CIMR Research Working Paper Series

Working Paper No. 56

Innovation Systems and Income Inequality: In Search of Causal Mechanisms

by

Thanos Fragkandreas*

Date

November 10, 2021

ISSN 2052-062X

* Chair for the Study of Economic Institutions, Innovation and East Asian Development, Department of Management and Microeconomics, Goethe University Frankfurt: fragkandreas@econ.uni-frankfurt.de & kfrag01@mail.bbk.ac.uk

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 causalmechanisms of (in)equality: ***five inequality-inducing causal mechanisms*** (competence concentration, 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 through innovation requires, among other things, the formation of 'strategy synergies' among focal (triple-helix) actors in innovation systems.

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

JEL Classification: O30, D30

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 andOsborne, 2017). For instance, echoing Thomas Piketty's (2014) bestselling book on inequality, the Organisation of Economic Co-operation and Development (OECD) states inone 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 (Caracostas, 2007, 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 experience food insecurity and hunger.

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 (Acemoglu and Autor, 2011), 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 in- equality 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 SBTCresearch 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 per-centiles) 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, forinstance, 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, 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 thedebate between markets, institutions and organisations, in particular between scholars at tributing 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 Co- hen, 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 thevarious stages of the innovation process which, in the end, shapes the direction, scope andstrength 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 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 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 discusses the relevant evidence, illustrating the existence of seven operative causal mechanisms. Section 5 concludes this paper by discussing findings and limitations, as well as analytical and policy implications.

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 income acquisition 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 the realist philosophy of social science, namely ***critical realism***.

2.1 Innovation Systems Approach: Key Aspects

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 (Storz, 2008). 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 in- novation 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.

2.2 Relational Inequality Theory: Key Aspects

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 in- equality 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 narrative 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 find- ings 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 Cum- mins, 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 em- bedded 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.

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, Blaikie and Priest, 2019, pp. 87-117). 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] (Benton and Craib, 2010, Blaikie and Priest, 2019). 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 not in recurrent empirical events (i.e., empirical regularities) but in structures (i.e., a dynamic ensemble of related elements), and particularly in the *causal powers* of structured entities (Elder-Vass, 2010; Danermark et al., 2002, Bhaskar, 2008). Causal powers refer to the inherent capacities of structures to act in certain ways, enabling them to bring about certain events but not others (Elder-Vass, 2010,

[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 Danermark et al. (2002), Sorrell (2018).

Bhaskar, 2008, 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.

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), 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, including our knowledge and research on them (Fleetwood, 2001, Bhaskar, 2008, 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, 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.

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 theorizing*** (Danermark et al., 2002, Bhaskar, 2008). 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 Mustikkama¨ki, 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) 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-destructivenature 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 structureof 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.

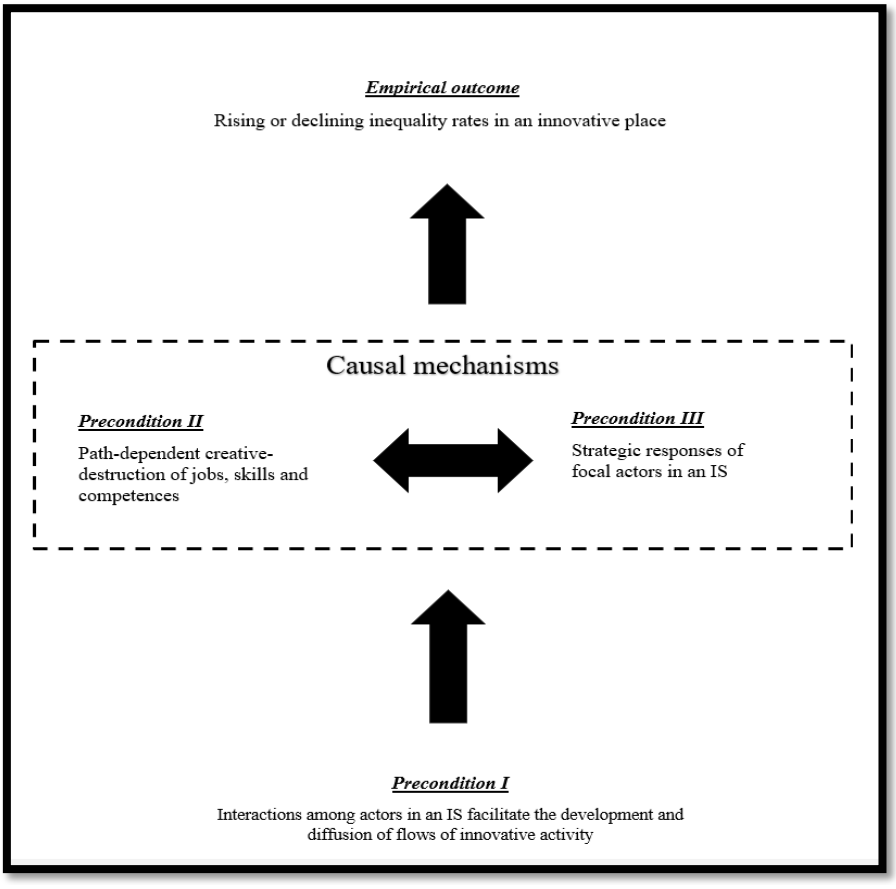
Precondition III: Strategic Responses. In line with RIT, as well as with the 'actor turn' in IS studies (e.g., Hung and Whittington, 2011, Watkins et al., 2015, Law- ton Smith, 2018, Grillitsch and Sotarauta, 2020, Musiolik et al., 2020), this study understands contingency as a set of relatively-enduring strategies that focal (triple-helix[2]) actors in ISs devise as a means of coping with key problems 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 ofdemand (Teece et al., 1997, Archibugi and Lundvall, 2001, Archibugi et al., 2013,

