strategic responses of focal actors is necessary to transform inclusive growth from a buzz, yet quite fuzzy, concept to a concrete socioeconomic outcome (Lee, 2019). To this end, the RIS approach can act as a catalyst for achieving inclusive growth. First, it can be utilised as the basis for designing broad-based regional innovation policies aimed at creating and nurturing region-specific spaces of strategic action, which are favourable to inclusive growth; second, the existing anatomy of RISs provides a ready-made platform to policy-makers, including other actors (e.g., universities, business associations and civil society organisations), who would like to initiate a discussion on what kind of place-specific 'strategy spaces' could be created and nurtured over time as a means to achieve inclusive growth in an increasingly globalising world. The formation of strategy spaces is of relevance to not only advanced regions but also to less advanced regions, including what Trippl et al. (2019) call 'intermediate regions'. Policy-makers in intermediate and less-developed regions often seek to plug regional assets (e.g., natural resources, research-intensive universities and cost-competitive human capital) into global value chains (Gereffi et al., 2005) as a means to either escape technological lock-ins or achieve regional competitiveness and growth by, for instance, attracting the

production activities of MNEs (Radosevic, 2018). As a result of this, these regions are often among the first to experience the negative effects of organisational restructuring, radical technological innovation and global economic crises.

The aforementioned implications are also relevant for the Smart Specialisation (SS) approach in general, and the vivid academic discourse that surrounds it in particular. Since the early 2010s, SS has become a major pillar for regional innovation policy action in the EU (Foray, 2014, Foray et al., 2018). Like the RIS approach, the SS approach offers a framework of regional policy action, particularly by providing insights into how regional actors could create and mobilise existing region-specific paths of growth and assets to boost regional innovative capability, competitiveness, growth, and endogenous development in a globalising world (McCann and Ortega-Argilés, 2013, Foray, 2014, Foray et al., 2018). However, and as is the case with the RIS approach, and the field of innovation studies in general, the SS approach has, thus far, paid no attention to the distribution of economic rewards within and between regions, including the destructive effects of regional innovation activities (cf. Carayannis and Rakhmatullin, 2014, Martin, 2016, Hassink and Gong, 2019, Biggi and Giuliani, 2021). While this confirms that the SS approach is erected upon a 'developmental' rather than a 'redistributive' logic of innovation-driven growth and policy (Capello and Kroll, 2016), the analysis in the present thesis implies that SS-inspired regional innovation policies are more likely to be genuinely 'smart'[2], when they are explicitly designed in such a way to foster consensus-building among regional innovation actors, especially on what kind of common, customised strategies must be devised during and after the "entrepreneurial discovery process" (Foray, 2014, p.494) in order to make innovation-driven growth more equitable and sustainable than hitherto.

[2]As Asheim et al. (2019, p.116) rightly point out, 'smart' implies 'sustainable' and 'inclusive' growth.

5.4 Limitations and Suggestions

This thesis has a few limitations which, in turn, provide not only food for thought, but also direction for future research. These limitations emanate from each of the constituents' papers in this thesis (Chapters 2-4), which are, for the sake of explication, reiterated below.

The systematic review in Chapter 2 was based on data taken from the Scopus database. Compared to the Web of Science database, the Scopus database contains almost twice as many publications on innovation and inequality as the Web of Science database. Due to this, the data collection process may have, unintentionally, excluded a few studies which are not included in the Scopus database. Similarly, due to time considerations and pragmatic reasons (e.g., the popularity of Skills theme), Chapter 2 did not use advanced bibliographic techniques (e.g., co-citation analysis and bibliographical coupling). Given the increasing number of published studies on innovation and inequality, future studies could utilise advanced bibliographic methods as a means to enhance our knowledge of the nine research themes, as these have been discussed in Chapter 2.

Chapter 3 provided a methodological analysis of the case study paradox in the field of IS studies. The dialectical method is a philosophical method, encompassing abstract, logical reasoning. Due to this, Chapter 3 sought to identify and compare essential methodological features and implications of the deductive thesis and the retroductive antithesis, rather than to provide a thorough methodological analysis of studies using either the HDME or the RME. Although this somewhat necessary omission has no significant impact on the quality of the analysis in Chapter 3, future research could look more closely into the methodological design of case study research on ISs as a means to enhance our understanding of both deductive and retroductive theses.

Although the primary purpose of Chapter 4 was to identify causal mechanisms through which ISs shape the distribution of income, the analysis in Chapter 4 was, to

some extent, restricted by the lack of a demographic (age and gender) sensitive dataset about the population of taxpayers in the region of Braunschweig. Given the provision of an appropriate dataset, future research could utilise the proposed conceptual model in Chapter 4 to search for an amalgam of (competing and complementary) causal mechanisms through which collectivities of innovating actors (e.g., ISs, clusters, innovation ecosystems) shape the distribution of income in contemporary societies. This is a promising research effort as we, currently, know very little about the causal mechanisms through which innovation as a collective process does both simultaneously, namely exacerbating and ameliorating inequality.

Finally, a few words need to be said here about the question of external validity, namely to what extent are the overall findings of this thesis "*generalisable beyond the immediate case study*"(Yin, 2009, p.49)? This question is noteworthy, as the present thesis draws most of its empirical material from the case study analysis in Chapter 4. While an extended version of this chapter would have qualified for the standard 'book-format' PhD thesis, the question of external validity would still constitute, especially from the standpoint of the deductive thesis (Chapter 3), a major limitation. This thesis approaches the question of external validity from the standpoint of the RME, and CR in general. As discussed in Chapter 3, the question of external validity does not undermine the epistemological significance of the findings of this thesis. The underlying reasoning is that externally valid knowledge about the relationship between innovation and inequality lies not in the empirical domain (e.g., empirical regularities) but in the causal capabilities of ISs, regardless of the empirical events generated by the functioning of ISs. Thus, from the standpoint of CR, the findings of this study imply that innovation as a collective-systemic process shapes the distribution of income, either positively or negatively, depending on the strategies of focal actors.

5.5 Concluding Remarks

This thesis has dealt with a highly-overlooked question, namely how does innovation as a collective, multi-actor activity shape income distribution in modern-day societies? To address this question, the present study articulated three related research questions; the development of each question was motivated by the existence of an appropriate research gap in the relevant literature. By utilising a tripartite methodology, this thesis shows that (a) there exists a rapidly-growing literature on innovation and inequality, although the existing literature (b) fails to explicitly address the question of causal mechanisms; (c) a promising, yet not sufficient on its own, way of conceptualising and analysing causal mechanisms is by using the critical realist approach to causal mechanisms as the underlying methodological foundation; (d) ISs are capable of simultaneously increasing and decreasing inequality; (e) it is the strategies of focal actors in ISs that facilitate the emergence of several causal mechanisms; (f) retroductive case study research on innovation and inequality is capable of producing generalisable knowledge about causality; lastly, (g) reducing inequality through inclusive growth in contemporary societies may not only require the reinforcement of 'old-fashioned' institutional mechanisms (e.g., progressive income taxation, increasing minimum wages, collective labour agreements and bargaining in low-wage service sectors) (e.g., Donegan and Lowe, 2008, Piketty, 2014), but also – and especially as far as innovative cities and regions are concerned – the formation of common spaces of strategic action in RISs.

