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

by

Thanos Fragkandreas[†]

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[†]School of Organisations, Economy and Society, Westminster Business School, University of Westminster fragkat@westminster.ac.uk

Centre for Innovation Management Research, Birkbeck University of London kfrag01@mail.bbk.ac.uk

Abstract

This paper deals with a largely unnoticed methodological paradox concerning the scientific status of case study research on innovation systems (ISs). While case study research constitutes the methodological catalyst to the genesis and establishment of the ISs approach as one of the most widely used theoretical and policy-relevant perspectives on innovation in the social sciences, many ISs scholars believe that this type of research can not infer causality and generality. To heighten our understanding of, as well as resolve, such an enduring methodological tension, this paper utilises the dialectical method, particularly the analytical triad of thesis, antithesis and synthesis. It shows that the paradox is attributable to the absence of a compelling antithesis to the ***deductive thesis***, wherein (and grounded in the hypothetico-deductive model of science) case study research on ISs is incapable of drawing causal, generalisable knowledge. In line with a growing number of critical realist studies on innovation, the paper employs the realist mode of scientific explanation known as *retroduction* as a means by which to articulate the ***retroductive antithesis***, whereby case study research on ISs is necessary to learn about the general aspects of causality, and especially causal mechanisms. The dialectical tension between the two antagonistic theses culminates into an original methodological perspective – the ***detroductive synthesis***, wherein *the ability of case study research on ISs to study causality and generality depends mainly upon the model of science that, either explicitly or implicitly, informs the analysis*. Overall, the present paper not only resolves the case study paradox but also enables innovation researchers to reimagine and conduct case study research in a stand-alone, paradox-free, causal explanatory and generalisable way. Thought-provoking implications for the peer-review process and innovation policy evaluation are also discussed.

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

JEL Codes: B49, B52, O39

1 Introduction

> "*A paradox is an idea involving two opposing thoughts or propositions which, however contradictory, are equally necessary to convey a more imposing, illuminating, life-related or provocative insight into truth than either fact can muster in its own right...What the mind seemingly cannot think, it must think.*"
>
> (Slaatte, 1968, p.4)

Understood as the set of interacting (private and public) organisations that, under specific institutional arrangements, facilitate the generation, use, and dissemination of new knowledge, learning and innovation (Freeman, 1987, Doloreux and Parto, 2005, Edquist, 2005), innovation systems (ISs) constitute an essential structural condition for achieving and sustaining a high level of (Schumpeterian) growth and development in modern-day capitalist societies (Freeman, 2002, Bergek et al., 2008, Filippetti and Archibugi, 2011, Castellacci and Natera, 2013, Radosevic and Yoruk, 2013, Chaminade et al., 2018, Asheim et al., 2019). Since the early 1990s, ISs have been a popular object of extensive research and policy action across the world (Sharif, 2006, Chaminade et al., 2018, Asheim et al., 2019, Rakas and Hain, 2019, Schot and Steinmueller, 2018, Fernandes et al., 2021). Over time, this has led to the emergence of the IS approach (Edquist, 2005), which is, by now, one of the most widely utilised theoretical perspectives on innovation in the social sciences (Fagerberg et al., 2012, Rakas and Hain, 2019).

This paper is among the first to scrutinise in a systematic manner the deeper assumptions that inevitably underpin our research on ISs. As such, both the analysis and findings of this paper complement recent stock-taking contributions to ISs (Teixeira, 2014, Chaminade et al., 2018, Asheim et al., 2019, Rakas and Hain, 2019, Fernandes et al., 2021, Lundvall, 2022). However, unlike these very interesting and informative contributions, the present study is motivated by the existence of two largely unnoticed yet contradictory methodological developments in the literature, which – as is shown throughout this paper – have formidable implications for the scientific image and qualities – i.e. *scientificity* – of the ISs approach.

On the one hand, the seminal work of the protagonists of the ISs approach – such as Freeman's (1987) analysis of the national IS in Japan, Nelson's (1993) collection of 14 case studies of various national ISs across the world, as well as the edited volumes of Braczyk et al. (1998) and Malerba (2004) on regional ISs and sectoral ISs – clearly demonstrate the methodological importance of case study research[1] for the field of ISs studies. On the other hand, a growing number of ISs scholars believe, implicitly or explicitly, that case study research is not scientific enough. The underlying argument can be summarised in the following way: since the principal aim of scientific research is to produce generalisable causal knowledge about the phenomena under investigation (Harvey, 1969, Chalmers, 2009), and case study research is, by design, small-N analysis (Eisenhardt, 1989, Flyvbjerg, 2006, Yin, 2009), this entails that, in contrast to large-N research on ISs, case study

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

research is highly unlikely to generate findings that extend beyond the case study context.

In propagating such a view, ISs scholars have unintentionally created several methodological ironies and impasses. For instance, if we provisionally accept the view that case study research is scientifically feeble, how do we explain the fact that this type of research is the most popular choice in the field of ISs studies (Carlsson, 2007, Teixeira, 2014, Doloreux and Porto Gomez, 2017)? Furthermore, since the current stock of knowledge on ISs is mainly based upon the findings of case study research (Freeman, 1987, Nelson, 1993, Braczyk et al., 1998), does this mean that the theoretical foundations of the ISs approach, including the analytical and policy implications that accrue from them (Metcalfe, 1995, Woolthuis et al., 2005), and which have – since the 1990s – been informing numerous innovation policies worldwide (e.g. Smith and Estibals, 2011, Schot and Steinmueller, 2018, Edquist, 2019), are of dubious scientific quality? Such largely unexamined methodological contradictions constitute the heart of the *case study paradox* in the field of ISs studies.[2]

This paper penetrates the deeper, and largely unexamined, assumptions that uphold the case study paradox. It does so by utilising the dialectic method (also known as dialectics), particularly the 'dialectic triad' (Popper, 1940, p.325) of the thesis, antithesis and synthesis (Hegel, 1977, Bhaskar, 2008*a*). By dialectically scrutinising the case study paradox, it is shown that the paradox in question is attributable to the absence of a compelling antithesis to the ***deductive thesis*** wherein, based on the hypothetico-deductive model of science (Hempel and Oppenheim, 1948), case study research is severely unfit when it comes to drawing causal, generalisable knowledge about ISs. In line with a growing number of critical realist contributions on innovation (e.g. Castellacci, 2006, Menzies, 2012, Koutsouris, 2012, Jackson et al., 2016, Adamides, 2018, Sorrell, 2018, Svensson and Nikoleris, 2018, Vega and Chiasson, 2019), the paper utilises the retroductive mode of explanation (Bhaskar, 2008*b*, Danermark et al., 2019) as a source of inspiration in formulating the ***retroductive antithesis***, wherein case study research is not only capable but also indispensable to causal explanatory research on ISs. Building on the dialectical tension between the two antagonistic theses, the paper advances the ***detroductive synthesis***, wherein, and *while case study research on ISs inherently possesses the ability to study causality and generality, the extent to which this will be realised in a concrete research project depends heavily upon the model of scientific explanation that informs the analysis*.