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

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

Figure 1: Conceptual Model



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 de- vise 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 invest-ments 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 functionof 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.

3 Research Design, Setting and Data

3.1 Research Design and Setting

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).

The primary research case 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

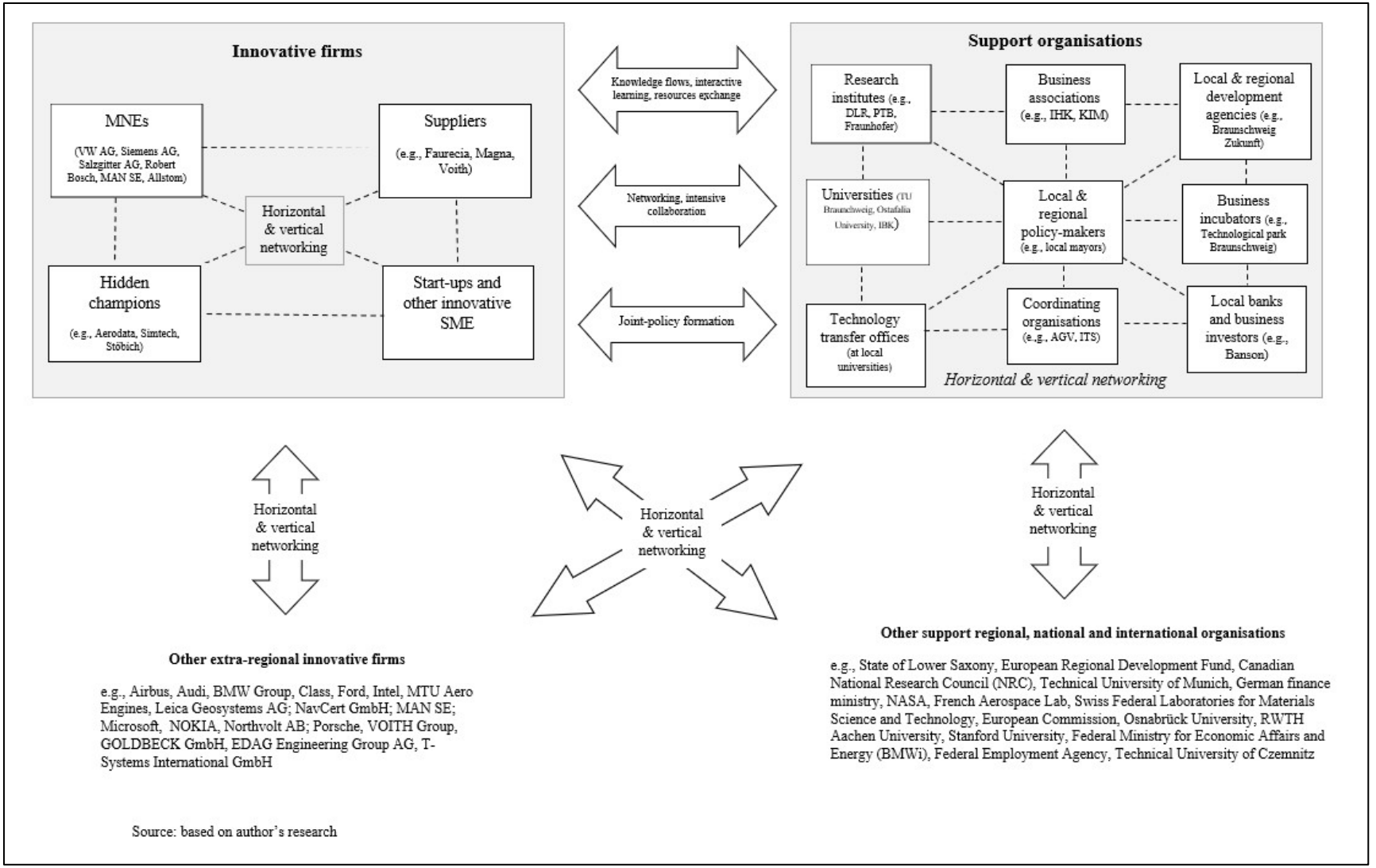
Braunschweig (*Regierungsbezirk Braunschweig*), the area in question is an economic region. It consists of, and is also governed by, economic and policy networks between the three urban districts (*Kreisfreie Städte*) of Braunschweig, Salzgitter, and Wolfsburg, and five rural districts (*Landkreise*) 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 regional gross domestic product (GDP) (5.9 billion EUR) in R&D activities, which is nearly threetimes higher than the R&D investment rate of Germany (3.07%) and four times that of the EU28 (2.04%). 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) (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-sizedenterprises (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 regional innovation system (RIS) in the region of Braunschweig that makes the region in question ideal to search for causal mechanisms.