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Appendix A

Studies on Innovation and Inequality

	Author	Year		Title	Journal	Field	Citations (Google Scholar*)
1	Frey C.B., Osborne M.A.		2017	The future of employment: How susceptible are jobs to computerisation?	Technological Forecasting and Social Change	Innovation studies	6,906
2	Autor D.H., Katz L.F., Kearney M.S.		2008	Trends in U.S. wage inequality: Revising the revisionists	Review of Economics and Statistics	Economics	2,807
3	Krueger A.B.		1993	How computers have changed the wage structure: Evidence from microdata, 1984–1989	Quarterly Journal of Economics	Economics	2,055
4	Krusell P., Ohanian L.E., Ríos-Rull J.-V., Violante G.L.		2000	Capital-skill complementarity and inequality: A macroeconomic analysis	Econometrica	Economics	2,012
5	Lemieux T.		2006	Increasing residual wage inequality: Composition effects, noisy data, or rising demand for skill?	American Economic Review	Economics	1,119
6	Dustmann C., Ludsteck J., Schönberg U.		2009	Revisiting the german wage structure	Quarterly Journal of Economics	Economics	1,066
7	Attanasio O., Goldberg P.K., Pavcnik N.		2004	Trade reforms and wage inequality in Colombia	Journal of Development Economics	Economics, development economics	677
8	Jaumotte F., Lall S., Papageorgiou C.		2013	Rising income inequality: Technology, or trade and financial globalization?	IMF Economic Review	Economics	641
9	Bernard A.B., Jensen J.B.		1997	Exporters, skill upgrading, and the wage gap	Journal of International Economics	Economics	630
10	Bresnahan T.F.		1999	Computerisation and wage dispersion: An analytical reinterpretation	Economic Journal	Economics	491
11	Liu K.-H., Tomaskovic-Devey D.		2013	Financialization and U.S. income inequality	American Journal of Sociology	Sociology	432
12	Baldwin R.E., Cain G.G.		2000	Shifts in relative U.S. Wages: The role of trade, technology, and factor endowments	Review of Economics and Statistics	Economics	310
13	Meschi E., Vivarelli M.		2009	Trade and Income Inequality in Developing Countries	World Development	Development studies	304
14	Haskel J., Slaughter M.J.		2001	Trade, technology and U.K. wage inequality	Economic Journal	Economics	284
15	Esquivel G., Rodríguez-López J.A.		2003	Technology, trade, and wage inequality in Mexico before and after NAFTA	Journal of Development Economics	Economics, development economics	279
16	Faggio G., Salvanes K.G., van Reenen J.		2010	The evolution of inequality in productivity and wages: Panel data evidence	Industrial and Corporate Change	Innovation studies	277
17	Freebairn D.K.		1995	Did the Green Revolution Concentrate Incomes? A Quantitative Study of Research Reports	World Development	Development studies	234
18	Arndt C., Benfica R., Tarp F., Thurlow J., Uaiene R.		2010	Biofuels, poverty, and growth: A computable general equilibrium analysis of Mozambique	Environment and Development Economics	Economics, development economics, environmental economics	233
19	Aghion P., Akcigit U., Bergeaud A., Blundell R., Hemous D.		2019	Innovation and Top Income Inequality	Review of Economic Studies	Economics	227
20	Fernandez R.M.		2001	Skill-biased technological change and wage inequality: Evidence from a plant retooling	American Journal of Sociology	Sociology	223
21	Kijima Y.		2006	Why did wage inequality increase? Evidence from urban India 1983-99	Journal of Development Economics	Economics, development economics	209
22	Juhn C., Ujhelyi G., Villegas-Sanchez C.		2014	Men, women, and machines: How trade impacts gender inequality	Journal of Development Economics	Economics, development economics	183
23	Martin S.P., Robinson J.P.		2007	The income digital divide: Trends and predictions for levels of internet use	Social Problems	Sociology	182
24	Chakraborty J., Bosman M.M.		2005	Measuring the digital divide in the United States: Race, income, and personal computer ownership	Professional Geographer	Geography	181
25	Greenwood J., Guner N., Kocharkov G., Santos C.		2016	Technology and the changing family: A unified model of marriage, divorce, educational attainment, and married female labor-force participation	American Economic Journal: Macroeconomics	Economics, macroeconomics	176
26	Comin D., Mestieri M.		2018	If technology has arrived everywhere, why has income diverged?	American Economic Journal: Macroeconomics	Economics, macroeconomics	176
27	Black S.E., Lynch L.M., Krivelyova A.		2004	How workers fare when employers innovate	Industrial Relations	Industrial, work and employment relations	174
28	Kristal T.		2013	The Capitalist Machine: Computerization, Workers' Power, and the Decline in Labor's Share within U.S. Industries	American Sociological Review	Sociology	168
29	Handel M.J., Gittleman M.		2004	Is there a wage payoff to innovative work practices?	Industrial Relations	Industrial, work and employment relations	161
30	McCall L.	2000a		Explaining levels of within-group wage inequality in U.S. labor markets	Demography	Sociology	150
31	Subramanian A., Qaim M.		2009	Village-wide Effects of Agricultural Biotechnology: The Case of Bt Cotton in India	World Development	Development studies	144
32	Stockhammer E.		2017	Determinants of the Wage Share: A Panel Analysis of Advanced and Developing Economies	British Journal of Industrial Relations	Industrial, work and employment relations	141
33	Ge S., Yang D.T.		2014	Changes in china's wage structure	Journal of the European Economic Association	Economics	129
34	Hilbert M.		2010	When is cheap, cheap enough to bridge the digital divide? Modeling income related structural challenges of technology diffusion in Latin America	World Development	Development studies	122
35	McCall L.	2000b		Gender and the new inequality: Explaining the college/ non-college wage gap	American Sociological Review	Sociology	122
36	Tansel A., Bodur F.B.		2012	Wage inequality and returns to education in Turkey: A quantile regression analysis	Review of Development Economics	Economics, development economics	108
37	Belman D.L., Monaco K.A.		2001	The effects of deregulation, de-unionization, technology, and human capital on the work and work lives of truck drivers	Industrial and Labor Relations Review	Industrial, work and employment relations	107
38	Florida R., Mellander C.		2016	The Geography of Inequality: Difference and Determinants of Wage and Income Inequality across US Metros	Regional Studies	Geography	103
39	Commander S., Kollo J.		2008	The changing demand for skills: Evidence from the transition	Economics of Transition	Economics	102
40	Doussard M., Peck J., Theodore N.		2009	After deindustrialization: Uneven growth and economic inequality in "Postindustrial" Chicago	Economic Geography	Geography	100
41	Fuchs C.		2009	The role of income inequality in a multivariate cross-national analysis of the digital divide	Social Science Computer Review	Other social sciences	99
42	Lee N., Rodríguez-pose A.		2013	Innovation and spatial inequality in Europe and USA	Journal of Economic Geography	Geography	98
43	Adams S.		2008	Globalization and income inequality: Implications for intellectual property rights	Journal of Policy Modeling	Economics	93
44	Xu B., Li W.		2008	Trade, technology, and China's rising skill demand	Economics of Transition	Economics	89
45	Wei Y., Liu X., Song H., Romilly P.		2001	Endogenous innovation growth theory and regional income convergence in China	Journal of International Development	Development studies	84
46	Blum B.S.		2008	Trade, technology, and the rise of the service sector: The effects on US wage inequality	Journal of International Economics	Economics	82
47	Adermon A., Gustavsson M.		2015	Job Polarization and Task-Biased Technological Change: Evidence from Sweden, 1975-2005	Scandinavian Journal of Economics	Economics	79
48	Lindley J., Machin S.		2014	Spatial changes in labour market inequality	Journal of Urban Economics	Geography	77
49	Perugini C., Pompei F.		2009	Technological change and income distribution in Europe	International Labour Review	Industrial, work and employment relations	73
50	Vona F., Patriarca F.		2011	Income inequality and the development of environmental technologies	Ecological Economics	Economics, environmental economics	71
51	Cozzi G., Impullitti G.		2010	Government spending composition, technical change, and wage inequality	Journal of the European Economic Association	Economics	68
52	Jerzmanowski M., Nabar M.		2013	Financial development and wage inequality: Theory and evidence	Economic Inquiry	Economics	66
53	Breau S., Kogler D.F., Bolton K.C.		2014	On the Relationship between Innovation and Wage Inequality: New Evidence from Canadian Cities	Economic Geography	Geography	62
54	Borghans L., ter Weel B.		2007	The diffusion of computers and the distribution of wages	European Economic Review	Economics	58
55	Gaggl P., Wright G.C.		2017	A short-run view of what computers do: Evidence from a UK tax incentive	American Economic Journal: Applied Economics	Economics	58
56	Machin S.		1998	Recent shifts in wage inequality and the wage returns to education in Britain	National Institute Economic Review	Economics	56
57	Lee J.-W., Wie D.		2015	Technological change, skill demand, and wage inequality: Evidence from Indonesia	World Development	Development studies	56
58	Kristal T., Cohen Y.		2017	The causes of rising wage inequality: The race between institutions and technology	Socio-Economic Review	Economics, Sociology	55
59	Wheeler C.H.		2005	Cities, skills, and inequality	Growth and Change	Geography, development studies	49
60	Gibson C.		2003	Digital divides in New South Wales: A research note on socio-spatial inequality using 2001 Census data on computer and Internet technology	Australian Geographer	Geography	47
61	Pastor M., Jr., Marcelli E.A.		2000	Men n the hood: Skill, spatial, and social mismatch among Male workers in Los Angeles County	Urban Geography	Geography	47
62	Roser M., Cuaresma J.C.		2016	Why is Income Inequality Increasing in the Developed World?	Review of Income and Wealth	Economics	46
63	Lee N.		2011	Are innovative regions more unequal? evidence from Europe	Environment and Planning C: Government and Policy	Geography	45
64	Ding S., Meriluoto L., Reed W.R., Tao D., Wu H.		2011	The impact of agricultural technology adoption on income inequality in rural China: Evidence from southern Yunnan Province	China Economic Review	Economics	43
65	Falkinger J., Zweimüller J.		1997	The impact of income inequality on product diversity and economic growth	Metroeconomica	Economics	43
66	Alene A.D., Coulibaly O.		2009	The impact of agricultural research on productivity and poverty in sub-Saharan Africa	Food Policy	Other multidisciplinary, food studies	43
67	Močnik D., Širec K.		2010	The determinants of Internet use controlling for income level: Cross-country empirical evidence	Information Economics and Policy	Economics, technology	40
68	Weinhold D., Nair-Reichert U.		2009	Innovation, Inequality and Intellectual Property Rights	World Development	Development studies	40
69	Echeverri-Carroll E., Ayala S.G.		2009	Wage differentials and the spatial concentration of high-technology industries	Papers in Regional Science	Geography	38
70	MacPhail F.		2000	What caused earnings inequality to increase in Canada during the 1980s?	Cambridge Journal of Economics	Economics	35
71	Hagos F., Jayasinghe G., Awulachew S.B., Loulseged M., Yilma A.D.		2012	Agricultural water management and poverty in Ethiopia	Agricultural Economics (United Kingdom)	Economics, Agricultural economics	34
72	Angelini E.C., Farina F., Pianta M.		2009	Innovation and wage polarisation in Europe	International Review of Applied Economics	Economics	32
73	James J., Khan H.		1997	Technology choice and income distribution	World Development	Development studies	30
74	Choi K.-S., Jeong J.		2005	Technological change and wage premium in a small open economy: The case of Korea	Applied Economics	Economics	29
75	Gray M., Golob E., Markusen A., Park S.O.		1998	New industrial cities? The four faces of Silicon Valley	Review of Radical Political Economics	Economics	29
76	Thapa G., Otsuka K., Barker R.		1992	Effect of modern rice varieties and irrigation on household income distribution in Nepalese villages	Agricultural Economics	Economics, Agricultural economics	29
77	Brouwer R., Brito L.		2012	Cellular phones in Mozambique: Who has them and who doesn't?	Technological Forecasting and Social Change	Innovation studies	28
78	Brynin M., Perales F.		2016	Gender wage inequality: The de-gendering of the occupational structure	European Sociological Review	Sociology	28
79	Tselios V.		2011	Is inequality good for innovation?	International Regional Science Review	Geography	27
80	Taylor K.		2006	UK wage inequality: An industry and regional perspective	Labour	Industrial, work and employment relations	27
81	Chennells L., Reenen J.V.		1998	Establishment level earnings, technology and the growth of inequality: Evidence from Britain	Economics of Innovation and New Technology	Innovation studies, economics	25
82	Cozzens S.E., Bobb K., Deas K., Gatchair S., George A., Ordonez G.		2005	Distributional effects of science and technology-based economic development strategies at state level in the United States	Science and Public Policy	Innovation studies	25
83	Antonelli C., Gehringer A.		2017	Technological change, rent and income inequalities: A Schumpeterian approach	Technological Forecasting and Social Change	Innovation studies	23