A dialectical analysis of the case study paradox makes several novel contributions to our understanding of the methodology and explanatory potential of case study research on ISs. Specifically, by articulating the retroductive antithesis, the paper debunks the methodological supremacy of the deductive thesis, whilst also clearing the methodological ground for a new type of causal-explanatory analysis based on the retroductive model of science. This enables IS researchers to address in a more productive (in terms of knowledge generation), yet methodologically consistent manner than hitherto, several key research challenges that the field of ISs studies is currently facing. For instance, recent contributions have identified three major research avenues for the field of ISs studies (Lundvall, 2013, Perez, 2013, Martin, 2016, Weber and Truffer, 2017, Chaminade et al., 2018, Pianta, 2018, Asheim et al., 2019, Rakas and Hain, 2019, Fragkandreas, 2022, Isaksen et al., 2022, Lund-

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

vall, 2022): (a) to study the emergence of new and the ongoing transformation of existing ISs; (b) to broaden the scope of ISs research (e.g. artificially intelligent technologies, digital innovation and inclusive entrepreneurship); (c) to develop policy-relevant knowledge about grand societal challenges such as declining labour productivity growth, environmental sustainability, economic resilience, inclusive growth, rising income inequality and technological unemployment. Overall, the paper makes it possible to address the aforementioned research challenges by means of causal explanatory case study research in a manner that would have otherwise been methodologically impossible, given the predominance of the deductive thesis in the relevant literature.

The remainder of this paper consists of four sections. Section 2 sets the scene by primarily offering a methodological overview of ISs research, paying particular attention to the paradoxical status of case study research. Section 3 introduces the dialectical method, whereas Section 4 articulates, compares and contrasts the three main theses (i.e. deductive thesis, retroductive antithesis and detroductive synthesis) that form the analytical core of this paper. Section 5 brings the paper to an end by discussing key implications that emanate from the dialectical resolution of the case study paradox, one of which concerns the fact that a pure deductive research agenda is counterproductive to innovation policy action and cumulative policy learning.

2 Case Study Research on ISs: Methodological Overview and Paradox

2.1 ISs Approach: Background, Emergence and Variants

Over the past four decades, numerous contributions have confirmed that innovation is by no means a single-actor, well-behaved, smooth, linear activity that begins with scientific research and development (R&D), before reaching the market through production, marketing and sales activities (Kline and Rosenberg, 1986, Lundvall, 2013). Central to such a non-linear perspective on innovation is the work of Neoschumpeterian economists (Fagerberg, 2003), in particular the work of Christopher Freeman, Bengt-Åke Lundvall, Dick Nelson, Carlota Perez, and Nathan Rosenberg (Eparvier, 2005, Sharif, 2006, Fagerberg and Sapprasert, 2011). Freeman (1987, 1988), for instance, demonstrates, in his seminal study on Japan that, behind the Japanese economic catch-up in the post-war period and the subsequent technological leadership in electronics in the 1970s and 1980s, was a well-functioning national IS, i.e. 'the networks of institutions in the public and private sectors whose activities and interactions initiate, modify and diffuse new technologies' (Freeman, 1987, p.1).

Motivated by the findings of Freeman's study in Japan, as well as by the early contributions on national ISs in the 1990s (e.g. Lundvall, 1992, Nelson, 1993), and particularly by the observation that the national scale is often too broad to understand the complexities that characterise innovation as a systemic process (Metcalfe, 1995, Cooke et al., 1997), several contributions have, since the late 1990s, attempted to ascertain whether ISs exist at the other levels of socio-economic organisation, such as in cities, regions, sectors, tech-

nologies and firms (e.g. Braczyk et al., 1998, Malerba, 2004, Bergek et al., 2008, Rikap and Lundvall, 2021). This has, over time, led to the emergence of the ISs approach, which currently constitutes a major theoretical pillar in the broader field of innovation studies (Martin, 2016, Lundvall, 2013, Rakas and Hain, 2019).

Mirroring its theoretical origins, which lie in a discipline-diverse body of knowledge on innovation (e.g. economic geography, economic sociology, evolutionary economics, industrial economics, institutional economics and organisational learning theory) (Radosevic, 1998, Lundvall et al., 2002, Nelson and Nelson, 2002, Malerba, 2004, Chaminade et al., 2018, Asheim et al., 2019), the ISs approach encompasses four main analytical variants: a *spatial variant* that studies national ISs and regional ISs (Chaminade et al., 2018, Asheim et al., 2019); a *sectoral-technological* variant that looks at sectoral (Malerba, 2004) and technological ISs (Bergek et al., 2008); a *configurational* variant which seeks to identify configurations of sectoral and technological ISs across the globe (Binz and Truffer, 2017, Weber and Truffer, 2017); and lastly, the *innovation (eco-)system* variant that deals with firm-based ISs (Granstrand and Holgersson, 2020, Rikap and Lundvall, 2021).