Figure 2: Map – Region of Braunschweig

Figure 3 provides a graphical representation of the composition of the Braunschweig regional innovation systems (BRIS). In a nutshell, it is shown that there, indeed, existsa 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, hid- den champions and other small innovative firms), as well as numerous support organisations, such as 27 research institutes, 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).

Figure 3: BRIS – Structural Anatomy



Source: based on author's research

More specifically, 22 semi-structured interviews (each of which lasted approximately 45-80 minutes) were conducted in the region of Braunschweig with focal actors[3] 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 interview protocol, 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 inter- views, 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).

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. Documentary data were analysed by using the coding template of interviews. 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). Statis- tical data were used mainly to (a) verify key empirical patterns that emerged from inter- views and documents, as well as (b) to gauge the level of income inequality in the region of Braunschweig[4]. 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

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

[4] 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).

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 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 (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.

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 2, namely causal power or liability (i.e., creative-destructive challenges in the innovation process) + relevant conditions (i.e., strategic responses of focal actors in the BRIS) = empirical out- come (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.

4.1 CM1 – Competence Concentration

Competence Enhancement 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.).

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 re-search 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 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 re- search 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). Clustering initiatives are also seen by policy-makers as necessary to capture some value locally by participating in extra-regionalknowledge 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 in-novation 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, Forschun- gRegion Braunschweig, etc.). Despite that the more recent regional initiatives have ameliorated fragmentation issues among regional policymakers, these activities seem, so far, tohave 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 1). Forinstance, 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, eco-nomic disparities have increased significantly in the region – a phenomenon known amongregional 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 early2000s: 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), andthe 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.

Table 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

Causal Mechanism$_1$: Regional Competence Concentration Close collabo ration 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 affluentdistricts.

4.2 Causal Mechanism$_2$ - Income Hoarding

Competence Dependencies The region of Braunschweig is home to numerous active innovative SMEs[5]. 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

[5] 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-houseis one of the highest in Europe (ranked 16th in Europe).

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 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, employing more than 100,000 employees (IHK Braunschweig, 2019, VolkswagenAG, 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*"[6] (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 Braun- schweig, 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). 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 aver- age personnel costs) in the firm, jumping to 575 times in 2008 (Dr Martin Winterkorn's tenure), and subsequently falling to 230 times in 2019 (Dr Hebert Diess' tenure).

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

Figure 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 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 thetop 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 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.

Table 2: Taxpayers with Income over 125.000 Euros by City and Year % of Taxpayers

Territory	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

Causal Mechanism$_2$: Income hoarding – The underlying composition of the BRIS favours, and is favoured by, the innovative activities 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.

4.3 Causal Mechanisms 3, 4 and 5 - Precarious Employment, Technological Unemployment and Gender Inclusiveness

Technological Unemployment Since the late 1980s, technological unemployment has been a recurrent challenge for the region of Braunschweig. Traditionally, technological un- employment 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 theseindustries in the region than twenty and thirty years ago*" (ibid.). However, technological unemployment has, more recently (circa the late 2000s), been afflicting employment in thesectors 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 everythingwe have experienced to date*"
>
> (Cremer and Schwartz, 2016).

To overcome these technological challenges, and to recover from the diesel gate scan- dal (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 techno- logical unemployment inevitable. For instance, the production of different parts of electricvehicles 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 inthe region.

> "*Many robots are coming into the production, and now many people are get- ting 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 in- stance, 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 un-employment 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[7], which has caused serious trouble for the top management of the firm, and under the pressure of the State ofLower Saxony[8], 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 carbatteries*" (source wv.com) in the city of Salzgitter[9]. 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 un- employment as a local (city-based) matter. A common

[7] 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.