	Author	Year	Title	Journal	Field	Citations (Google Scholar*)
84	Álvarez R., López R.A.	2009	Skill upgrading and the real exchange rate	World Economy	Economics, international relations	22
85	Hyytinen A., Toivanen O.	2011	Income Inequality and Technology Diffusion: Evidence from Developing Countries	Scandinavian Journal of Economics	Economics	22
86	Reshef A.	2013	Is technological change biased towards the unskilled in services? An empirical investigation	Review of Economic Dynamics	Economics	22
87	Belman D., Levine D.I.	2004	Size, skill and sorting	Labour	Industrial, work and employment relations	22
88	Colclough G., Tolbert C.M., II	1990	High Technology, Work, and Inequality in Southern Labor Markets	Work and Occupations	Industrial, work and employment relations	22
89	Antonczyk D., Deleire T., Fitzenberger B.	2018	Polarization and rising wage inequality: Comparing the U.S. and Germany	Econometrics	Economics	21
90	Mendonça S., Crespo N., Simões N.	2015	Inequality in the network society: An integrated approach to ICT access, basic skills, and complex capabilities	Telecommunications Policy	Other multidisciplinary, technology	20
91	Kim C., Sakamoto A.	2008	Does inequality increase productivity?: Evidence from U.S. Manufacturing industries, 1979 to 1996	Work and Occupations	Industrial, work and employment relations	19
92	Otsuka K., Cordova V.G., David C.C.	1990	Modern rice technology and regional wage differentials in the Philippines	Agricultural Economics	Economics, Agricultural economics	18
93	Mosher J.S.	2007	U.S. wage inequality, technological change, and decline in union power	Politics and Society	Other political science	18
94	Cook P., Uchida Y.	2008	Structural change, competition and income distribution	Quarterly Review of Economics and Finance	Economics	17
95	Warman C., Worswick C.	2015	Technological change, occupational tasks and declining immigrant outcomes: Implications for earnings and income inequality in Canada	Canadian Journal of Economics	Economics	17
96	Hanley C.	2014	Putting the Bias in Skill-Biased Technological Change? A Relational Perspective on White-Collar Automation at General Electric	American Behavioral Scientist	Sociology	17
97	Bogliacino F.	2009	Poorer Workers. The Determinants of wage Formation in Europe	International Review of Applied Economics	Economics	14
98	Hatipoglu O.	2012	The relationship between inequality and innovative activity: A Schumpeterian theory and evidence from cross-country data	Scottish Journal of Political Economy	Economics, political science	14
99	Kharlamova G., Stavytskyy A., Zarotiadis G.	2018	The impact of technological changes on income inequality: The EU states case study	Journal of International Studies	Sociology, Economics	14
100	Broccolini C., Turco A.L., Presbitero A.F., Staffolani S.	2011	Individual earnings, international outsourcing and technological change: Evidence from Italy	International Economic Journal	Economics	13
101	Kawaguchi D., Mori Y.	2016	Why has wage inequality evolved so differently between Japan and the US? The role of the supply of college-educated workers	Economics of Education Review	Economics	13
102	Rijkers B., Ruggeri Laderchi C., Teal F.	2010	Who Benefits from Promoting Small Enterprises? Some Empirical Evidence from Ethiopia	World Development	Development studies	13
103	Adrián Risso W., Sánchez Carrera E.J.	2019	On the impact of innovation and inequality in economic growth	Economics of Innovation and New Technology	Innovation studies, economics	13
104	Woodson T., Alcantara J.T., do Nascimento M.S.	2019	Is 3D printing an inclusive innovation?: An examination of 3D printing in Brazil	Technovation	Innovation studies	13
105	Thakur D.	2012	A limited revolution - The distributional consequences of Open Source Software in North America	Technological Forecasting and Social Change	Innovation studies	13
106	Thakur D.	2012	Market competition and the distributional consequences of mobile phones in Canada	Technological Forecasting and Social Change	Innovation studies	13
107	Langer L.	2001	The consequences of state economic development strategies on income distribution in the American states, 1976 to 1994	American Politics Research	Other political science	13
108	Richmond K., Triplett R.E.	2018	ICT and income inequality: a cross-national perspective	International Review of Applied Economics	Economics	12
109	Tsou M.-W.	2002	Wage differentials in Taiwanese manufacturing, 1982-1997	Asian Economic Journal	Economics	12
110	Consoli D., Vona F., Saarivirta T.	2013	Analysis of the Graduate Labour Market in Finland: Spatial Agglomeration and Skill-Job Match	Regional Studies	Geography	12
111	Walton M., Pallitt N.	2012	'Grand Theft South Africa': Games, literacy and inequality in consumer childhoods	Language and Education	Other, education	12
112	Manso E.P.	2006	The influence of earnings on income distribution in the United States	Journal of Socio-Economics	Economics	11
113	Brown C., Campbell B.	2001	Technical change, wages, and employment in semiconductor manufacturing	Industrial and Labor Relations Review	Industrial, work and employment relations	11
114	Eriksson T., Pytliková M., Warzynski F.	2013	Increased sorting and wage inequality in the Czech Republic: New evidence using linked employer-employee dataset	Economics of Transition	Economics	10
115	Echeverri-Carroll E.L., Oden M.D., Gibson D.V., Johnston E.A.	2018	Unintended consequences on gender diversity of high-tech growth and labor market polarization	Research Policy	Innovation studies	10
116	Asplund R., Lilja R.	2014	Wage formation and gender wage gaps: Is there a role for job-task evaluation schemes?	International Journal of Manpower	Industrial, work and employment relations	10
117	Cirillo V., Sostero M., Tamagni F.	2017	Innovation and within-firm wage inequalities: empirical evidence from major European countries	Industry and Innovation	Innovation studies	9
118	Toh R., Tat H.W.	2012	Trade liberalization, labor demand shifts and earnings inequality in Singapore	Review of Urban and Regional Development Studies	Geography	9
119	Katz V.S., Gonzalez C., Clark K.	2017	Digital inequality and developmental trajectories of low-income, immigrant, and minority children	Pediatrics	Other, health	9
120	Almeida A., Afonso O.	2010	SBTC versus trade: Testing skill-premia evidence across 25 oecd countries	Applied Economics Letters	Economics	8
121	Dell'Anno R., Solomon H.O.	2014	Informality, Inequality, and ICT in Transition Economies	Eastern European Economics	Economics	8
122	Ojala J., Pehkonen J., Eloranta J.	2016	Deskilling and decline in skill premium during the age of sail: Swedish and Finnish seamen, 1751–1913	Explorations in Economic History	Economics	8
123	Mukhopadhyay S., Nandi R.	2007	Unpacking the assumption of gender neutrality: Akshaya project of the Kerala IT mission in India	Gender, Technology and Development	Development studies, gender	8
124	Lee S.	2017	International trade and within-sector wage inequality: The case of South Korea	Journal of Asian Economics	Economics	7
125	Otioma C., Madureira A.M., Martinez J.	2019	Spatial analysis of urban digital divide in Kigali, Rwanda	GeoJournal	Geography	7
126	Wlodarczyk J.	2017	Innovations and income inequalities – A comparative study	Journal of International Studies	Sociology, Economics	7
127	Bruinshoofd A., Hollanders H., Ter Weel B.	2001	Knowledge spillovers and wage inequality: An empirical analysis of Dutch manufacturing	Labour	Industrial, work and employment relations	7
128	Moreno-Galbis E., Wolff F.-C.	2011	Evidence on new technologies and wage inequality in France	Applied Economics	Economics	6
129	Peng F., Kang L.	2013	Labor market institutions and skill premiums: An empirical analysis on the UK, 1972-2002	Journal of Economic Issues	Economics, interdisciplinary	6
130	Xu Y., Ouyang A.Y.	2015	China wage inequality: The role of trade and technology	Applied Economics	Economics	6
131	Goel M.	2017	Inequality Between and Within Skill Groups: The Curious Case of India	World Development	Development studies	6
132	Mehic A.	2018	Industrial employment and income inequality: Evidence from panel data	Structural Change and Economic Dynamics	Innovation studies	6
133	Shahabadi A., Nemati M., Hosseinidoust S.E.	2017	The Effect of Knowledge Economy Factors on Income Inequality in the Selected Islamic Countries	Journal of the Knowledge Economy	Innovation studies	6
134	Engelmann S.	2014	International trade, technological change and wage inequality in the UK economy	Empirica	Economics	5
135	Santos M., Sequeira T.N., Ferreira-Lopes A.	2017	Income Inequality and Technological Adoption	Journal of Economic Issues	Economics, interdisciplinary	5
136	Martorano B., Sanfilippo M.	2015	Structural Change and Wage Inequality in the Manufacturing Sector: Long Run Evidence from East Asia	Oxford Development Studies	Development studies	4
137	Colclough G.S., Tolbertii C.M.	2001	Transformations of hightech labor markets and socioeconomic inequalities	Sociological Focus	Sociology	4
138	Englehardt S.J.	2009	The evolution of skill-biased effects on American wages in the 1980s and 1990s	Journal of Labor Research	Industrial, work and employment relations	4
139	Barua A., Ghosh P.	2017	Factor specificity and wage inequality in a developing economy: The role of technology and trade in Indian manufacturing	International Review of Economics and Finance	Economics	3
140	Hühne P., Herzer D.	2017	Is inequality an inevitable by-product of skill-biased technical change?	Applied Economics Letters	Economics	3
141	Nogueira M.C., Afonso Ó., Soukiazis E.	2018	Skill premium in Portuguese manufacturing industries	Applied Economics Letters	Economics	3
142	Mishel L., Bernstein J.	2003	Wage inequality and the new economy in the US: Does IT-led growth generate wage inequality	Canadian Public Policy	Other political science	3
143	Jung H., Seo I., Jung K.	2018	Mediating Role of Entrepreneurship in Explaining the Association Between Income Inequality and Regional Economic Performance	Economic Development Quarterly	Economics, development economics	2
144	Suphanachart W.	2019	Effects of technological change on income inequality in Thailand	Southeast Asian Journal of Economics	Economics	2
145	Martorano B., Park D., Sanfilippo M.	2017	Catching-up, structural transformation, and inequality: Industry-level evidence from Asia	Industrial and Corporate Change	Innovation studies, economics, management	2
146	Thewissen S., van Vliet O., Wang C.	2018	Taking the Sector Seriously: Data, Developments, and Drivers of Intrasectoral Earnings Inequality	Social Indicators Research	Other, interdisciplinary	2
147	Cozzens S.E., Bobb K.	2003	Measuring the relationship between high technology development strategies and wage inequality	Scientometrics	Other social sciences	2
148	Scott P.	2011	Still a niche communications medium: The diffusion and uses of the telephone system in interwar Britain	Business History	Other management	2
149	Arendt Ł., Grabowski W.	2019	Technical change and wage premium shifts among task-content groups in Poland	Economic Research-Ekonomska Istrazivanja	Economics	1
150	Croce G., Ghignoni E.	2020	The evolution of wage gaps between STEM and non-STEM graduates in a technological following economy	Applied Economics	Economics	1
151	Nogueira M.C., Afonso Ó.	2018	Intra-country wage inequality in the OECD countries	Panoeconomicus	Economics	1
152	Antonelli C., Scellato G.	2019	Wage inequality and directed technological change: Implications for income distribution	Technological Forecasting and Social Change	Innovation studies	1
153	Tyrowicz J., Smyk M.	2019	Wage Inequality and Structural Change	Social Indicators Research	Other, interdisciplinary	1
154	Martínez M.-S.C., Fuensanta M.J.R., Rodríguez I.M.	2013	The influence of socioeconomic factors on entrepreneurship and innovation	Journal of Small Business Strategy	Other management	1
155	Hope D., Martelli A.	2019	The Transition to the Knowledge Economy, Labor Market Institutions, and Income Inequality in Advanced Democracies	World Politics	Other political science	1
156	Hall J.D.	2019	Measuring the Diffusion of Technologies Through International Trade	International Advances in Economic Research	Economics	0
157	Pehkonen J., Neuvonen T., Ojala J.	2019	Technological change and wage premiums amongst high-skilled labour	Applied Economics Letters	Economics	0
158	Saini S., Mehra M.	2018	Impact of strengthening Intellectual Property Rights Regime on income inequality: An Econometric Analysis	Economics Bulletin	Economics	0
159	Torres N., Afonso Ó., Soares I.	2017	Manufacturing Skill-biased Wage Inequality, Natural Resources and Institutions	Review of Development Economics	Economics, development economics	0
160	Guo Q.	2019	Analysis on the Relationship between Regional Innovation and Income Inequality in Chinese City Regions	Professional Geographer	Geography	0
161	Cheng S., Chauhan B., Chintala S.	2019	The rise of programming and the stalled gender revolution	Sociological Science	Sociology	0
162	Chang Y., Cho S., Kim I., Khang Y.-H.	2019	Socioeconomic inequalities in e-cigarette use in Korea: Comparison with inequalities in conventional cigarette use using two national surveys	International Journal of Environmental Research and Public Health	Other interdisciplinary, Environmental studies	0
163	Nakara W.A., Messeghem K., Ramaroson A.	2019	Innovation and entrepreneurship in a context of poverty: a multilevel approach	Small Business Economics	Other entrepreneurship	0
164	Bonjean I.	2019	Heterogeneous incentives for innovation adoption: The price effect on segmented markets	Food Policy	Other, multidisciplinary / food studies	0
165	Dueñas-Fernández D., Iglesias-Fernández C., Llorente-Heras R.	2015	Is there less gender inequality in the service sector? The gender wage-gap in knowledge-intensive services	Social Science Information	Other social sciences	0
166	Permana M.Y., Lantu D.C., Suharto Y.	2018	The effect of innovation and technological specialization on income inequality	Problems and Perspectives in Management	Other management	0

Total	27,030.00
Citation per contribution	162.83

* July, 2020

Appendix B

Investments in R&D

Table B.1: R&D Investments as a % of GDP

All sectors	Percentage of GDP			Million Euros			Euro per inhabitant		
	2003	2017	Change %	2003	2017	Change %	2003	2017	Change %
Braunschweig region (s)	8.47	8.52	0.59	3,619.331	5,875.971	62.35	2,173.3	3,682.6	69.45
Lower Saxony	2.84	3.13	10.21	5,285.434	8,921.263	68.79	662.3	1,122.8	69.53
Germany	2.47	3.07	24.29	54,727.818	99,553.616	81.91	663.1	1,206.4	81.93
EU28	1.79	2.08	16.20	189,016.333	320,029.015	69.31	385.2	625.8	62.46

Business enterprise sector	Percentage of GDP			Million Euros			Euro per inhabitant		
	2003	2017	Change %	2003	2017	Change %	2003	2017	Change %
Braunschweig region (s)	6.52	6.42	-1.53	2,788.74	4,428.7	58.81	1,674.5	2,775.6	65.76
Lower Saxony	2.06	2.22	7.77	3,835.3	6,329	65.02	480.6	796.5	65.73
Germany	1.72	2.12	23.26	38,029	68,787.3	80.88	460.8	833.6	80.90
EU28	1.13	1.37	21.24	119,930.876	211,846.804	76.64	244.4	414.3	69.52

Government sector	Percentage of GDP			Million Euros			Euro per inhabitant		
	2003	2017	Change %	2003	2017	Change %	2003	2017	Change %
Braunschweig region (s)	0.99	1.17	18.18	421.778	807.24	91.39	253.3	505.9	99.72
Lower Saxony	0.31	0.37	19.35	573.686	1,056.618	84.18	71.9	133	84.98
Germany	0.33	0.42	27.27	7,307.4	13,484.009	84.53	88.5	163.4	84.63
EU28	0.23	0.23	0.00	24,749.72	35,434.652	43.17	50.4	69.3	37.50

Higher education sector	Percentage of GDP			Million Euros			Euro per inhabitant		
	2003	2017	Change %	2003	2017	Change %	2003	2017	Change %
Braunschweig region (s)	0.96	0.93	-3.12	408.813	640.031	56.56	245.5	401.1	63.38
Lower Saxony	0.47	0.54	14.89	876.448	1,535.645	75.21	109.8	193.3	76.05
Germany	0.42	0.53	26.19	9,391.418	17,282.307	84.02	113.8	209.4	84.01
EU28	0.4	0.46	15.00	42,783.751	70,316.975	64.35	87.2	137.5	57.68

(s) stands for the statistical region of Braunschweig

Source: Eurostat, own elaboration

Appendix C

Regional Innovation Scoreboard Data

Table C.1: Region of Braunschweig: Score and Rank in the Regional Innovation Scoreboard

Index	Score	Rank among European regions (n=239)
Population with tertiary education	0.377	105
Lifelong learning	0.279	44
Scientific co-publications	0.813	18
Most-cited publications	0.596	42
R&D expenditure public sector	1.000	1
R&D expenditure business sector	1.000	1
Non-R&D innovation expenditures	0.903	11
Product or process innovators	0.764	16
Marketing or organisational innovators	0.612	49
SMEs innovating in-house	0.811	8
Innovative SMEs collaborating with others	0.207	135
Public-private co-publications	0.631	23
PCT patent applications	0.558	32
Trademark applications	0.221	135
Design applications	0.260	142
Employment MHT manufacturing & knowledge-intensive services	0.816	7
Sales of new-to-market and new-to-firm innovations	0.438	119