Despite their analytical differences, especially with regard to the primary context of analysis (e.g. nation, region, sector, technology, and firm), all variants of the ISs approach share the same semantic core – they all theorise and analyse systemic interactions among the *production base* (i.e. innovating firms) and the *institutional support* base (i.e. universities, research institutes, government organisations, suppliers, consultants, etc.) (Lundvall, 1992, Malerba, 2004, Edquist, 2005, Stamboulis, 2007, Bergek et al., 2008, Asheim et al., 2011). Special attention is paid to how such a dynamic ensemble of interacting actors facilitates the creation and exchange of relational resources (e.g. financial and social capital, knowledge) and processes (e.g. interactive learning) necessary for the successful development and commercialisation of innovative activities in contemporary capitalist societies (Radosevic, 1998, Nielsen, 2003, Lundvall, 2007). Correspondingly, all variants of the ISs approach are grounded on the assumption that innovation policy is more effective when it seeks to address a variety of *system-specific problems* (e.g. interaction failures, infrastructural failures, institutional failures, lock-in and capability failures) that hinder the development of promising innovative activities and paths of growth, rather than when it is exclusively designed to correct *market failures* (Metcalfe, 1995, Tödtling and Trippl, 2005, Woolthuis et al., 2005, Bergek et al., 2008, Bleda and Del Rio, 2013, Schot and Steinmueller, 2018).

2.2 Case Study Research on ISs: A Curious Case?

In line with Joseph Schumpeter's (1954/2006*b*) methodologically-eclectic approach to socio-economic research (Shionoya, 2004), ISs researchers have utilised several research designs and methods to study the 'empirically rich' (Asheim and Gertler, 2005, p.300), 'institutionally diverse' (Radosevic, 1998, p.76) and 'structurally heterogeneous' (Cirillo et al., 2019, pp.908-909) nature of ISs. In alphabetical order, the following research designs are currently in wide use ***advanced statistical analysis and econometrics*** (e.g. Vilanova and Leydesdorff, 2001, Buesa et al., 2006, Belussi et al., 2010, Herrmann and Peine, 2011, Filippetti and Archibugi, 2011, Castellacci and Natera, 2013, Ivanova and Leydesdorff, 2015), ***case study research*** (e.g. Doloreux, 2004, Asheim and Coenen, 2005, Storz,

2008, Lawton Smith et al., 2014), ***historical research*** (e.g. Negro and Hekkert, 2008, Fagerberg et al., 2009), ***grounded theory*** (e.g. Abolhasani et al., 2014), ***network analysis*** (e.g. Belussi et al., 2010, Kauffeld-Monz and Fritsch, 2013, Rikap, 2022), ***qualitative (fuzzy-set) comparative analysis*** (e.g. Meuer et al., 2015, Crespo and Crespo, 2016, Wang et al., 2021), and ***simulation research*** (e.g. Lee and Von Tunzelmann, 2005, Samara et al., 2012, Uriona and Grobbelaar, 2019).

Despite such a rich methodological menu, it is the case study method that has, since the inception of the IS approach in the late 1980s, been the most popular option among ISs scholars (e.g. Freeman, 1987, Nelson, 1993, Braczyk et al., 1998, Doloreux, 2004, Malerba, 2004, Asheim and Coenen, 2005, Lawton Smith et al., 2014). Bibliometric analyses confirm that most studies on ISs are either single or multiple case studies (Carlsson, 2007, Teixeira, 2014, Doloreux and Porto Gomez, 2017, Suominen et al., 2019). For instance, Doloreux and Porto Gomez (2017) find in their systematic review of two decades of research on regional ISs that 61% (182 studies) of all published studies (n=292) are case studies.

Table 1 lists a selection of *some of the most often cited* case study contributions on ISs. Although the number of citations is by no means a reliable indication of scientific quality, nor does it indicate methodological novelty and sophistication[3] (Macdonald and Kam, 2011, Osterloh and Frey, 2020), the table in question confirms that some of the most influential works on ISs are based on case study research. This is also reflected in the total number of citations, which stood at 43,819 citations in early 2022, corresponding to 2,191 citations per case study, with the classics of Freeman (1987) and Nelson (1993) being the most cited contributions. In addition, as shown in Table 1 (albeit in part), case study research has acted as a methodological vehicle for introducing the ISs approach to new fields of study, such as *agricultural studies* (e.g. Klerkx et al., 2010), *development studies* (e.g. Papaioannou et al., 2016), *energy studies* (e.g. Foxon et al., 2005), *sustainability studies* (e.g. Negro and Hekkert, 2008) and *tourism studies* (e.g. Mattsson et al., 2005, Hjalager, 2010).

Considering the above, one would have assumed that ISs scholars would be among the most ardent supporters of case study research in the social sciences. In fact, for many social scientists, the literature on ISs would provide ample methodological inspiration and instruction on how to conduct highly influential, yet policy-relevant case studies. Surprisingly, neither of these occurs.

Specifically, Dodgson (2009), as well as Dodgson et al. (2008), point out in their studies on ISs in Asia that case studies are 'well suited to studying emerging phenomena and behaviour...[and] how things evolve over time and why they evolve in that way' (Dodgson, 2009, p.605). However, as these authors acknowledge, the findings of case study research on ISs 'cannot, of course, be generalised' (ibid.). Smith and Estibals (2011) emphasise, in a policy report on innovation and growth in the United Kingdom, that '[c]ase studies have the advantage of being able to explore the complexity of the innovation process...in a depth that is not otherwise possible'(p.115). However, the 'disadvantage [is] that [the] results lack generality' (ibid.). Like Oliveira and Natário (2016), whose case study analysis focuses on the agro-food IS in the Tagus Valley, Trippl (2011) states that her case study

[3]I would like to thank an anonymous reviewer for encouraging me to emphasise this.

findings regarding the Vienna food IS 'cannot and should not be generalised' (p.1606). While some studies associate the question of external validity with the breadth of case study data (see, for instance, Trippl, 2011), it is stated elsewhere that collecting additional data does not mitigate the question of external validity. For example, Hung and Whittington (2011) conducted more than 160 interviews with IT firm managers, journalists and technical experts, as well as triangulated the interview data with insights obtained from archival materials (e.g. company annual reports, analysts coverage and articles from the specialized and more general business press). Despite collecting a wealth of data, these authors state that the findings derived from their case study on the Taiwanese IS are 'unlikely to generalize in a simple fashion to larger, more pluralistic countries' (p. 537).

All in all, the above confirms that despite having given birth to, established and popularised the ISs approach, a great deal of ISs scholars uphold that case study research is mainly a descriptive-exploratory type of analysis, the findings of which can not be extrapolated to other ISs. This methodological consensus begets the *case study paradox* in the field of ISs.