[8] 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)

[9] 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).

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 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 ser-vice 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, increas- ing 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-timeemployees 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[10]. 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 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 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 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 (empirical outcome).

Causal Mechanism$_5$: Gender Inclusive Employment – Facilitated by a mix of

[10] 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).

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 ofBraunschweig. This has narrowed down the gender (employment and income)gap in the region.

4.4 Causal Mechanisms $_{6\&7}$: 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 ratesof 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 con- duct a significant portion of their R&D activities in the region. For instance, VW employsmore 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 conductingR&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).

On the other hand, the region of Braunschweig has a vibrant scientific base which, ac- cording 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 in- stitutes – 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 regional 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'sexpertise lies in industrial design: "*Braunschweig has a lot of designers, both graphic andindustrial; 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 concernsthe 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 continuesto 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 (Boschma, 2005), 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 ofthese 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, ma- chine 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 yearto 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 hold- ing 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 per- sons 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 wasmuch 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% I n 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, Acemoglu and Autor, 2011). However, as is shown in Table 4, the percentage of tax-payers 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 – 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.

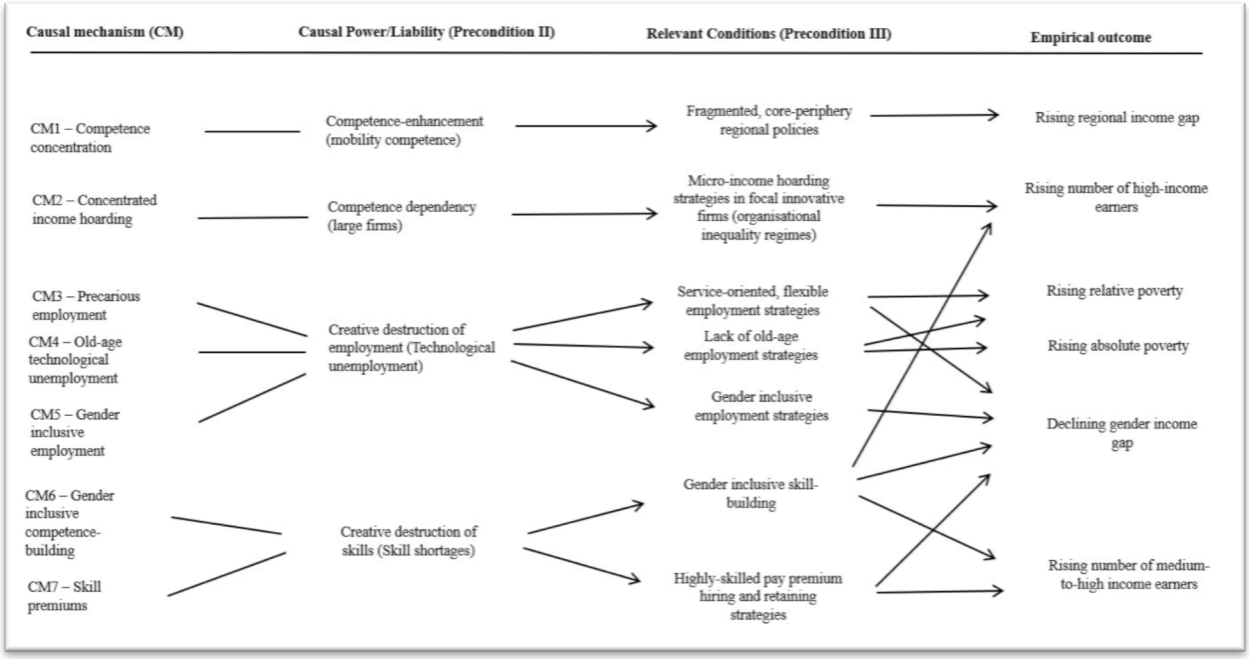
5 Concluding Discussion, Implications, Limitations and Suggestions

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 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 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 un- packed the composition of 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.

Figure 5: Causal Mechanisms



Furthermore, and as illustrated in Figure 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 sameempirical 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 techno- logical 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 isevident from the analysis, in particular by the identification of two causal mechanisms that reduce inequality (i.e., CM6 and CM7), is that reducing 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 in the region of Braunschweig.

5.2 Analytical and Policy Implications

An important question that arises from the analysis in this study is that of *external valid- ity*, 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 ISs are structurally heterogeneous (Nelson, 1993, Braczyk et al., 1998, Malerba, 2002) and that the strategies of focal actors are extremely unlikely to be identical. However, the underlying composition in each causal mechanism (i.e., combi- nations of causal powers and relevant conditions) allows us to develop two generalisable theoretical propositions about the relationship between ISs and inequality.