Source: own elaboration, Regional innovation scoreboard (2019)

Appendix D

Research Institutes

Table D.1: Research Institutes in the Region of Braunschweig

Name	Expertise	Location
Braunschweig State Museum	–	Braunschweig city
Bundesamt für Strahlenschutz (BfS)	Waste and nuclear safety radiation protection in medicine, disposal of nuclear	Salzgitter
Clausthaler Umwelttechnik-Institut GmbH (CUTEC)	Energy	Salzgitter
Deutsche Sammlung von Mikroorganismen und Zellkulturen (DSMZ)	The German Collection of Microorganisms and Cell Cultures, DSMZ, is the most important resource centre for biological materials in Europe. Scientists from all over the world order microorganisms, plant viruses, and cell lines for their research at the DSMZ	Braunschweig city
Federal Aviation Office (LBA)	The Federal Office of Civil Aviation is responsible for the defence against potential dangers, for aviation safety as well as for the safety of the general public and adherence to safety rules.	Braunschweig city
Federal Office for Aircraft Accident Investigation (BFU)	The Bundesstelle für Flugunfalluntersuchung is responsible for the investigation and determination of the cause of accidents and serious incidents involving civil aircraft within Germany.	Braunschweig city
Federal Office for Radiation Protection	The Federal Office for Radiation Protection (BfS) is an organisationally independent scientific-technical higher federal authority in the portfolio of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety	Salzgitter
Federal Office of Consumer Protection and Food Safety (BVL)	The Federal Office of Consumer Protection and Food Safety (BVL) fulfils many tasks in the area of food safety. The aim of the BVL is to make the communication of risks more transparent and to manage risks before they turn into crises.	Braunschweig city
Fraunhofer Institute for Surface Engineering and Thin Films (IST)	Research on Films, fuels and lubricants	Braunschweig city
Fraunhofer Institute for Wood Research (WKI)	Wood research	Braunschweig city
Georg Eckert Institute - Leibniz Institute for International Textbook Research (GEI) (GEI)	The “Georg-Eckert-Institut” uses comparative educational media research to analyse different cultures of remembrance and identification processes at national and international level.	Braunschweig city
German Aerospace Center (DLR)	With the aid of worldwide unique aircraft, helicopters, wind tunnels and simulators, the DLR develops solutions for safe, efficient and environmentally friendly road and air traffic of the future.	Braunschweig city
Gesellschaft für Anlagen- und Reaktorsicherheit (GRS)	GRS carries out research and analysis in its fields of competence, namely reactor safety, radioactive waste management as well as radiation and environmental protection. GRS is Germany's central expert organisation in the field of nuclear safety and radioactive waste management.	Braunschweig city
Helmholtz-Zentrum für Infektionsforschung (HZI)	How do bacteria and viruses make us ill? How does the immune system respond to these pathogens? Scientists at the Helmholtz Centre for Infection Research are trying to find answers to these questions.	Braunschweig city
Herzog Anton Ulrich Museum	–	Braunschweig city
Institut für angewandte Funksystemtechnik GmbH (IAF)	IAF carries out application-oriented research and development projects in the field of digital radio transmission technology. IAF focuses its activities on digital radio transmissions with high data rates for applications in mobile communication and digital broadcasting.	Braunschweig city
International Research Association for Feed Technology eV (IFF)	The International Research Association of Feed Technology IFF is the international scientific centre for process engineering for the compound feed industry and its suppliers. Investigations on aspects of process technology are the focus of the centre‘s research activities.	Braunschweig city
Johann Heinrich von Thünen-Institut (vTI) Federal Research Institute for Rural Areas, Forests and Fisheries	The vTI has a broad approach to research with the objective to further develop agriculture, forestry and fishery in a sustainable way while taking economic, ecological and technological aspects into account	Braunschweig city
Julius Kühn Institute - Federal Research Institute for Cultivated Plants	Plant genetics, plant cultivation, plant nutrition, soil science, plant protection and plant health	Braunschweig city
Leibniz Institute DSMZ - German collection of microorganisms and cell cultures	Research on various aspects of biodiversity in prokaryotes and eukaryotes.	Braunschweig city
Museum of Natural History	–	Braunschweig city
Open Hybrid LabFactory eV	Research on hybrid components for production	Wolfsburg
Physikalisch-Technische Bundesanstalt (PTB)	The PTB is home to the second, the meter, the kilogram, the volt, the newton etc. The PTB is the German metrology institute and as such is working on all issues of measuring, ranging from basic research on the system of units, to the industrial application of complex measuring tasks, to consumer protection. The PTB is considered an authority in the measuring world at national, European and international level.	Braunschweig city
Research airport Braunschweig		Braunschweig city
Städtisches Klinikum Braunschweig	With 1.440 beds and approximately 3.750 members of staff, the hospital is one of the largest hospitals in Northern Germany. Furthermore, within the frame of clinical trials and research projects experienced partners work alongside hospital staff at the 17 clinics, 11 independent clinical departments and 6 institutes.	Braunschweig city
Thünen Institute - Federal Research Institute for Rural Areas, Forests and Fisheries	Sustainable development of rural areas.	Braunschweig city

Appendix E

Interview Protocol

Theme I: About you, Your Organisation and Innovation

- Please tell me a bit about your position and your organisation.
- Innovation is often defined as the first introduction of an invention on the market, what does innovation mean for you?

Theme II: Innovation in The Region

- Would you say that the region of Braunschweig is an innovative region?
    - Examples of probes:
        - Please name some important players of innovation in the region.
        - What are the key challenges that firms face when it comes to undertaking innovative activities in the region?
        - (if applicable) In what ways, has your organization helped firms to cope with these challenges?

Theme III: Innovation and Economic Outcomes

- Based on your experience, would you say that innovation leads to higher levels of income in the region?
    - Examples of probes:
        - How does innovation affect employment in the region? Have you observed any significant different differences over the years (e.g., early or late 2000s and early or later 2010s)?
        - Based your experience, would you say that innovation benefits all parties involved equally in the region? Could you give me some examples that illustrate your view?

Theme IV: Closing Part

- Would you like to add anything else?
- Whom else do you think I should talk to about this topic?
- Would you like to receive a copy of this interview?
- 'Thank You'

Date:
Time:
Place:
Interviewee:
Interviewer:

Appendix F

Code Template

Table F.1: Final Code Template

Code category	Code	Examples of quotes
Structure (Precondition I)	Large innovative firms (C1)	"I would say in general the large companies here are very innovative companies" (Interview 4) "We have a lot of companies and a lot of institutes and big companies like Volkswagen, Siemens, Alstom and so on." (Interview 3) "Siemens is here I know that. Siemens it does a lot of train systems here." (Interview 2)
	Innovative suppliers (C2)	"We have three great factories here, in Wolfsburg, Braunschweig and Salzgitter with appropriate suppliers who are also to my mind very innovative. They also perform research and development in regards to the subject of cars" (Interview 8)" "Many companies came here because Volkswagen is here like many suppliers." (Interview 2)
	Hidden champions (C3)	"Yes, and then we have a lot of companies which are small companies which are so-called hidden champions. I remember one of the hidden champions was a company." (Interview 3) "We call them 'hidden champions' and they are very innovative in their specific fields like fire-extinguishing for example in Goslar, and is leading company in Europe and in the world." (Interview 8)
	Innovative SMEs (C4)	"And I think innovative ideas in small companies are more hidden and not so well published and not so well known. Large companies are better at marketing their ideas. There is a large number of small companies in the region as well." (Interview 4)" "We have very interesting SMEs here." (Interview 8)
	Research institutes (C5)	"That another aspect. There is also, of course, large companies around in this area dedicated to market research or they dedicate they research more or less to markets. Well we work together with these companies and you know they bring new ideas into our institute that triggers new fundamental research, and this fundamental research is then grabbed by these companies and they create new products out of it. I think this will be an ideal circle sort of thing." (Interview 4) "We have a lot of scientific institutions here. They do some research in fields that are important for the future of our society: mobility, energy and health." (Interview 15) "To my mind, the main reason for the high innovative potential of the region of Braunschweig is that meanwhile more than 15.000 people work in more than 250 companies of the high-technology sector and 27 research institutes. This includes the Helmholtz-Zentrum for Infectious Diseases, the German Center for Aviation and Space flights, the second to largest Research Airport in Europe or the biggest chip research centre of Intel in Europe. This high density of research institutions in Braunschweig leads to interdisciplinary networks of these institutes. " (Interview 5)
	Universities (C6)	"There are four universities in the region" (Interview 8) "Well designers are here because of the University of Arts. Some say is the best university of arts in Germany and they do have the design as one of the big fields" (Interview 5) "I think simply because there are plenty of research centres and universities. For that reason, there is a lot of new research results." (Interview 16)
	Business and Networking Associations (C7)	"I am actually very optimistic because the links between the universities and the economic associations are very strong. In the IHK (chamber of commerce), the link between IHK and the university is very strong in Braunchweig, and also, the employer's association. The cooperation in machines made in Braunschweig (KIM) is also an initiative of employer's association. They also organised it and they are looking for cooperation with institutes and universities. They are very interested to have common development, common research projects, so on." (Interview 16)
	Finance (C8)	"You know when it comes to finance, we know a lot of people who can help...There is one association, it is called Business angel association (BANSON)" (Interview 4). "Their idea is not only to get not only money but have a kind of mentor who helps alongside with decisions with the company." (Interview 8) "There are some good sources for spin-off companies to get venture capital" (Interview 4) "BANSON stands for the promotion and establishment of the start-up culture in the Braunschweig, Wolfsburg and Lüneburg area The BANSON e. V. is an association that promotes business start-ups as well as the start-up culture and networking between business and the start-up scene in the region."(banson.de)
	Regional development agencies (C9)	"The Project region of Braunschweig was founded in 2005. It has a history that goes far back. Before that, we had this company and other two companies, the region market GMBH and another one which was more scientific. The government of Lower Saxony promoted that regions come together under the "Regionale Koncept". It was made here in this region. It was in Wolfsburg and was also made in lower Saxony around Göttingen, also in Hannover. After, the government spend some thousands of euros to work on this concept, and afterwards, they had to think and take this decision what to do to start this organisation and it has 15 shareholders. The eight cities and the Landkraise, Braunschweig, Salzgitter, Wolfsburg, Peine, Ghoslar, Gifron, Wolfenbüttel. We have on the other side, the big companies such as VW, Salzgiter AG, energy provider, and regional insurance, and all the other small medium-sized companies are represented by AVG. On the other side, the union of employees association" (Interview 8)
	Other support organisations (C10)	"Another point which is important is the cooperation among universities and economic associations is very good. For example, IHK [Chamber of Commerce] and employers associations. Employers associations are very important in the region of Braunschweig. They support new ideas, they try to link industrial companies. " (Interview 16)
	Interactions among firms and support organisation (C11)	"Scientists work at the university and other research institutes on the solutions of complex problems and consequently enable the technology transfer between the companies and research institutes....we have a good network between each other and we work together quite closely" (Interview 5) "I think it's also a very healthy relationship between research institutions and companies because generally in companies, you have a very close look at your products, whereas at the university: you have a wider perspective for a whole field. So, I think it is a very healthy relationship to technology transfer...But these institutes they don't only work together with the companies of the region, they work together with other companies outside of the region. So, it is not necessarily that the ideas are produced here are directly transferred to the companies in the region." (Interview 4)
Causal impact on jobs, skills and competences (Precondition II)	Jobs (12)	"The whole region has some problems. Now many robots are coming into the production and now many people getting unemployed here. That's really a big problem here...We have many basic workers...who work in the factory of VW, I guess these people do not earn so much. And if they lose their job, where they can work?" (Interview 8) "I would say the industry changed as, that there are still a number of companies that are still pretty old. They have been here all the time...The companies are much smaller now that there is less people working for these industries than twenty and thirty years ago " (Interview 5) "By implementing the FveMotion measures, it was possible to reduce staff levels, in particular at Volkswagen AG. At the end of the year, a total of 178,689 people worked in our companies in Germany (+ 0.8\%), while the number of employees outside Germany was 166,213 (+ 0.6\%). In the field of financial services, the number of employees fell slightly, owing primarily to the sale of the Europcar Fleet Services foreign companies." (VW annual report 2005, p.55)
	Skills (C13)	"Creativity is one of the assets we have here. We have many creative designers...So you do have a lot of designers here. Most of them go to Berlin afterwards, after they study here." (Interview 5) "I think we are becoming older and older here. All the young people are leaving and searching for jobs elsewhere." (Interview 9) "I think for every company in the IT department, the main challenge and the main difficulty is to find and to keep high qualified personnel such as programmers, and that is the main challenge for every company." (Interview 10) "So firstly, we have here a very high proportion of work places in the area of research and development. This is to my knowledge the highest density of work places in the field of research and development in Germany." (Interview 18)
	Competences (C14)	"We are dealing with mobility and especially with road traffic, and if you are looking to Braunschweig, then you also at Wolfsburg, and then Volkswagen is the big driver. The automotive industry spends a lot of money in research, and I think this branch is driven by innovation, and that pushes a lot of activities. Well by tradition here in Braunschweig, we have not only individual transport, but we also mobility in general. I told you that we also dealing with rail traffic, and we are dealing with aviation. Well, there are a lot of synergies between the different traffic modes." (Interview 19) "There is intensive avionic research in this region. We even have a research airport. But the big-big plane manufacturers and engine manufacturers are not right here in this region. There is a number of companies in Hamburg, they are some in Southern France, there are some in Bremen and in many other regions in Europe. Or, even if you think of the US – Boeing or Airbus is spread all over Europe, Britain, Germany, Spain and many other countries. So, the research results are implemented somewhere else in a different region. But then I think these regions where they have the manufacturing plants or the R&D whatever they gain a lot of the results coming out of this region. So, in other words, economic growth has produced somewhere else than where the innovative idea." (Interview 4) "All over sadden, the Braunschweig people recognised, there is a research cluster around the airport." (Interview 2) "Nowhere else outside the USA, except perhaps Toulouse, can boast the level of aerospace competence to be found in Braunschweig. " (Organisational document 11)
Strategies (Precondition III)	Firm strategic responses (C14)	"Yes, I assume so. There is no manufacturing here for SIEMENS. In Salzgitter, you find another car-maker MAN, they produce tracks. They are reducing also the amount of products they do here. The same is with Alstrom, they produce train and trams, and they are also reducing production. This I do not know why. " (Interview 2) "On the one hand it is a big advantage to have these large companies, but on the other hand, we have a little bit problem with these companies, they are under very strong international pressure. They are forced to reach more and more turnover with fewer employees. The output of these large companies has to become bigger and bigger, but at the same time employment is sinking" (Interview 17) "Our biggest employer in the region is Volkswagen. VW wants to be the world's largest car manufacturer. Still, Toyota is the largest car manufacturers but VW wants to overtake them. We have three great factories here, in Wolfsburg, Braunschweig and Salzgitter with appropriate suppliers who are also to my mind very innovative. They also perform research and development in regards to the subject of cars and we think even further, all around the theme of mobility – in other words, how the future means of transportation will look like. It does not necessarily have to be a car. The large company VW is an important answer to the question of innovation," (Interview 18) "Cooperation within the field of research is given clear preference over the buying-in of know-how." (Salzgitter AG, 2005) "Our biggest employer in the region is Volkswagen. VW wants to be the world's largest car manufacturer. Still Toyota is the largest car manufacturers but VW wants to overtake them. We have three great factories here, in Wolfsburg, Braunschweig and Salzgitter with appropriate suppliers who are also to my mind very innovative. They also perform research and development in regards to the subject of cars and we think even further, all around the theme of mobility – in other words, how the future means of transportation will look like. It does not necessarily have to be a car. The large company VW is an important answer to the question of innovation." (Interview 18) "Cooperation within the field of research is given clear preference over the buying-in of know-how." (Salzgitter AG, 2005)
	Universities, research institutes strategic responses (C15)	"That another aspect. There is also, of course, large companies around in this area dedicated to market research or they dedicate they research more or less to markets. Well we work together with these companies and you know they bring new ideas into our institute that triggers new fundamental research, and this fundamental research is then grabbed by these companies and they create new products out of it. I think this will be an ideal circle sort of thing...We produce research results but then these results then have to be taken and developing to a product. For us, there is a strong differentiation between pure research and like designing or developing a product. That's not our task to develop and produce a product. Our task is to do research and educate students. That's our main tasks. But usually, in between, the research results and the finished product, there is a gap. And this gap has to be filled financially. In other words, if companies come and ask me for new research results, they often look at the results, they are very interested, and they think it is a great result, and then they think about it, and then they discover they need to do a lot of development work, not research, development work to get the final product. Sometimes, they are cautious to invest that money, because new ideas are not necessarily guaranteed for a product that is very profitable-that makes a lot of profit. I think that are the challenges we face." (Interview 4) "For me, if people do some research here in Braunschweig for aviation or medical, it does not pay off here. Other companies, for example, AIRBUS in Hamburg or Toulouse makes the money, and there might be some growth. Research does not generate income here. Only for the people who are working, of course, they make some salaries. But the mass, the labour force, this is not above average. You find of course different companies, insurance companies and banks, and staff. But, there is only one bank who is located here. Otherwise looking to the bigger cities where you find some. Research made here but production is not here". (Interview 2) "The Federal State of Lower Saxony, the Volkswagen AG and the Technical University of Braunschweig are investing in the NFF together with other partners with top-level international research" (Organisational document 10)
	(Local) policy organisations strategies and responses (C16)	"Yes, The first one is automotive. The second one is automotive and the third one is automotive. What else? That's what there were looking at this 'regionale...', would you say automotive or you say traffic technology, then you have some actors like Siemens or Alstom or MAN, or the research airport in Braunschweig. Or in the Hartz some chemical industry." (Interview 8) "So we just tried some months ago to initiate a funded cluster, called mobility, and I think this describes quite well the history and the potential of the region here, because, I think at least in the last twenty years, we have the competence to handle mobility in general, and I told you that body design, propulsion, engines, driving dynamics, driver behaviour or pilot behaviour, aerodynamics, telematics, and we can handle all these topics in the research I have to say and link the different experts quite easily together, because, we have a community they understand each other between very well." (Interview 19)
	Other organisational responses (C17)	"The cooperation in machines made in Braunschweig (KIM) is also an initiative of the employer's association. They also organised it and they are looking for cooperation with institutes and universities. They are very interested to have common development, common research projects, so on. We plan to establish a new task force between KIM and universities and those professors who are interested to have institutional connections institutional link to these companies they are coming. " (Interview 16)
Causal mechanisms	Competence concentration	Combinations of codes (C15, C16,C17, C18)
	Concentrated income closure	Combinations of codes (C14, C15)
	Skill premiums	Combinations of codes (C13, C15, C16, C17)
	Precarious employment	Combinations of codes (C12, C14, C15,C16,C17)
	Gender-inclusive competence building	Combinations of codes (C12,C13, C14, C15, C16, C17, C18)
	Gender-inclusive competence building	Combinations of codes (C12,C13, C14, C15, C16, C17, C18)

Appendix G

Documents, Organisational Websites and News

Table G.1: List of Organisational Reports

Document Title	Year	Organisation	Pages	Code
Moving Progress: Momentum	2005	Volkswagen AG	81	BOR01
Annual Report	2001	Volkswagen AG	147	BOR02
Kompakt-Information	2008	IHK Braunschweig	99	BOR03
Kompakt-Information	2014	IHK Braunschweig	100	BOR04
Kompakt-Information	2015	IHK Braunschweig	100	BOR05
Kompakt-Information	2019	IHK Braunschweig	93	BOR06
Research Region Braunschweig: Compactly	2009	Braunschweig Stadtmarketing GmbH	36	BOR07
7 Good Reasons to Invest in Brunswick	2013	Braunschweig Zukunft GmbH	1	BOR08
Cooperative Traffic	2017	CAR 2 CAR	2	BOR09
From Gauß to Galileo	2009	Braunschweig Stadtmarketing GmbH	40	BOR10
Up at the top in Germany	2009	State of Lower Saxony	12	BOR11
Nidersachen Global	2010	Niedersachsen Global GmbH	80	BOR12
Niedersachsen – Your Business Location	2009	Niedersachsen Global GmbH	14	BOR13
Welcome to 150 Years	2016	Voith GmbH & Co. KgaA	224	BOR14
Technology and Start-Up Centre	2015	Komsis.de	3	BOR15
Nidersachen Global (February)	2010	Niedersachsen Global GmbH	76	BOR16
International Suppliers Fair (IZB): Mobility Goes Digital	2016	Wolfsburg AG	2	BOR17
The energy industry in Niedersachsen	2010	Niedersachsen Global GmbH	2	BOR18
Kompakt-Information	2018	IHK Braunschweig	102	BOR19
COMPANY PROFILE Siemens Aktiengesellschaft	2016	MarketLine	56	BOR20
Bertrandtmagazine	2013	Bertrandt AG	35	BOR21
The Horizons of Digitalization: Annual Report 2015	2015	Continental AG	226	BOR22
Annual Report 2005	2005	Volkswagen AG	200	BOR23
Annual Report 2019	2019	Volkswagen AG	354	BOR24
Annual Report 2005	2005	Salzgitter AG	232	BOR25
Annual Report 2019	2019	Salzgitter AG	180	BOR26
Annual Report 2006	2005	Volkswagen AG	207	BOR27
Annual Report 2018	2018	Volkswagen AG	351	BOR28
Annual Report 2017	2017	Volkswagen AG	425	BOR29
Annual Report 2005	2005	Siemens AG	232	BOR30
Annual Report 2019	2019	Siemens AG	172	BOR31
Annual Financial Report 2019	2019	ALSTOM SE	18	BOR32
Annual Financial Report 2005	2005	ALSTOM SE	218	BOR33
Annual Report 2005	2005	MAN SE	172	BOR34
Annual Report 2019	2019	MAN SE	176	BOR35
Annual Report 2005	2005	Robert Bosch GmbH	177	BOR36
Annual Report 2019	2019	Robert Bosch GmbH	128	BOR37
Annual Report 2006	2006	Volkswagen AG	207	BOR38
Annual Report 2007	2007	Volkswagen AG	308	BOR39
Annual Report 2008	2008	Volkswagen AG	294	BOR40
Annual Report 2009	2009	Volkswagen AG	370	BOR41
Annual Report 2010	2010	Volkswagen AG	340	BOR42
Annual Report 2011	2011	Volkswagen AG	436	BOR43
Annual Report 2012	2012	Volkswagen AG	368	BOR44
Annual Report 2013	2013	Volkswagen AG	494	BOR45
Annual Report 2014	2014	Volkswagen AG	422	BOR46
Annual Report 2015	2015	Volkswagen AG	424	BOR47
Annual Report 2016	2016	Volkswagen AG	422	BOR48
Annual Report 2006	2006	Salzgitter AG	207	BOR49
Annual Report 2018	2018	Salzgitter AG	176	BOR50