Table 1: A List of Well-Cited Case studies on ISs

	Author	Year	Title	Type of case Study	Unit of analysis	Data collection and analysis	Book/article	Journal/publisher	Citations(*)
1	Nelson R.	1993	National Innovation Systems: A Comparative Analysis	Multiple case studies	National systems of innovation in 12 countries	Multiple sources of evidence	Book	Oxford University Press	14,085
2	Freeman, C.	1987	Technology, Policy, and Economic Performance: Lessons from Japan	Single case study	Japan's national system of innovation	Multiple sources of evidence	Book	Pinter	10,279
3	Braczyk, H. J., Cooke, P. N., & Heidenreich, M.	1998	Regional Innovation Systems: the Role of Governance in a Globalized World	Multiple case studies	14 case studies on different regional innovation systems	Multiple sources of evidence	Book	Routledge	3,858
4	Asheim B.T., Isaksen A.	2002	Regional innovation systems: The integration of local 'sticky' and global 'ubiquitous' knowledge	Multiple case studies	3 regional clusters of firms in Norway	Multiple sources of evidence	Article	Journal of Technology Transfer	2,267
5	Asheim B.T., Coenen L.	2005	Knowledge bases and regional innovation systems: Comparing Nordic clusters	Multiple case studies	Case studies of five different industries and their corresponding RISs in Denmark, Norway and Sweden	Multiple sources of evidence	Article	Research Policy	2,129
6	Malerba, F	2004	Sectoral Systems of Innovation: Concepts, Issues and Analyses of Six Major Sectors in Europe	Multiple case studies	Case study analysis of six sectoral innovation systems (e.g. pharmaceuticals, chemicals, software, machinery, serveices, and internet and communication)	Multiple sources of evidence	Book	Cambridge University Press	2,080
7	Muller, E; Zenker, A	2001	Business services as actors of knowledge transformation: the role of KIBS in regional and national innovation systems	Multiple case studies	5 regions in France and Germany	Firm surveys of manufacturing and knowledge intensive firms	Article	Research Policy	1,441
8	Asheim B.T., Isaksen A.	1997	Location, agglomeration and innovation: Towards regional innovation systems in Norway?	Multiple case studies	2 industrial agglomerations of innovating firms in Norway	Interviews with managers	Article	European Planning Studies	1,196
9	Liu, XL; White, S	2001	Comparing innovation systems: a framework and application to China's transitional context	Single case study	An analysis of different ISs in China	Descriptive statics and narrative	Article	Research Policy	1,105
10	Klerkx et al.	2010	Adaptive management in agricultural innovation systems: The interactions between innovation networks and their environment	Multiple case studies	Analysis of two cases in the Dutch agri-food sector	Multiple sources of evidence	Article	Agricultural Systems	759
11	Foxon, T., et al.,	2005	UK innovation systems for new and renewable energy technologies: drivers, barriers and systems failures	Single case study	An analysis of different TISs in the UK	Multiple sources of evidence	Article	Energy Policy	722
12	Hekkert, Marko P.; Negro, Simona O.	2009	Functions of innovation systems as a framework to understand sustainable technological change: Empirical evidence for earlier claims	Multiple case studies	5 case studies	Process analysis based on documents	Article	Technological Forecasting and Social Change	669
13	Gilsing, V; Nooteboom, B	2006	Exploration and exploitation in innovation systems: The case of pharmaceutical biotechnology	Single case study	Pharmaceutical biotechnology in the Netherlands	Narative analysis of key facts and developments	Article	Research Policy	553
14	Intarakumnerd P., Chairatana P.-A., Tangchitpiboon T.	2002	National innovation system in less successful developing countries: The case of Thailand	Single case study	A single case study analysis of the Thai NIS	Narative analysis of key facts and developments	Article	Research Policy	429
15	Belussi, Fiorenza et al.	2010	Learning at the boundaries in an Open Regional Innovation System: A focus on firms' innovation strategies in the Emilia Romagna life science industry	Single case study	Analysis of life science firms in the region of Emilia Romagna in Itally	Survey of firms	Article	Research Policy	376
16	Surrs, Roald A. A.; Hekkert, Marko P.	2009	Cumulative causation in the formation of a technological innovation system: The case of biofuels in the Netherlands		Analysis of the biofuels TIS in the Netherlands	Multiple sources of evidence	Article	Technological Forecasting and Social Change	339
17	Binz, Christian et al.	2014	Why space matters in technological innovation systems-Mapping global knowledge dynamics of membrane bioreactor technology	Multiple case studies	Analysis of the membrane bioreactor TIS	Network analysis	Article	Research Policy	330
15	Doloreux D.	2004	Regional innovation systems in Canada: A comparative study	Multiple case studies	A comparative analysis of two RISs in Canada	Multiple sources of evidence	Article	Regional studies	311
18	Doloreux D.	2003	Regional innovation systems in the periphery: The case of the Beauce in Québec (Canada)	Single case study	A single case study of Beauce RIS	Multiple sources of evidence	Article	International Journal of innovation management	306
19	Edquist, C; Hommen, L	2009	Small country innovation systems: globalization, change and policy in Asia and Europe	Multiple case studies	Case studies of 10 national innovation system in different countries across the world	Multiple sources of evidence	Book	Edward Elgar	294
20	Doloreux D. Dionne, S.	2008	Is regional innovation system development possible in peripheral regions? Some evidence from the case of La Pocatière, Canada	Single case study	A single case study of the La Pocatière region in Canada	Interviews, documents and secondary statistics	Article	Entrepreneurship and Regional Development	263

* Source: own elaboration, Google Scholar, April 2022

Average citation	2,191
Total	43,819

2.3 Case Study Paradox: Essence, Formal Turn and its Discontents

2.3.1 Paradox and Formal Turn

As is the case with every paradox, central to the case study paradox on ISs lies a dynamic contradiction between two elements (Slaatte, 1968, Werner and Baxter, 1994, Andriopoulos and Lewis, 2009, Andriopoulos and Gotsi, 2017, Fragkandreas, 2017). On the one hand, there is the undeniable, historically-substantiated fact that case study research has been the methodological catalyst to the emergence and success of the ISs approach in the domains of both science and policy – ***Element$_1$***. On the other hand, contemporary IS scholars believe that case study research is mainly a descriptive type of analysis that falls short when it comes to meeting the most defining features of science (Harvey, 1969, Flyvbjerg, 2001, Chalmers, 2009), namely causal explanation and generalisation – ***Element$_2$***.