> ***Theoretical proposition I****: ISs* ***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****: ISs* ***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 theinnovation process.

These two theoretical propositions have two interesting policy implications. First, the fact that it is the organisational strategies of focal actors in ISs 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, in- novation 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, ISs offer a ready-made, yet largely-underutilised, platform (or arena) to establish 'strategic coalitions' among focal actors which are favourable to inclusive growth.

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. This is a promising research effort, which, as shown throughout the present study, deserves the attention of innovation (system) researchers and policy-makers.

References

Acemoglu, D. (2002), 'Technical change, inequality, and the labor market', *Journal of Economic Literature* **40**(1), 7–72.

Acemoglu, D. and Autor, D. (2011), Skills, tasks and technologies: Implications for employment and earnings, *in* O. Ashenfelter and D. Card, eds, 'Handbook of Labor Economics', Elsevier, Amsterdam, pp. 1043–1171.

Acker, J. (2006), 'Inequality regimes: Gender, class, and race in organizations', *Gender & Society* **20**(4), 441–464.

Archibugi, D., Filippetti, A. and Frenz, M. (2013), 'Economic crisis and innovation: is destruction prevailing over accumulation?', *Research Policy* **42**(2), 303–314.

Archibugi, D. and Lundvall, B.-A. (2001), *The Globalizing Learning Economy*, Oxford University Press, Oxford.

Asheim, B. T. and Coenen, L. (2005), 'Knowledge bases and regional innovation systems:

Comparing Nordic clusters', *Research Policy* **34**(8), 1173–1190.

Asheim, B. T. and Gertler, M. S. (2005), The Geography of Innovation: Regional In- novation Systems, *in* 'The Oxford Handbook of Innovation', Oxford University Press, Oxford, pp. 291–317.

Asheim, B. T., Isaksen, A. and Trippl, M. (2019), *Advanced Introduction to Regional Innovation Systems*, Edward Elgar Publishing, Cheltenham.

Asheim, B. T., Isaksen, A. and Trippl, M. (2020), The role of the regional innovation sys-tem approach in contemporary regional policy: Is it still relevant in a globalised world?, *in* 'Regions and Innovation Policies in Europe', Edward Elgar Publishing, Cheltenham.

Autor, D. H., Katz, L. F. and Kearney, M. S. (2008), 'Trends in US wage inequality: Revising the revisionists', *The Review of Economics and Statistics* **90**(2), 300–323.

Avent-Holt, D. and Tomaskovic-Devey, D. (2014), 'A relational theory of earnings inequal- ity', *American Behavioral Scientist* **58**(3), 379–399.

Beebee, H., Hitchcock, C. and Menzies, P. (2009), *The Oxford Handbook of Causation*, Oxford University Press, Oxford.

Benton, T., and Craib, I. (2010), *Philosophy of Social science: The Philosophical Foundations of Social Thought*. Macmillan, London.

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S. and Rickne, A. (2008), 'Analyzing the functional dynamics of technological innovation systems: A scheme of analysis', *Research Policy* **37**(3), 407–429.

Bhaskar, R. (2008), *A Realist Theory of Science*, Verso, London.

Boschma, R. (2005). Proximity and innovation: a critical assessment. *Regional Studies*, *39*(1), 61-74.

Biggi, G. and Giuliani, E. (2021), 'The noxious consequences of innovation: What do we know?', *Industry and Innovation* **28**(1), 19–41.

Blaikie, N., and Priest, J. (2019). *Designing Social Research: The Logic of Anticipation*. John Wiley & Sons, Cambridge.

Braczyk, H.-J., Cooke, P. and Heidenreich, M., eds (1998), *Regional Innovation Systems: The Role of Governance in a Globalized World*, Routledge, London.

Braunschweig Stadtmarketing GmbH (2009*a*), From Gauss to Galileo, Technical report, Braunschweig.

Braunschweig Stadtmarketing GmbH (2009*b*), Research Region Braunschweig, Technicalreport, Braunschweig.

Breau, S., Kogler, D. F. and Bolton, K. C. (2014), 'On the relationship between innova- tion and wage inequality: New evidence from canadian cities', *Economic Geography* **90**(4), 351–373.

Brynjolfsson, E. and McAfee, A. (2012), *Race Against the Machine: How the Digital Rev-olution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy*, Digital Frontier Press.

Caracostas, P. (2007), The policy-shaper's anxiety at the innovation kick: how far do in-novation theories really help in the world of policy, *in* 'Perspectives on Innovation', Cambridge University Press, pp. 464–489.

Carlsson, B., Jacobsson, S., Holmén, M. and Rickne, A. (2002), 'Innovation systems: analytical and methodological issues', *Research Policy* **31**(2), 233–245.