Total	9,241.00

Table G.2: List of News Articles

Code	Title	Date	Source	Code	Title	Date	Source
BN01	Could 400,000 car industry jobs in Germany be lost?	09.07.2020	Deutschewelle	BN51	Prosecutors seek charges against Volkswagen managers over labor bonuses	12.11.2019	Reuters
BN02	Volkswagen to spend 60 billion EUR on switch to electric cars	15.11.2019	Deutschewelle	BN52	Volkswagen's electric future	04.11.2019	Deutschewelle
BN03	Volkswagen withdraws Golf car ad that sparked racism row	22.05.2020	The Guardian	BN53	Volkswagen Group unveils five-year investment plan	17.11.2017	Deutschewelle
BN04	Car parts maker Faurecia sees record profits in 2022, shares rise	25.11.2019	Reuters	BN54	Germany's Merkel wants 1 million electric car charge points by 2030	03.11.2019	Deutschewelle
BN05	China's electric vehicle market to see sales rebound next year, executives say	26.11.2020	Reuters	BN55	Electric cars: Low earners may never get to drive one	20.09.2019	Deutschewelle
BN06	VW to float 10\% of truck unit, seeks to raise 1.9 billion euros	14.06.2019	Reuters	BN56	Germany to hike electric car subsidies as VW launches car	04.11.2019	Reuters
BN07	Ex-VW boss Martin Winterkorn charged in Dieselgate scandal	15.04.2019	Deutschewelle	BN57	Germany needs immigrants to stay competitive: economist	07.11.2019	Deutschewelle
BN08	Increased external risks fuel German business uncertainty: ministry	22.08.2019	Reuters	BN58	Daimler to slash 1,100 management positions: report	08.11.2019	Deutschewelle
BN09	Audi to join Mercedes, BMW development alliance – paper	22.08.2019	Reuters	BN59	Carmakers launch pan-European e-car charging network	08.11.2019	Deutschewelle
BN10	Volkswagen not interested in buying Tesla stake	22.08.2019	Reuters	BN60	Will millions of electric vehicles disrupt Germany's power grid?	03.09.2019	Deutschewelle
BN11	Germany unveils plan for climate-friendly aviation	21.08.2019	Deutschewelle	BN61	Opinion: VW: New strategy, better luck?	16.06.2016	Deutschewelle
BN12	Porsche invests in Israeli road visibility startup TriEye	21.08.2019	Reuters	BN62	Siemens plans biggest ever restructuring	07.11.2019	Deutschewelle
BN13	Toyota, Subaru team up to develop electric SUV in battle against costs	06.06.2019	Reuters	BN63	German steelworkers strike benchmark pay deal	17.03.2017	Deutschewelle
BN14	Low-level graduates neglected in Germany's 'dual' vocational system	14.04.2015	Deutschewelle	BN64	Better steels through horizontal casting	19.11.2014	Deutschewelle
BN15	Toyota speeds up electric vehicle schedule as demand heats up	07.06.2019	Reuters	BN65	BMW orders more than 10 billion euros' worth of battery cells	21.11.2019	Reuters
BN16	Aurora partners with Fiat Chrysler over self-driving tech	10.06.2019	Reuters	BN66	Exclusive: Tesla's secret batteries aim to rework the math for electric cars and the grid	14.05.2020	Reuters
BN17	VW and Ford close to deal on self-driving and electric cars: VW	10.06.2019	Reuters	BN67	Volkswagen: 'e-car leader by 2025'	22.11.2016	Deutschewelle
BN18	European lithium projects gain attention amid push towards electric vehicles	13.06.2019	Reuters	BN68	VW to cut 30,000 jobs amid restructuring	18.11.2016	Deutschewelle
BN19	Cheaper sensors could speed more self-driving cars to market by 2022	12.06.2019	Reuters	BN69	Salzgitter expects sales to rebound in 2020	16.03.2020	Reuters
BN20	In VW Chattanooga vote, UAW seeks elusive U.S. southern toehold	13.06.2019	Reuters	BN70	Zalando sets target for more women in top management	15.10.2019	Reuters
BN21	Uber unveils next-generation Volvo self-driving car	12.06.2019	Reuters	BN71	Waymo tests 'rider only' service and looks beyond robo-taxis	16.03.2020	Reuters
BN22	VW enters partnership with Swedish battery maker Northvolt	28.05.2019	Deutschewelle	BN72	Daimler third-quarter operating profit up 8 per cent, boosted by Mercedes sales	24.10.2019	Reuters
BN23	End of the road for Volkswagen's self-driving Aurora deal	11.06.2019	Reuters	BN73	Electric cars — when will the stars align?	23.10.2019	Reuters
BN24	Ampaire test-flies world's biggest electric plane	07.06.2019	Deutschewelle	BN74	Toyota's not alone in the slow lane to self-driving cars	25.10.2019	Reuters
BN25	Electric carmakers must make 'ethical battery': Amnesty	21.03.2019	Deutschewelle	BN75	Electric cars: Low earners may never get to drive one	20.09.2019	Deutschewelle
BN26	Germany to invest 58 billion EUR in electric, autonomous cars	02.03.2019	Deutschewelle	BN76	VW sees mild growth for China auto market over next three to four years	21.11.2019	Reuters
BN27	How Volkswagen wants to drive e-mobility revolution	19.02.2019	Deutschewelle	BN77	Hitachi, Honda suppliers to merge parts business to cut EV, self-driving costs	30.11.2019	Reuters
BN28	Germany: The struggle for educational equality	03.05.2012	Deutschewelle	BN78	Beiersdorf adhesives sales hit by auto industry slowdown	29.09.2019	Reuters
BN29	Volkswagen second-quarter operating profit up 30% as SUV push pays off	25.06.2019	Reuters	BN79	Automakers seeking profitable autonomous safety features - Aptiv CEO	30.10.2019	Reuters
BN30	The long road to 'greener' steel	29.07.2019	Deutschewelle	BN80	German exports to shrink for first time since global financial crisis: DIHK	30.10.2019	Reuters
BN31	German auto supplier Eisenmann files for insolvency	30.06.2019	Reuters	BN81	Germany unveils aid plan to combat regional inequality	10.07.2019	Deutschewelle
BN32	Truck maker Traton warns first-half order intake slowed as profit rose	29.07.2019	Reuters	BN82	PSA-Fiat Chrysler merger driven by global demands	31.10.2019	Deutschewelle
BN33	Getting under the hood of Amazon's auto ambitions	29.07.2019	Reuters	BN83	Continental, Osram cut costs as autos downturn hits suppliers	12.11.2019	Reuters
BN34	German prosecutors charge ex-Audi boss Stadler over emissions cheating	31.08.2019	Reuters	BN84	Better steels through horizontal casting	19.11.2014	Deutschewelle
BN35	Aston Martin shares plunge to new low as carmaker slumps to half-year loss	31.08.2019	Reuters	BN85	Germany's car industry struggles with transformation amid coronavirus crisis	08.09.2020	Deutschewelle
BN36	Mini Power Plants Run On VW Natural Gas Motors (Made in Germany)	02.09.2009	Deutschewelle				
BN37	The Car Making World: VW MEXICO	07.09.2011	Deutschewelle				
BN38	How do they do it (VW)	19.07.2012	Deutschewelle				
BN39	Made in Germany — Engineering in Braunschweig	04.08.2009	Deutschewelle				
BN40	No time to rest as Siemens prepares for the future	15.11.2017	Deutschewelle				
BN41	Short-time work: Germany resorts to well-proven tool again	04.07.2019	Deutschewelle				
BN42	Continental AG seeks deeper cost cuts as profit drops	07.08.2019	Reuters				
BN43	Indicators point to sustained period of German industrial weakness: ministry	22.09.2019	Reuters				
BN44	David and Goliath: Large firms working with tiny startups	23.07.2019	Deutschewelle				
BN45	Daimler, Bosch get approval to test driverless valet parking	23.07.2019	Reuters				
BN46	Volvo Cars aims to be climate neutral by 2040	16.10.2019	Reuters				
BN47	BMW open for new partners in mobility services venture – FAS	20.10.2019	Reuters				
BN48	Volkswagen to invest up to 4 billion euros in digital transformation	30.05.2019	Reuters				
BN49	Keen to develop self-driving cars, Hyundai Motor Group unveils $35 billion investment plan	15.10.2019	Reuters				
BN50	VW announces massive e-mobility investment in China	16.11.2017	Deutschewelle				

Table G.3: List of Organisational Websites

Website	Organisation
https://www.aerodata.de/	Aerodata AG
https://www.allianz-fuer-die-region.de/	Allianz für die Region
https://www.alstom.com/	Alstom SA
https://banson.de/	Banson Business Angels
https://www.braunschweiger-zeitung.de/	Braunschweig News
https://www.arl-bs.niedersachsen.de/startseite/	Braunschweig Regional Development Office
http://www.hbk-bs.de/en/	Braunschweig University of Art (HBK)
http://www.braunschweig.de/	City of Braunschweig
www.gifhorn.de	City of Gifhorn
https://www.goslar.de/	City of Goslar
helmstedt.de/index.php	City of Helmstedt
https://www.peine01.de/	City of Peine
https://www.salzgitter.de/	City of Salzgitter
https://www.wolfsburg.de/	City of Wolfsburg
https://die-region.de/	Die Region Braunschweig Wolsfburg
https://www.iff.fraunhofer.de/	Fraunhofer-Institut für Fabrikbetrieb und -automatisierung IFF
https://www.dlr.de/	German Aerospace Centre (DLR)
http://gravionic.com/	Gravionic GmbH
https://www.haz.de/	Hannover Allgemeine
https://www.hausderwissenschaft.org/	Haus der Wissenschaft Braunschweig GmbH
https://helmstedt-vision.de/	Helmstedt regional management
https://www.igm-bs.de/igm-bsnews/news	IG Metal Braunschweig
https://www.braunschweig.ihk.de/	IHK Braunschweig
https://www.invent-gmbh.de/	Invent GmbH
https://its-mobility.de/	ITS mobility
https://www.jlgoslar.de/	JL Goslar GmbH
https://www.corporate.man.eu/en/index.html	MAN SE
www.nglobal.de	Niedersachsen Global GmbH
https://northropgrumman.litef.com/home.html	Northrop Grumman LITEF GmbH
https://www.ostfalia.de/	Ostfalia University of Applied Sciences
https://www.ptb.de/cms/en.html	Physikalisch-Technische Bundesanstalt (National Meteorology institute)
https://www.regionalverband-braunschweig.de/	Regional association for the greater Braunschweig area
http://www.forschungsflughafen.de/	Research Airport Braunschweig
https://www.forschungregion.de/	Research region Braunschweig
https://uk.reuters.com/	Reuters news agency
https://www.bosch.com/company/	Robert Bosch GmbH
https://www.wis-salzgitter.de/	Salzgitter Business and Innovation Promotion
https://www.siemens.com/	Siemens AG
https://www.niedersachsen.de/startseite/	State of Lower Saxony
https://www.stoebich.com/	Stoebich GmbH
https://cars.stanford.edu/about/volkswagen-automotive-innovation-lab	Volkswagen Automotive Innovation Lab at Stanford University
https://www.tu-braunschweig.de/	Technical University of Braunschweig
http://www.hbk-bs.de/	University of Fine Arts Braunschweig
voith.com	Voith Group
https://www.volkswagen.de/	Volkswagen AG (Germany)
https://www.volkswagen.de/com	Volkswagen AG (global)
www.volkswagen-newsroom.com	Volkswagen AG (news)
www.tgz-salzgitter.de	WI Salzgitter GmbH
http://www.witech-engineering.de/	WiTech Engineering GmbH
https://www.wolfsburg-ag.com/	Wolfsburg AG

Appendix H

Quality Criteria

As is the case with every study, a key issue in case study research concerns its quality. In general, two main perspectives inform the contemporary discourse on the quality of case study research: the *methodical* view (Gibbert et al., 2008, Yin, 2009); and the *philosophical* view (Healy and Perry, 2000, Wynn and Williams, 2012). According to the first perspective, the quality of case study research needs to be assessed in the exact same way as research informed by econometrics and experimental research. According to the second perspective, the quality of case study research is best established by using a set of criteria that is compatible with fundamental tenets of the philosophical perspective that informs case study research, "*not by the assumptions or tenets of some other method*" (Myers, 2019, p.84).

> "*Because a paradigm is a world view, spanning ontology, epistemology and methodology, the quality of scientific research done within a paradigm has to be judged by its own paradigm's terms*."
>
> (Healy and Perry, 2000, pp.120-121)

Since this study is informed by the critical realist philosophical tradition, the philosophical view on quality is adopted. In particular, the present study uses a comprehensive set of critical realist quality criteria as developed by Healy and Perry (2000).

Table H.1 provides an overview of each criterion, also showing the practices that this research has adopted to meet each criterion.