When Elements$_{1\&2}$ are in isolation, they appear innocuous and somewhat in harmony. However, when juxtaposed, these two elements are utterly contradictory, and have several critical practical ramifications for the scientificity of ISs approach. For instance, accepting the *Element$_2$* inevitably leads to the following conclusion: as long as case study research is the most popular choice, the ISs approach will remain 'under-theorised'(Edquist, 2005, p.186) in the sense that research on such system-like entities will not be in a position to test 'clear propositions regarding causal relations among variables' (ibid.). Harris (2011) links the fact that '[m]ost of the evidence supporting the existence and importance of such systems is case-study based' (p.933) to the scientificity of the ISs approach. To illustrate his point, he refers to the seminal paper by Bergek et al. (2008) on the functions of ISs. As he put it, 'the approach taken by Bergek and her collaborators is not about modelling (and therefore testing any hypotheses)...rather the approach remains descriptive and subjective' (Harris, 2011, p.933).

To improve the scientificity of IS research, a growing number of studies adopt a formal approach to research, such as ***hypothesis development and model testing*** (e.g. Allard et al., 2012, Liu and Chen, 2012, Castellacci and Natera, 2013, Hipp and Binz, 2020, Tsouri et al., 2021), ***formal modelling techniques*** (e.g. Lee and Von Tunzelmann, 2005, Guan and Chen, 2012, Samara et al., 2012, Walrave and Raven, 2016), as well as ***advanced quantitative and econometric analysis*** (e.g. Leydesdorff and Fritsch, 2006, Ivanova and Leydesdorff, 2015, Zhao et al., 2015, Cirillo et al., 2019, Proksch et al., 2019, Filippetti and Guy, 2020). Table 2 summarises the methodological profile of papers on ISs published in Research Policy, which is the leading, and thus trend-setting, journal in the field of innovation studies (Fagerberg et al., 2012, Rakas and Hain, 2019). It shows that the share of formal studies relative to the other types of papers (e.g. conceptual, case studies and descriptive quantitative studies) has increased significantly: from 13% in the 2000s to 50% in 2010, reaching 100% in the early 2020s. In a nutshell, the field of ISs is undergoing a *formal turn* where 'soft' studies have gradually been replaced by 'hard' ones (see also Martin, 2016, Chaminade et al., 2018).

Table 2: Published Papers on ISs in Research Policy

Period	Number of contributions containing the term 'innovation system(s)' in the title	Conceptual papers (% of the total in the period)	Case studies (% of the total in the period)	Descriptive quantitative studies (% of the total in the period)	Formal (mathematical modelling, econometrics, advanced regression) studies (% of the total in the period)
1990-1999	11	27	55	0	18
2000-2009	30	33	43	10	13
2010-2019	28	21	25	4	50
2020 – 2021	2	0	0	0	100
All years	72	26	36	7	31

Note: Own elaboration, Scopus

While the formal turn signals to a particular type of social scientists (e.g. mainstream economists) that research on ISs is significantly more methodologically mature and rigorous than previously – hence, in formal methodological terms, it is on par with mainstream economic studies (Fagerberg, 2003, Eparvier, 2005, Sharif, 2006). The irony, however, is that the formal turn fuels and solidifies the case study paradox. In fact, the more formal studies are published, the sharper the underlying tension in the paradox becomes. Take, for instance, the fact that formal research is often justified on the ground that, since the existing literature is 'dominated by qualitative case approaches'(Walrave and Raven, 2016, p.1833), it is 'mostly descriptive'(Cirillo et al., 2019, p.907). Thus, for the formal turn to flourish, its practitioners must, either implicitly or explicitly, defend $Element_2$ in the case study paradox; otherwise, and if case study research can, indeed, study causality and generality (Tsoukas, 1989, Easton, 2010), this significantly limits the methodological monopoly of formal analysis as the essential means by which causality and generality in ISs are inferred.

This paper maintains that resolving the case study paradox requires neither the ongoing formalisation of ISs research nor the elimination of case study research from the methodological armoury of innovation research. Instead, it requires IS scholars to step back for a little while from actual research practice and critically reflect on the more profound and taken-for-granted philosophical assumptions which have, in the first place, engendered the paradox in question. In a sense, the present paper invites ISs scholars to embrace, in a more explicit manner than hitherto, Schumpeter's (1954/2006*b*) invaluable methodological observation that philosophy, (innovation) theory and research are always intertwined[4]. In this Schumpeterian spirit, the remainder of this paper conducts a deeper-than-usual methodological analysis of case study research on ISs. It does so by adopting the dialectical method as the guide to the analysis.

However, before the discussion turns to the dialectical method, a few rather critical words about the formal turn need to be said. This is not meant to provide a fully-blown critique of formal research on ISs[5]. Instead, it seeks by means of critical reflection to introduce the relevant jargon and, thus, to set the scene for what follows in this paper.

2.3.2 Formal Turn and its Discontents

The formal turn raises many crucial methodological questions, most of which remain unaddressed. Chief among them is the question of *naturalism* (Bhaskar, 1979, Flyvbjerg, 2001), i.e. to what extent are the methods of the natural sciences, such as physics, that have long been regarded by positivist social scientists (including neoclassical economists[6])

[4]Along similar lines, John Maynard Keynes (1883-1946), who was one of Schumpeter's contemporaries, stated that the economist 'must possess a rare combination of gifts... He must be a mathematician, historian, statesman, philosopher – in some degree' (Skidelsky, 2010, p.10).

[5]To avoid misunderstandings, including unnecessary critique, this paper does not oppose the use and relevance of advanced statistical analyses on ISs. Instead, it questions and rejects the *deductivist* view that it is *only* through hypothesis-testing, mathematical models, and advanced statistical analysis that our research can examine the general aspects of causality in ISs.