Casper, S. (2007), *Creating Silicon Valley in Europe: Public Policy Towards New Technol-ogy Industries*, Oxford University Press, Oxford.

Chaminade, C., Lundvall, B.-A. and Haneef, S. (2018), *Advanced Introduction to National Innovation Systems*, Edward Elgar Publishing, Cheltenham (UK).

Cobb, A. (2016), 'How firms shape income inequality: Stakeholder power, executive de- cision making, and the structuring of employment relationships', *Academy of Manage-ment Review* **41**(2), 324–348.

Cozzens, S. E., Bobb, K. and Bortagaray, I. (2002), 'Evaluating the distributional con-sequences of science and technology policies and programs', *Research Evaluation* **11**(2), 101–107.

Cremer, A. and Schwartz, J. (2016), 'Volkswagen to cut 30,000 jobs', *Reuters* .
URL: *https://www.reuters.com/article/us-volkswagen-costs-idUSKBN13D0UJ*

Danermark, B., Ekström, M., Jakobsen, L. and Karlsson, J. C. (2002), *Explaining Society: Critical Realism in the Social Sciences*, Routledge, London.

Donegan, M. and Lowe, N. (2008), 'Inequality in the creative city: is there still a place for"old-fashioned" institutions?', *Economic Development Quarterly* **22**(1), 46–62.

Echeverri-Carroll, E. L., Oden, M. D., Gibson, D. V. and Johnston, E. A. (2018), 'Unin- tended consequences on gender diversity of high-tech growth and labor market polar- ization', *Research Policy* **47**(1), 209–217.

Edquist, C. (2005), Systems of Innovation: Perspectives and Challenges, *in* J. Fagerberg, D. C. Mowery and R. R. Nelson, eds, 'The Oxford Handbook of Innovation', Oxford University Press, Oxford, pp. 181–208.

Elder-Vass, D. (2010), *The Causal Power of Social Structures: Emergence, Structure and Agency*. Cambridge University Press, Cambridge.

Etzkowitz, H. and Leydesdorff, L. (2000), 'The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university–industry–government relations', *Research Policy* **29**(2), 109–123.

European Commission (2019), Regional innovation scoreboard 2019, Technical report, Brussels.

Fagerberg, J. (2003), 'Schumpeter and the revival of evolutionary economics: An appraisalof the literature', *Journal of Evolutionary Economics* **13**(2), 125–159.

Fagerberg, J. and Srholec, M. (2008), 'National innovation systems, capabilities and eco-nomic development', *Research Policy* **37**(9), 1417–1435.

Fleetwood, S. (2001), 'Causal laws, functional relations and tendencies', *Review of Politi-cal Economy* **13**(2), 201–220.

Florida, R. L. (2007), *The Flight of The Creative Class: The New Global Competition for Talent*, HarperCollins, New York.

Florida, R. and Mellander, C. (2016), 'The geography of inequality: Difference and deter-minants of wage and income inequality across US metros', *Regional Studies* **50**(1), 79–92.

Fragkandreas, T. (2013), 'When innovation does not pay off: Introducing the European regional paradox', *European Planning Studies* **21**(12), 2078–2086.

Freeman, C. (1987), *Technology, Policy, and Economic performance: Lessons from Japan*,Pinter Publishers, London.

Frey, C. B. and Osborne, M. A. (2017), 'The future of employment: How susceptible are jobs to computerisation?', *Technological Forecasting and Social Change* **114**, 254–280.

Granstrand, O. and Holgersson, M. (2020), 'Innovation ecosystems: A conceptual reviewand a new definition', *Technovation* **90**, in press.

Gray, M., Golob, E., Markusen, A. and Park, S. O. (1998), 'New industrial cities? the fourfaces of Silicon Valley', *Review of Radical Political Economics* **30**(4), 1–28.

Grillitsch, M. and Sotarauta, M. (2020), 'Trinity of change agency, regional developmentpaths and opportunity spaces', *Progress in Human Geography* **44**(4), 704–723.

Guo, Q. (2019), 'Analysis on the relationship between regional innovation and income inequality in Chinese city regions', *The Professional Geographer* **71**(3), 472–490.

Hanley, C. (2014), 'Putting the bias in skill-biased technological change? A relational perspective on white-collar automation at General Electric', *American Behavioral Scientist***58**(3), 400–415.

Healy, M. and Perry, C. (2000), 'Comprehensive criteria to judge validity and reliability of qualitative research within the realism paradigm', *Qualitative Market Research: An International Journal* **3**(3), 118–126.

Hung, S.-C. and Whittington, R. (2011), 'Agency in national innovation systems: Insti- tutional entrepreneurship and the professionalization of Taiwanese it', *Research Policy* **40**(4), 526–538.