Table H.1: Quality Criteria

Criteria		Description	Suggested techniques	Key practices in this study
Ontological Criteria	Ontological appropriateness	Research problem deals with complex social science phenomena, involving reflexive agents	Investigate a 'how' and 'why' research problem	A 'how' research problem is pursued; the main objects of this research are the structural components of the RIS in the region of Braunschweig and the strategic responses of focal actors; both phenomena are complex entities, and exist independently of this research
	Contingent Validity	Context-specific analysis of generative mechanisms (mechanisms-based analysis) rather than a simple cause-and-effect analysis (variable-based analysis)	Purse in-depth analysis of causal mechanisms and context	An in-depth contextually-rich analysis of identifies the causal powers of causal mechanisms and the conditions that make them contingent
Epistemological criteria	Reflexivity	Research is neither value-free nor value-laden, but value aware	Self-description and awareness of own values	Since the outset of this study, I have been fully aware of my own theoretical values, i.e., I understand scientific research from the standpoint of critical realism; I understand innovation from the standpoint of the field of innovation system studies; and I understand inequality from the standpoint of relational inequality theory.
	Multiple perceptions	The importance of including multiple approaches to support causal analysis participant's perceptions are being studied because they provide a window on to a reality beyond those perceptions.	Use variety of data types and sources, analytical methods, and theoretical perspectives; reports for peer review	22 interviews with multiple actors holding different positions in different organisations in the region of Braunschweig were held; relevant material from the websites of numerous organisations was also gathered
Methodological criteria	Methodological trustworthiness	Research is trustworthy – it can be audited.	Use case study database; use relevant quotations and matrices than summarise data; descriptions of procedures like case selection and interviews	A case study database was created; I have used relevant quotations and tables summarising the data; I have also described the case selection criteria and the interview sampling procedures; and the processes through which the mechanisms were identified are clearly reported
	Transfactual-analytical generalisation	Theory-building and testing generalisation about the transfactually-operating causal powers of causal mechanisms (including structures), rather than statistical generalisation	Identify theoretical issues prior to data collection and incorporate them in the data collection process (e.g., interviews); use existing theory and multiple theoretical perspectives	Data triangulation was used; I have used the RIS framework which allows for analytical generalisation; the conceptual model was used as a signpost in the analysis
	Construct validity	It refers to the quality of the conceptualization or operationalization of the relevant concepts used in the study	Use of prior theory to construct variables and codes; case study database; and triangulation of data; having key informants review the draft	Both RIS theory and key dimensions in the conceptual model were used to construct a set of initial codes; these codes were further developed and refined by the data triangulation process

Source: Healy and Perry (2000), Gibbert et al. (2008), Yin (2009)

Appendix I

Regional and Extra-Regional Collaboration and Networks: Examples and Quotes

Table I.1: Examples and Quotes of Collaboration among Actors

Intra-regional interactions		Extra-regional interactions	
Quote or description	**Source**	**Quote or description**	**Source**
Science and research co-operate closely with the economy – a particularly impressive example of this can be seen at the Research Airport, where successful knowledge networking has made Braunschweig a European centre for mobility research	braunschweig.de	The German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) and MTU Aero Engines are focusing on a fuel cell propulsion system, which they will jointly develop and validate.	dlr.de
Some of the highlights of Braunschweig's technology transfer are Siemens AG's CargoMover, a kind of truck running on rails, Europe's second largest research airport, and Salzgitter Mannesmann Forschung GmbH's Hightech Steel	braunschweig.de	the US National Aeronautics and Space Administration (NASA) and the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR)...signed an agreement on close research collaboration.	dlr.de
The Open Hybrid LabFactory e. V. (OHLF), the TU Braunschweig and the Fraunhofer Gesellschaft provide a joint platform for industrial partners and the public institutions involved in order to accelerate research and development projects.	tu-braunschweig.de	Researchers at the DLR Institute of Aerodynamics and Flow Technology in Braunschweig and the French Aerospace Lab (Office National d'Etudes et de Recherches Aérospatiales; ONERA) can now use their computational data to demonstrate that the RACER can fly at over 400 kilometres per hour, making it 100 to 200 kilometres per hour faster than any conventional helicopter.	dlr.de
The Technical University of Braunschweig and the Helmholtz Centre for Infection Research are in the process of establishing the new Integrated Centre for Systems Biology – BRICS.	Org. Document 10	The internationally oriented application centre for the European satellite project Galileo is currently being built with support from the Federal State of Lower Saxony and is just one successful example for the continuous development of the research airport as a centre of excellence“ (BOR10)	Org. Document 10
“ Through the current investment of almost 40 mill. EUR, the internationally recognised Research Airport Braunschweig experiences another growth spurt, giving Braunschweig the possibility to raise its profile as technology hotspot in Europe even further. In November 2009, the Campus Forschungsflughafen (Campus Research Airport) was inaugurated. Modern teaching and research at the highest level are combined under the umbrella of the Campus. Here, the German Aerospace Centre and the Technical University of Braunschweig, in close collaboration with the industry sector, are developing new technologies for a “people-friendly aircraft”, where attention is focused on safer, less noisy and environmentally friendlier flying.	Org. Document 10	“Braunschweig has a lot of designers, graphic and industry designers. If you look at the yellow pages, you find there are many companies. We have many creative designers. Some have been pretty big working for global companies, Nokia for example, and some have very good reputation, design agencies, graphic agencies are pretty good. I guess design is an innovative sector in here the city. ”	Interview 3
the Technology Park Braunschweig...Since 1986, over 100 successfully operating businesses have been based at the technology park, in which far more than 1.000 highly skilled engineers and technicians find employment.” (BOR10)	Org. Document 10	The Federal State of Lower Saxony, the Volkswagen AG and the Technical University of Braunschweig are investing in the NFF together with other partners with top-level international research” (Organisational document 10)	Organisational document 10
The newly founded Institute for Transportation Design (ITD) of the Braunschweig University of Visual Arts represents a particularly interesting example of the collaboration between business, science and culture...In numerous third party funded projects the ITD, together with representatives of the mobility sector, has succeeded in realising praxis-oriented and marketable designs and with that it has sparked growing interest from the industry.” (BOR10)	Org. Document 10	“Volkswagen is now a giant step closer to transforming this dream into reality. Having joined forces with Stanford University in California, working in a team coordinated by the Volkswagen AG Electronic Research Laboratory in the nearby city of Palo Alto, VW Group Research took part in the Grand Challenge 2005 in the USA – the only race in the world with automated test vehicles”	Volkswagen annual report (2005)
The “Haus der Wissenschaft” was established on the premises of the former Kant University next to the Natural History Museum and is the central meeting point of the research location Braunschweig. It is a venue where temporary exhibitions, public lectures and discussion events for the interested general public and professional audiences alike are being hosted. The “Haus der Wissenschaft” promotes the dialog between industry, science and ordinary people. It is a meeting place where scieists and business people have the opportunity to exchange views, ideas and information, and in line with the spirit of “Kitchen of Ideas”, develop new projects, cooperationsand “concepts for the future”. (BOR10)	Org. Document 10	We work closely with partners from business and science: over 200 research institutions, industrial partners, small and medium-sized suppliers, associations, authorities and experts in Lower Saxony, Hamburg and Saxony-Anhalt are involved.	Alliance for the Region
The BANSON e. V. is an association that promotes business start-ups as well as the start-up culture and networking between business and the start-up scene in the region.”(banson.de)	Org. Document 10	Conference ”Automated & Networked Driving” in Braunschweig The conference was organized for the 19th time by the network for intelligent mobility ITS mobility with the support of the German Aerospace Center (DLR), the Lower Saxony Research Center for Vehicle Technology (NFF) and the Alliance for the Region.	Alliance for the Region
Many people here have known each other since university, and are benefiting from this large network, which, although it's roots are here, is well connected internationally and can draw upon a large number of contacts. Everyone here knows everyone else, trusts one another, finds the courage to do something new, receives valuable advice without unnecessary detours, and has the chance to expand a fledgling business into a medium-sized enterprise at a manageable risk – a motivating signal from the lively young entrepreneur scene. Successful specialists such as Aerodata, delair, etamax, IntegNav, mavionics, messwerk, Oecon and Simtec started out in this environment.'	Org. Document 10	The Lower Saxony Ministry of Economics has now provided a consortium of ITS automotive nord GmbH, Allianz für die Region GmbH, Wolfsburg AG and Lower Saxony Research Center Vehicle Technology (NFF) with funding of 434,000 euros for the next few years. The European Regional Development Fund (ERDF for short) is to be used to further develop the network as a reference for intelligent mobility in Lower Saxony.	Alliance for the Region
With established large-scale corporations like Volkswagen, Bosch and Siemens on site and close by, researchers can readily find a local partner in the industry sector. Airbus and EADS, Deutsche Flugsicherung (DFS) (German Air Traffic Control) and EUROCONTROL have numerous business connections of all kinds with the research airport, which is successfully involved in major European research and development programmes.	Org. Document 10	The Battery Safety Campus has high-caliber staff and receives active support from the region. Stakeholders include Allianz für die Region GmbH, CUTEC-Institut GmbH, the Fraunhofer Heinrich Hertz Institute, the Energy Research Center Lower Saxony and the Clausthal University of Technology.	die-region.de
The BANSON e. V. is an association that promotes business start-ups as well as the start-up culture and networking between business and the start-up scene in the region.”(banson.de)	banson.de	‘Braunschweig 2030 – Living. Designing. Together.’ project, the Braunschweig University of Technology and Hanover Medical School are examining how innovative new living environments for all generations and the widest range of life situations can be created in cities in the future.	die-region.de
TU Braunschweig and Ostfalia receive around two million euros for start-up funding Both universities are convincing in the ”EXIST-Potentiale” competition of the Federal Ministry for Economic Affairs and Energy With their joint “International TechKnowledgy Hub” concept, the Technical University of Braunschweig and the Ostfalia University of Applied Sciences are among the winners of the EXIST-Potentiale competition	tu-braunschweig.de	University of Braunschweig with their vehicle “Caroline” took 7th place on their very first attempt. Stanford University's vehicle “Junior”, which has been developed in cooperation with the Volkswagen AG, Wolfsburg, came second.	Organisational document 10
there is a dense network of centres of excellence that serve as knowledge exchange interfaces between institutes of higher education, universities of applied science and companies. The close ties between universities, research institutions and private enterprise mean that scientific findings can be integrated into the development of new products, processes and services very quickly.		Ostfalia university cooperates with more than 100 universities all over the world, offering its students and teaching personnel an opportunity to gain international experience. The International Relations Office's qualified liaison personnel are Ostfalia's point of contact for (partner) universities seeking to arrange and shape such partnerships.	Ostafalia.de
Voith Group and the Technical University of Braunschweig build together the world largest paper airplane	Org. Document 15	AERONAUTICS RESEARCH CENTRE NIEDERSACHSEN (NFL) – Technical University of Braunschweig, the German Aerospace Center (DLR) and additional partners are bringing together their broad areas of expertise. The Campus Research Airport is a joint scientific undertaking of the research institutes of aerospace and aeronautics at TU Braunschweig, the DLR, and Leibnitz University (LU) in Hannover.	Forschungsflughafen.de
“Salzgitter Mannesmann Forschung GmbH (SZMF) is the central coordinating unit for research and development activities concerned with innovative processes, and structures the key contents and project areas. On the one hand, it is possible for SZMF to map and reproduce the entire process chain, from the production of liquid metal to the finished product, both in theory and on laboratory scale. On the other hand, SZMF performs an intermediary function between both application-oriented research conducted in-house, as well as basic research carried out at centers of expertise such as public research institutions, universities and colleges. A total of 53 active multilateral projects involving international participation bear impressive witness to this position within an extensive research network. Cooperation within the field of research is given clear preference over the buying-in of know-how. As a result, there was no expenditure for the latter in 2005. In 2005, the Salzgitter Group spent 58 million EUR on R&D activities and on R&D-relevant and -related quality management projects. Of these, 59\% were attributable to the Steel Division, 36\% to Tubes Division and 5\% to the Services Division. R&D expenses amounted to 2.9\% of Group value-added. Some 706 employees were engaged in R&D activities.” (BOR 25 – Salzgitter annual report 2005)	Org. Document 25	The registered association with the same name was founded more than 10 years ago. The shareholders are 30 members of small and medium sized enterprises being active in the transportation domain. Further support, both in form of personnel and financial aid, is granted by the business development agency of the City of Braunschweig and the State of Niedersachsen.	Forschungsflughafen.de