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

as the most legitimate for studying social phenomena, are a feasible methodological option for research on ISs? Put differently, if we accept the *realist premise* that reality is an open system constituted by different strata, with each stratum holding its own unique constellation of emergent powers (Bhaskar, 2008*a*, Benton and Craib, 2010, Elder-Vass, 2010), why should the IS scholar regard as ideal the methods of lower strata (e.g. physics, biology, chemistry, physiology) for studying the causal powers of upper strata (e.g. human beings and society)?[7]

These concerns are not only in line with Schumpeter's overall methodological outlook[8], they also concern actual research practice. For instance, regardless of the type (e.g. regression, econometrics, simulation, fuzzy-set analysis etc.), formal studies suffer from two critical problems: *over-simplistic assumptions* and lack of *satisfactory data*. Crescenzi (2005), for instance, builds a formal (production function) model to study the relationship between regional ISs and economic growth in European regions. Like Walrave and Raven (2016), who conducted a simulation study on the modelling dynamics of technological ISs, Crescenzi (2005) acknowledges that 'some simplistic assumptions' (Crescenzi, 2005, p.477) had to be made to keep the analysis 'as parsimonious as possible' (Walrave and Raven, 2016, p.1843). This was necessary to 'reveal a few regularities' (ibid.) regarding the 'complexity of the underlying mechanism[s]'(ibid.).

Innovation is, by definition, a qualitatively new phenomenon (Schumpeter, 1911/1983, Freeman and Louçã, 2001, Lundvall, 2007). It emerges from novel combinations of existing resources, including the creation of new resources, and it can take various forms such as new product, process, organisational model and institutional arrangements (Schumpeter, 1911/1983, Asheim and Gertler, 2005, Edquist, 2005, Fragkandreas, 2017). Due to the dynamic, qualitative nature of innovation, a formal study of the latter constantly encounters a significant shortage of sophisticated statistical data (Smith, 2005, Lundvall, 2007). To address this challenge, formal studies often resort to a sort of 'reductionist-biased approach' (Lundvall, 2007, p.111) where the systemic character of innovation is, on the other hand, understood in a 'broad' way – for instance, as an interactive learning process, embedded and occurring in a specific institutional context (Lundvall, 1992, Radosevic, 1998, Lundvall et al., 2002). On the one hand, these studies analyse ISs in a 'narrow' way, i.e. focusing exclusively on science and technology indicators (e.g. patents and R&D statistics) (Lundvall, 2007, Jensen et al., 2007). This, among other issues, confirms that formal studies often fail to meet the *construct validity* criterion, i.e., 'the extent to which a study investigates what it claims to investigate'(Gibbert et al., 2008, p.1466).

Unconscious bias is another major issue that undermines the construct validity of for-

[7](a) Following Kuhn's (1962/2012) seminal work on scientific paradigms, one could add here that it is the methods of the upper strata sciences that significantly enhance our understanding of the lower strata of reality (see also, Flyvbjerg, 2001). The same holds for phenomena such as environmental pollution, the underlying causes of which originate and act in a top-down manner (i.e. downward causation) in the upper strata (e.g. society and economy) (Elder-Vass, 2010)

(b) Interestingly, Bhaskar (2008*b*) argues, in his book *A Realist Theory of Science*, that, except astronomy, most empirical regularities, which are held significant by natural scientists, are the product of human (experimental) control.

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

mal research. For instance, Pearl and Mackenzie (2018) argue that formal analysis, is, by design, bias-prone[9]. By introducing new confounding variables to the analysis, the formal scholar also introduces new biases. To overcome such inherent methodological weaknesses, some innovation scholars have resorted to (semi-)experimental methods (Sørensen et al., 2010, Boudreau and Lakhani, 2015, Engel and Kleine, 2015). However, as is the case with formal studies, experimental studies seek to eliminate at all costs the influence of contextual factors ('context is noise'), for instance, by engineering a methodologically (semi-)closed system. This methodological practice makes one wonder whether the closed system logic that underpins most types of formal research (Lawson, 1997, Fleetwood, 2017) can produce useful knowledge about an inherently dynamic (open system), context-specific phenomenon such as the interactive, and constantly evolving, character of innovation (Carlsson et al., 2002, Nelson and Nelson, 2002, Lundvall, 2007).

Furthermore, formal studies are liable to conflate empirical measurement ('what counts is what can be counted') with both statistical significance and scientific relevance (Lawson, 1997, McCloskey, 1998, Louçã, 2007). Consider, for instance, the case of formal (correlational) research. As stated in every introductory book on statistics, correlation is not a reliable indicator of a causal relationship (De Vaus, 2014). However, formal research commonly treats the absence of a statistically significant relationship among variables as conclusive evidence for absent causality. This illustrates that it is not formal modelling and statistical significance that generates and tests causal theories but the researcher's interpretation of the data (Sutton and Staw, 1995, McCloskey, 1998). As Pearl and Mackenzie (2018) put it, 'data do not understand causes and effects...humans do' (p.21) . In this regard, as with case study research on ISs, formal research on such system-like entities is largely a narrative-rhetorical analysis.

Given that formal research is also fraught with some severe methodological weaknesses and limitations, the following questions must be asked: why do a growing number of ISs researchers believe that a formal turn is necessary to make the ISs approach more scientific? In other words, why does a formal methodological approach provide a reliable yardstick to judge the scientificity of case study research on ISs, including the scientific qualities of the ISs approach in general? Given that more than half of the total number of ISs studies are case studies, how many more case studies do ISs scholars need to conduct until the findings of case studies are regarded as scientifically legitimate as the ones generated by formal studies? Is there a threshold which, once met, will mean that case study research on ISs offers a legitimate basis for causal explanation and generalisation? Does the same threshold apply to large-N formal studies on ISs? If no, why is this? It is these largely overlooked methodological questions that the dialectical analysis in this paper seeks to address.