IHK Braunschweig (2008), Kompaktinformation, Technical report, Braunschweig. IHK Braunschweig (2019), Kompaktinformation, Technical report, Braunschweig.

King, N. and Brooks, J. M. (2017), *Template Analysis for Business and Management Stu-dents*, Mastering Business Research Methods, Sage, Los Angeles ; Thousand Oaks, CA. OCLC: ocn968904911.

Krätke, S. (2010), 'Regional knowledge networks: A network analysis approach to the interlinking of knowledge resources', *European Urban and Regional Studies* **17**(1), 83–97.

Kristal, T. (2019), 'Computerization and the decline of American unions: Is computeriza- tion class-biased?', *Work and Occupations* **46**(4), 371–410.

Kristal, T. and Cohen, Y. (2017), 'The causes of rising wage inequality: The race between institutions and technology', *Socio-Economic Review* **15**(1), 187–212.

Krusell, P., Ohanian, L. E., R´ıos-Rull, J.-V. and Violante, G. L. (2000), 'Capital-skill complementarity and inequality: A macroeconomic analysis', *Econometrica* **68**(5), 1029– 1053.

Kuznets, S. (1955), 'Economic Growth and Income Inequality', *The American Economic Review* **45**(1), 1–28.

Lam, A. and Lundvall, B.-A. (2006), The learning organisation and national systems of competence building and innovation, *in* L. B. Lorenz E, ed., 'How Europe's economieslearn: Coordinating competing models', Oxford University Press, Oxford, pp. 109–139.

Lawton Smith, H. (2018), Entrepreneurship Policies and the Development of Regional Innovation Systems: Theory, Policy and Practice, *in* A. Isaksen, R. Martin and M. Trippl,eds, 'New Avenues for Regional Innovation Systems - Theoretical Advances, EmpiricalCases and

Policy Lessons', Springer, Cham, pp. 239–256.

Lazonick, W. and Mazzucato, M. (2013), 'The risk-reward nexus in the innovation- inequality relationship: who takes the risks? who gets the rewards?', *Industrial and Corporate Change* **22**(4), 1093–1128.

Lee, N. (2011), 'Are Innovative Regions More Unequal? Evidence from Europe', *Environment and Planning C: Government and Policy* **29**(1), 2–23.

Lundvall, B.-A. (2002), *Innovation, Growth and Social Cohesion: The Danish Model*, Edward Elgar.

Lundvall, B.-Å., Johnson, B., Andersen, E. S. and Dalum, B. (2002), 'National systems of production, innovation and competence building', *Research Policy* **31**(2), 213–231.

Malerba, F. (2002), 'Sectoral systems of innovation and production', *Research Policy* **31**(2), 247–264.

Markard, J. and Truffer, B. (2008), 'Technological innovation systems and the multi-level perspective: Towards an integrated framework', *Research Policy* **37**(4), 596–615.

Martin, B. R. (2016), 'Twenty challenges for innovation studies', *Science and Public Pol- icy* **43**(3), 432–450.

Mingers, J. and Standing, C. (2017), 'Why things happen–developing the critical realist view of causal mechanisms', *Information and Organization* **27**(3), 171–189.

Musiolik, J., Markard, J., Hekkert, M. and Furrer, B. (2020), 'Creating innovation sys- tems: How resource constellations affect the strategies of system builders', *Technologi- cal Forecasting and Social Change* **153**, 119209.

Nelson, R. R., ed. (1993), *National Innovation Systems: A Comparative Analysis*, Oxford University Press, New York.

Niedersachsen Global GmbH (2013), Niedersachsen – your Business Location, Technicalreport, Hannover.

Nielsen, K. (2003), 'Social capital and the evaluation of innovation policies', *International Journal of Technology Management* **26**(2-4), 205–225.

Nielsen, K. and Johnson, B. (1998), *Institutions and Economic Change*, Edward Elgar Publishing, Cheltenham.

OECD (2015), *In It Together: Why Less Inequality Benefits All*, OECD, Paris.

Papachristos, G. and Adamides, E. (2016), 'A retroductive systems-based methodology for socio-technical transitions research', *Technological Forecasting and Social Change* **108**, 1–14.

Pianta, M. (2005), Innovation and employment, *in* J. Fagerberg, D. C. Mowery and R. R. Nelson, eds, 'The Oxford Handbook of Innovation', Oxford University Press, Oxford, pp. 568–598.

Piketty, T. (2014), *Capital in the Twenty-First Century*, The Belknap Press of Harvard University Press, Cambridge MA.

Radosevic, S. and Yoruk, E. (2013), 'Entrepreneurial propensity of innovation systems: Theory, methodology and evidence', *Research Policy* **42**(5), 1015–1038.