Appendix J

Largest Employers in the Region of Braunschweig

Table J.1: A List of the Largest Employers in the Region of Braunschweig

Company	City	Sector	Production and competences	2008	2019	Change (%)
Volkswagen AG Werk Wolfsburg	Wolfsburg	Automotive	Plastics manufacturing, vehicle construction, chassis division	-	54,000	-
Volkswagen AG Technical Development	Wolfsburg	Automotive	Research, development, technical development	-	11,000	-
Salzgitter AG	Salzgitter	Steel	Steel: hot-rolled strip, fine strip and refined products, high-quality steel materials; construction-steel elements; spiral-welded large pipes, especially for the high-pressure range.	8,000	8,000	0.00
Volkswagen AG Werk Salzgitter	Salzgitter	Automotive	Engines for cars and commercial vehicles the brands VW, Audi, Seat and Skoda	6,300	7,200	14.29
Volkswagen AG Werk Braunschweig	Braunschweig	Automotive	Chassis construction and vehicle parts; Rear axles, front axles, steering, Brakes, foot controls, battery systems; Machine and tool construction: Cutting and casting tools, welding plants, assembly facilities, Plastic parts	6,400	7,000	9.38
Siemens AG Mobility Division	Braunschweig	Automotive	Railway safety technology,Operational management systems.	2,900	3,000	3.45
MAN Truck & Bus AG Werk Salzgitter	Salzgitter	Automotive	Axles and crankshafts for commercial vehicles, Logistics center for worldwide shipping of spare parts	1,500	2,650	12.77
ALSTOM Transport Deutschland GmbH	Salzgitter	Automotive	Railcars and multiple units with electric or diesel drive, subway and light rail wagons, passenger cars of all kinds, freight cars (Sliding wall, bulk material, container, hood as well as tank cars, bogies of all kinds, Couplings for all vehicle types, wagon-repair, components for the rail-traffic made of steel and glass fiber reinforced plastics	2,350	2,300	-2.13
Robert Bosch Elektronik GmbH	Salzgitter	Automotive	Manufacturing of electronic systems for motor vehicles (control units)	1,800	1,500	-16.67
H.C. Starck-Gruppe	Goslar	Steel, metallurgy	Refractory metals - tungsten, molybdenum, tantalum, niobium, rhenium - and their compounds like borides, carbides, nitrides, oxides, silicides and sulphides; cobalt and nickel metal; cobalt and nickel compounds; boron and Boron compounds; high purity materials for microelectronics; raw materials for high-performance ceramics; alloyed powders.	1,400	980	-30.00
Westermann-Gruppe	Braunschweig	Publisher	School books, books, magazines, shipping house catalogs, advertising catalogs, printed matter, all kinds of cartographic products	800	900	12.50
Fels-Werke GmbH	Goslar	Mining, manufacturing	Burnt and unburnt lime products, mixtures of minerals	130	100	-23.08
Peiner Träger GmbH	Peine	Steel	Peiner beams and other profile steel types such as European beams, sheet piles and Special profiles	1,250	790	-36.80
BS ENERGY	Braunschweig	Energy	Electricity generation and distribution, District heating generation and distribution, Gas and water supply	570	730	28.07
Streiff-Firmengruppe	Braunschweig	Packaging	Packaging and printed products, logistics, electronics distribution, foil- and injection moulding production etc.	800	650	-18.75
Bühler GmbH	Braunschweig	Manufacturing	Machines and plants for grain processing tion, for the food and coffee industry, for breweries and maltings, the compound feed-and oil industry and for cocoa processing; silo and handling systems, conveyor systems, environmental technology equipment, die casting equipment, Rubber and carbon black plants.	700	550	-21.43
BMA Braunschweigische Maschinenbauanstalt AG	Braunschweig	Manufacturing	Plants, components and individual units for the food industry and the environmental technology	250	500	100.00
J.M. Voith SE & Co. KG	Salzgitter	Manufacturing	Drive technology, railway couplings	380	500	31.58
MKN Maschinenfabrik Kurt Neubauer GmbH & Co. KG	Wolfenbüttel	Manufacturing	Commercial kitchen equipment and installations in series and special construction.	350	500	42.86
FIBAV-Unternehmensgruppe	Helmstedt	Construction	Building construction (residential properties)	380	450	18.42
Mast-Jägermeister SE	Wolfenbüttel	Alcoholic beverages	Herbal liqueur	500	450	-10.00
Kroschke sign-international GmbH	Braunschweig	Manufacturing	Warning, information and prohibition signs, markings, health and safety products	320	400	25.00
Zollern BHW Gleitlager GmbH & Co. KG	Braunschweig	Automotive	Plain bearings for large diesel engines, comcompressors, turbines, gears, generators, pumps, blowers; valve plates and block cylinders for axial piston pumps; plain bearing metals; Plain bearing repair; Plain bearing qualification and constructions as well as plain bearing injury assessment	380	370	-2.63
Magna International Stanztechnik GmbH	Salzgitter	Automotive	Stamped, pressed and welded parts for the automotive industry	300	350	16.67
Avacon AG	Helmstedt	Energy	Operation of energy networks in Lower Saxony and Saxony-Anhalt, and in conjunction with it hanging services	500	350	-30.00
Röchling Automotive Germany SE & Co. KG	Peine	Automotive	Interior door panels for motor vehicles, plastic interior equipment, automotive-industry suppliers	400	350	-12.50
Sport-Thieme GmbH	Helmstedt	Sports	Production and dispatch of sports articles for school sports, club sports, fitness and therapy	200	340	70.00

Company	City	Sector	Production and competences	2008	2019	Change (%)
Strube D & S GmbH	Helmstedt	Agriculture	Seeds for agriculture	160	340	112.50
Crown Foodcan Germany GmbH	Goslar	Packaging	Metal packaging for the food industry industry	350	320	-8.57
Faurecia Innenraum Systeme GmbH	Peine	Automotive	Bumpers and interior door panels of plastic, control panels of plastic	570	320	-43.86
Richard Bretschneider GmbH	Braunschweig	Packaging	Product packaging including displays, packing service	250	300	20.00
Heubach GmbH	Goslar	Manufacturing	Manufacturer of pigment preparations, anticorrosive pigments, organic and inorganic pigments	270	300	11.11
EEW Energy from Waste GmbH	Helmstedt	Energy	Waste incineration for electricity generation, disposal	100	300	200.00
Günther Till GmbH & Co. KG Präzisionsmechanik	Helmstedt	Manufacturing	Hydraulic valves, control blocks of all kinds, hydraulic cylinders	240	300	25.00
Wilhelm Stoll Maschinenfabrik GmbH	Peine	Agricultural manufacturing	Agricultural machinery: Front loaders, mowers, Tedders, windrowers, forage mixers, manure spreaders, forage harvesters, sugar beet harvesting machines	340	300	-11.76
Mann + Hummel Automotive GmbH	Goslar	Automotive	Plastic assemblies and systems for the automotive industry in blow moulding and injection moulding casting technique	380	295	-22.37
Pelikan PBS Produktionsgesellschaft mbH & Co. KG	Peine	Manufacturing	Writing instruments, erasers, wax crayons, opaque paint and watercolour boxes, inks, cartridges and inks	320	260	-18.75
Hoffmann Maschinen- und Apparatebau GmbH	Peine	Manufacturing	Filter systems for cooling lubricants, return cooling systems, oil mist separators, ultrafiltration	170	260	52.94
Sattler Media Press GmbH	Wolfenbüttel	Print	Print and mail	200	250	25.00
Schaper & Brümmer GmbH & Co. KG	Salzgitter	Pharmaceuticals	Herbal medicines	210	230	9.52
Nordzucker AG	Braunschweig	Food	Sugar production	200	210	5.00
Arnold Andre GmbH & Co. KG	Helmstedt	Tobacco	Cigarettes, cigars	230	210	-8.70
Ficosa International GmbH	Wolfenbüttel	Automotive	Automotive parts, especially exterior and interior mirrors, water tanks	155	210	35.48
Meisterbäckerei Steinecke GmbH & Co. KG	Helmstedt	Food	Bakery products, wholesale bakery with extensive branch network	160	200	25.00
Peiner Umformtechnik GmbH	Peine	Automotive	Fasteners for the automotive industry industry, HV screw fittings, high-fixed screws, special screws and moulded parts.	345	190	-44.93
Grillo Zinkoxid GmbH	Goslar	Mining, manufacturing	Zinc metallurgy and sulfur chemistry	150	185	23.33
Seyfert GmbH	Salzgitter	Packaging	Production of corrugated cardboard in sheets, cuts and cardboard boxes	190	180	-5.26
Alape GmbH	Goslar	Manufacturing	Washbasins and washstands	200	180	-10.00
esco - european salt company GmbH & Co. KG	Helmstedt	Mining	Food grade salts, industrial salts, de-icing salts, regenerating salts for water softening Systems	190	180	-5.26
Auerswald GmbH & Co. KG	Wolfenbüttel	Telecommunications	Telecommunications equipment, electronic assemblies.	180	180	0.00
Uhlig Rohrbogen GmbH	Goslar	Manufacturing	Pipeline components such as pipe bends, T-pieces, reducers and piping brackets for industrial plants	150	175	16.67
Medienhaus Krause Goslarsche Zeitung Karl Krause GmbH & Co KG	Goslar	Media	Newspaper publisher	165	165	0.00
Chemetall GmbH	Goslar	Chemical, metal	Aircraft sealants, corrosion inhibitors, cleaning products, chemicals for surface treatment of metals.	700	160	-77.14
Meyer GmbH	Salzgitter	Manufacturing, logistics	Hydraulic attachments for industrial trucks	140	150	7.14
JL Goslar GmbH	Goslar	Metallurgy, steel	Non-ferrous products, semi-finished metal products, apparatus and Installations made of lead, tin and its alloys	230	150	-34.78
SOLIDA Textil- und Netzwarenmanufaktur GmbH & Co. KG	Helmstedt	Textile	Hair nets, hairdressing caps, hairdressing capes, shower and bath bonnets, industrial protection bonnets, hygienic headgear for the medical sector.	210	150	-28.57
Nordzucker AG Werk Schladen	Peine	Manufacturing	Sugar production	150	140	-6.67
Weibler Confiserie Chocolaterie GmbH & Co. KG	Wolfenbüttel	Manufacturing	Galvanic surface coatings	95	140	47.37
Galvanotechnik Kessel GmbH & Co. KG	Peine	Manufacturing	Electroplated surface coatings	130	135	3.85
Kraftwerk Mehrum GmbH	Peine	Energy	Power generation	130	120	-7.69
Kümper + Schwarze Baubetriebe GmbH	Wolfenbüttel	Manufacturing	Construction work of all kinds	180	120	-33.33
Gurtec GmbH	Wolfenbüttel	Manufacturing	Conveying technology for bulk and piece goods – transport	120	110	-8.33
			Total	**-**	**115,344**	**-**

Source: own elaboration, IHK Braunscheig (2008 and 2019), volkswagen.com

Appendix K

Top Executive Compensation

Table K.1: Top Executive Compensation at VW AG and Salzgitter AG

Volkswagen AG									
Financial Data and Compensation	**2005**	**2019**	**Change (%)**	***Board of directors***	**2005**	**2019**	***CEO profile***	**2005**	**2019**
Revenue (in Millions Euro)	50,245.00	80,621.00	60.46	Total	6	8	Name	Bernd Pischetsrieder	Herbert Diess
Net income/loss (in Millions Euro)	741.00	4,958.00	569.10	Male	6	7	Gender	Male	Male
Number of employees	101,028.00	119,401.00	18.19	Female	0	1	Age	57	60
Personnel costs (salaries, social and pension costs insurance)	14,644.00	42,913.00	193.04	Female/male ratio	0.00	12.50	Education	Diplom	PhD
CEO total compensation (in Millions Euro)	2,835,074.00	9,850,742.00	247.46				Field	Engineering	Mechanical engineering
Board of management compensation (in Millions Euro)	11,272,513.00	45,394,271.00	302.70						
Number of members	6.00	8.00	33.33						
Average board of management compensation (in Millions Euro)	1,878,752.17	5,674,283.88	202.02						
Income share (CEO per personnel costs)	193.60	229.55	18.57						
Income share (top management board per personnel costs)	128.30	132.23	3.07						

Salzgitter AG									
Financial Data and Compensation	**2005**	**2019**		***Board of directors***	**2005**	**2019**	***CEO profile***	**2005**	**2019**
Revenue (in Millions Euro)	7,152.00	8,547.00	19.51	Total	4	3	Name	Wolfgang Leese	Heinz Jörg Fuhrmann
Net income/loss (in Millions Euro)	842.00	-237.00	-128.15	Male	4	3	Gender	Male	Male
Number of employees	17,036.00	25,227.00	48.08	Female	0	0	Age	59	63
Personnel costs (salaries, social and pension costs insurance)	57,000.00	71,974.47	26.27	Male-female ratio	0.00	0.00	Education	PhD	PhD
CEO total compensation (in Millions Euro)	1,000,851.00	2,826,000.00	182.36				Field	Engineering	Engineering
Board of management compensation (in Millions Euro)	2,902,311.00	6,037,000.00	108.01						
Number of members	4.00	3.00	-25.00						
Average board of management compensation (in Millions Euro)	725,577.75	2,012,333.33	177.34						
Income share (CEO per personnel costs)	17.56	39.26	123.61						
Income share (top management board per personnel costs)	12.73	27.96	119.64						

Source: Own elaboration, annual reports VW AG and Salzgitter AG