3 Dialectic Method: An Overview

The method of dialectic originates in the work of Ancient Greek philosophers such as Socrates, Plato and Aristotle (Bhaskar, 2008*a*, Russell, 2008, Adorno, 2017). According to ancient Greek philosophers, especially Plato, dialectics constitutes 'the art of conversa-

[9]I would like to thank an anonymous reviewers for bringing this issue to my attention.

tion', enabling the interlocutors to structure their world views in a coherent way (Russell, 2008, Adorno, 2017). However, during and after the Enlightenment era, one finds in the work of notable philosophers (e.g. Immanuel Kant, Friedrich Hegel, Søren Kierkegaard, and Karl Marx) a particular construal of dialectics as the method of tackling contradictions in the domain of both matter and intellect (Slaatte, 1968, Elster, 1986, Adorno, 2017, Hargrave and Van de Ven, 2017, Smith et al., 2017, Maybee, 2019). Today, the dialectic method constitutes a methodological paradigm, rather than a single method, encompassing several varieties and approaches (for an accessible overview, see Clegg and Cunha, 2017). Despite this, common to all versions of the dialectic is the interplay between mutually-opposing elements (i.e. thesis and antithesis) and the qualitative change (i.e. synthesis) that emanates from it (Bhaskar, 2008*a*, Adorno, 2017, Hargrave and Van de Ven, 2017).

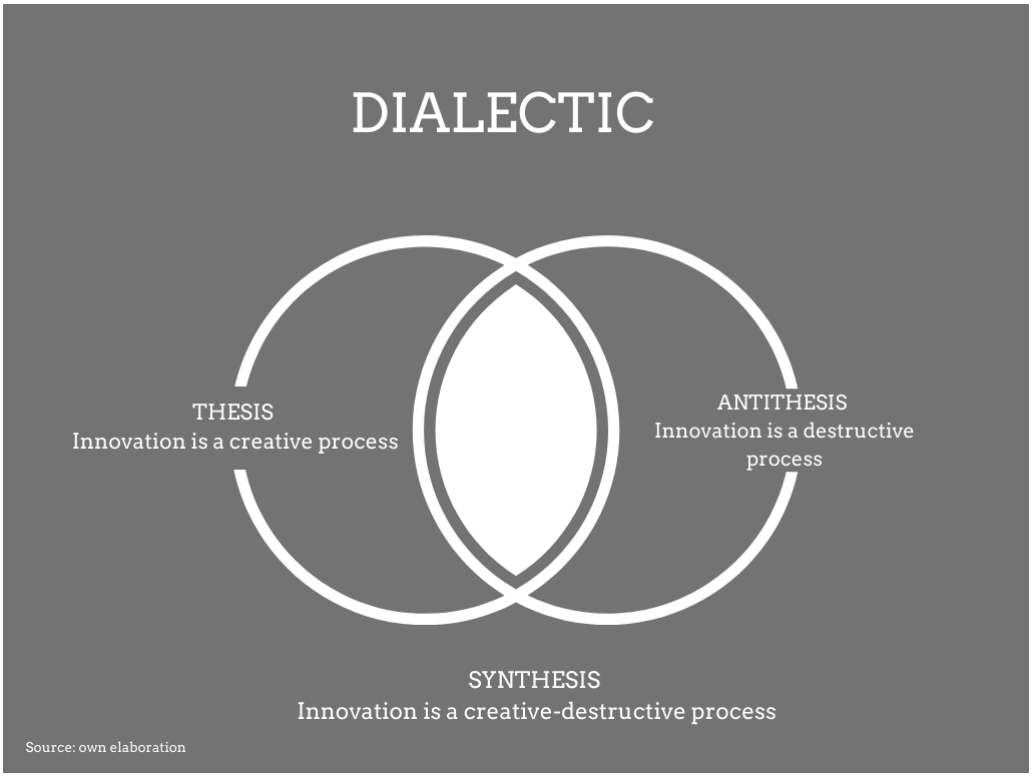
Sir Karl Popper (1940) summarises the key components of the dialectical method in the following way.

> "*First, some idea or theory or movement is given, which may be called '**thesis**'. Such a thesis will often produce opposition, because probably it will be, like most things in this world, of limited value – it will have its weak spots. This opposing idea or movement is called '**antithesis**', because it is directed against the first, the thesis. The struggle between the thesis and the antithesis goes on until some solution develops which will, in a certain sense, go beyond thesis and antithesis by recognising the relative value of both, i.e., by trying to preserve the merits and to avoid the limitations of both. This solution, which is the third step, is called '**synthesis**'. Once attained, the synthesis may in turn become the first step of a new dialectic triad, and it will, if the development does not stop with the particular synthesis reached.*"
>
> (Popper, 1940, p.325, emphasis added)

To illustrate briefly how the dialectical method works in practice, the following utilises Schumpeter's (1944/2006*a*) famous (Nietzschian) conceptualisation of innovation as a 'creative-destructive' process (Reinert and Reinert, 2006). Figure 1 provides a schematic representation of the dialectical method applied to Schumpeter's conception of innovation. The *thesis* is that innovation is a creative activity, adding new skills, competencies, jobs, knowledge, new products and services into the economic system; the *antithesis* is that innovation destroys existing skills, jobs, competencies and knowledge; and the *synthesis* is that innovation does both simultaneously – it is a creative-destructive process. As Schumpeter (1944/2006*a*) famously puts it, innovation is the 'entrepreneurial function' (Schumpeter, 1911/1983, p.59) that 'incessantly revolutionises the economic structure from within, incessantly destroying the old one, and incessantly creating a new one' (Schumpeter, 1944/2006*a*, p.83).

This study utilises the basic analytical scheme of the thesis, antithesis, and synthesis. However, it does so in a somewhat different and novel manner which is, nonetheless, consistent with the key principles of the dialectical method. The dialectical analysis in this paper is inspired by the work of the realist philosopher of science, Roy Bhaskar (1952-2014). Although not easy to summarise here (for an accessible introduction to Bhakar's work, see

Figure 1: The Schumpeterian Dialectic of Innovation



Collier, 1994, Norrie, 2009), Bhaskar's overall approach to the dialectical method is original in the sense that it makes it possible to analyse not only the presence of a thesis but also the absence of an antithesis.