Rakas, M. and Hain, D. S. (2019), 'The state of innovation system research: What happens beneath the surface?', *Research Policy* **48**(9), 103787.

Runde, J. (1998), 'Assessing causal economic explanations', *Oxford Economic Papers* **50**(2), 151–172.

Salzgitter AG (2005), Annual report, Technical report, Salzgitter.

Salzgitter AG (2019), Annual report, Technical report, Salzgitter.

Schot, J., & Steinmueller, W. E. (2018). Three frames for innovation policy: R&D, systems of innovation and transformative change. *Research Policy*, *47*(9), 1554-1567.

Schumpeter, J. A. (1944/2006), *Capitalism, Socialism and Democracy*, HarperPerennial, New York.

Sharif, N. (2006), 'Emergence and development of the National Innovation Systems con-cept', *Research Policy* **35**(5), 745–766.

Simmonds, C. (2017), 'The Silicon Valley paradox: one in four people are at risk of hunger', *The Guardian* .
URL: *https://www.theguardian.com/us-news/2017/dec/12/the-silicon-valley-paradox- one-in-four-people-are-at-risk-of-hunger*

Sorrell, S. (2018), 'Explaining sociotechnical transitions: A critical realist perspective', *Research Policy* **47**(7), 1267–1282.

Sotarauta, M. and Mustikkamäki, N. (2015), 'Institutional entrepreneurship, power, and knowledge in innovation systems: institutionalization of regenerative medicine in Tampere, Finland', *Environment and Planning C: Government and Policy* **33**(2), 342–357.

Storz, C. (2008), 'Dynamics in innovation systems: Evidence from Japan's game software industry', *Research Policy* **37**(9), 1480–1491.

Svensson, O. and Nikoleris, A. (2018), 'Structure reconsidered: Towards new foundations of explanatory transitions theory', *Research Policy* **47**(2), 462–473.

Teece, D. J., Pisano, G. and Shuen, A. (1997), 'Dynamic capabilities and strategic management', *Strategic Management Journal* **18**(7), 509–533.

Tilly, C. (1998), *Durable Inequality*, University of California Press, Berkeley.

Tomaskovic-Devey, D. (2014), 'The relational generation of workplace inequalities', *Social Currents* **1**(1), 51–73.

Tomaskovic-Devey, D. and Avent-Holt, D. (2019), *Relational Inequalities: An Organizational Approach*, Oxford University Press, USA, Oxford.

Tripsas, M. (1997), 'Unraveling the process of creative destruction: Complementary assets and incumbent survival in the typesetter industry', *Strategic Management Journal* **18**(S1), 119–142.

Tsoukas, H. (1989), 'The Validity of Idiographic Research Explanations.', *Academy of Management Review* **14**(4), 551–561.

Vallas, S. and Cummins, E. (2014), 'Relational models of organizational inequalities: Emerging approaches and conceptual dilemmas', *American Behavioral Scientist* **58**(2), 228–255.

Van Reenen, J. (2011), 'Wage inequality, technology and trade: 21st century evidence', *Labour Economics* **18**(6), 730–741.

Volkswagen AG (2005), Annual report, Technical report, Wolfsburg. Volkswagen AG (2010), Annual report, Technical report, Wolfsburg.Volkswagen AG (2018), Annual report, Technical

report, Wolfsburg.Volkswagen AG (2019), Annual report, Technical report, Wolfsburg.

Watkins, A., Papaioannou, T., Mugwagwa, J. and Kale, D. (2015), 'National innovation systems and the intermediary role of industry associations in building institutional capacities for innovation in developing countries: A critical review of the literature', *Re- search Policy* **44**(8), 1407–1418.

Welle, D. (2019*a*), 'How Volkswagen wants to drive e-mobility revolution', *DW.COM* . **URL:** *https://www.dw.com/en/how-volkswagen-wants-to-drive-e-mobility-revolution/a-47586417*

Welle, D. (2019*b*), 'Volkswagen's electric future', *DW.COM* .
URL: *https://www.dw.com/en/volkswagens-electric-future/a-51107675*

Wynn, D. and Williams, C. K. (2012), 'Principles for conducting critical realist case study research in information systems', *MIS Quarterly* pp. 787–810.

Xing, J. L. and Sharif, N. (2020), 'From creative destruction to creative appropriation: A comprehensive framework', *Research Policy* **49**(7), 104060.

Yin, R. K. (2009), *Case Study Research: Design and Methods*, 4th edn, Sage, Los Angeles.

Ylikoski, P. K. and Hedström, P. (2010), 'Causal mechanisms in the social sciences', *Annual Review of Sociology* **36**, 49–67.

Zehavi, A. and Breznitz, D. (2017), 'Distribution sensitive innovation policies: Conceptualization and empirical examples', *Research Policy* **46**(1), 327–336.