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

Bhaskar's approach to dialectics is of significance to our understanding and resolution of the case study paradox. It implies that when it comes to dialectically analysing the paradox in question, the absence of an antithesis can be as significant as the presence of a thesis. The remainder of this paper explores such a Bhaskarian methodological implication. It does so by (a) formulating the *deductive thesis* that case study research on ISs cannot study causality and generality, as well as by (b) showing that once a sound antithesis has been advanced based on the retroductive model of science (retroductive antithesis), *the case study paradox appears to be a special case of the deductive thesis rather than a general flaw of case study research on IS.*

4 Case Study Paradox: A Dialectical Analysis

4.1 Deductive Thesis: Case Study Research on ISs Cannot Study the General Aspects of Causality

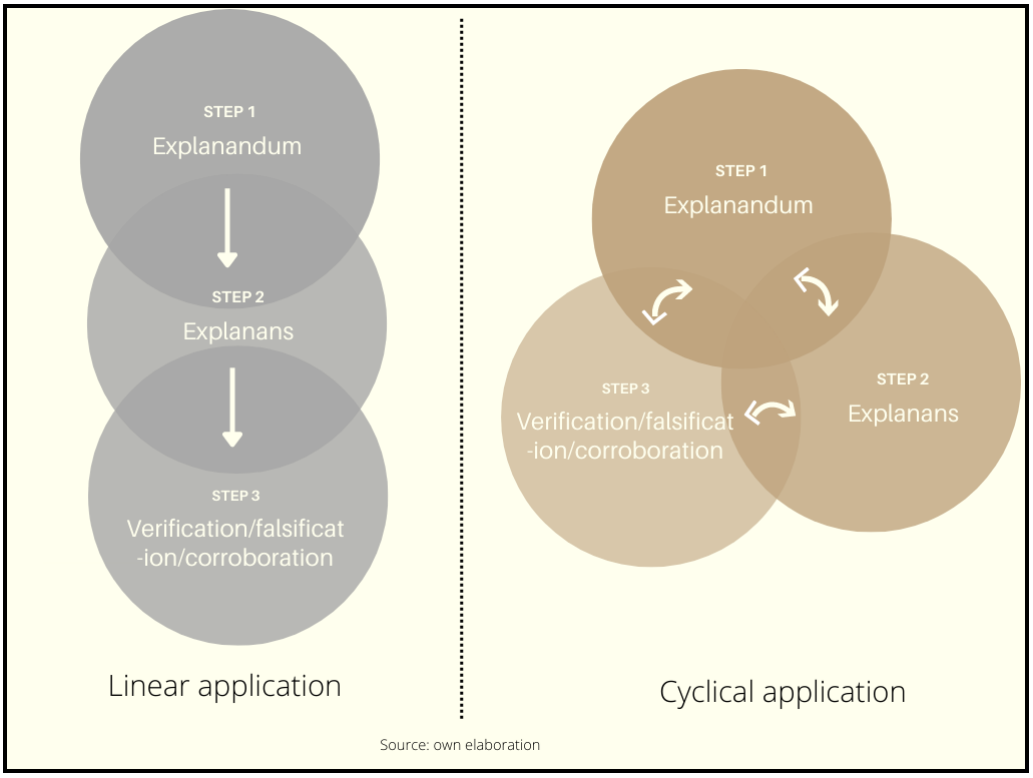
In general, deduction refers to the inferential process through which knowledge about a phenomenon of interest is obtained via deductive (logical) syllogisms and (formal) reasoning, particularly by deducing knowledge about the particular from the general (Harvey, 1969, Blaikie and Priest, 2019). The hypothetico-deductive model of explanation (HDME) has long been regarded as the most representative form of deductive reasoning and analysis in both natural and social sciences (Hempel and Oppenheim, 1948, Harvey, 1969, Gorski, 2004, Chalmers, 2009, Benton and Craib, 2010).Methodologically, the HDME model encompasses a three-stage, *formal analytical* process, which can be implemented either in a linear or iterative way (see Figure 2).

- *Step 1: Explanandum* – An interesting empirical phenomenon is identified;
- *Step 2: Explanans* – Based on the current stock of knowledge (best known as the *initial conditions*), the researcher deduces either a formal model or a set of formal hypotheses in the form of 'if event X is present, event Y follows or tends to follow' in order to account for the explanandum;
- *Step 3: Verification/falsification* – The validity of the explanans is *verified or falsified* through the identification of constant sequences or successions of empirical events (i.e., empirical regularities), ideally through the identification of statistically significant associations between variables.

However, as practised today in the social sciences (including the field of innovation studies), the HDME is not as homogeneous as is often portrayed in the work of proponents and critics (Hempel and Oppenheim, 1948, Lawson, 1997, Gorski, 2004, Popper, 2014). In fact, the model in question encompasses four main variants, each of which has several crucial implications for case study research on ISs.

1. **Verificationism** refers to the standard version of HDME (Hempel and Oppenheim, 1948, Harvey, 1969, Webb, 1995, Chalmers, 2009). According to verificationism, causal explanatory research on ISs proceeds by verifying theoretical constructs (e.g. formal models and hypotheses) through the identification of large-scale empirical (law-like) regularities (Lawson, 1997, Sharif, 2006). Despite the stance of Karl Hempel (1905-1997), who was one of the leading figures of HDME (Hempel and Oppenheim, 1948), and who was fully aware of the flaws of this model (Gorski, 2004), social scientists – most notably neoclassical economists (Lawson, 1997, Louçã, 2007) – have long regarded deductive verification as ideal to a social science that seeks to emulate the methods of natural science (i.e. naturalism), especially the methodological apparatus of the 19th century physics (Harvey, 1969, Bhaskar, 1979, Gorski, 2004). By placing the identification of empirical regularities as the ultimate

Figure 2: HDME: Linear and Cyclical Applications



quality criterion of explanatory research on ISs, verificationism makes it impossible to see how an in-depth case study analysis of one IS enables us to draw reliable knowledge about the entire population of ISs.

2. **Falsificationism** is the second main variant of the HDME. It mainly emanates from the work of Karl Popper (1902-1994). The latter has famously argued that what distinguishes a scientific theory from a non-scientific one lies in its ability to be falsified – the falsification criterion (Chalmers, 2009, Popper, 2014). According to falsificationism, case study research on ISs can be conducted as a 'critical test' of an established assumption, preposition or hypothesis (Flyvbjerg, 2006, Yin, 2009). However, even in this case, the findings of falsifying case studies are treated with severe methodological suspicion. For instance, Cooke et al. (2000) found in their study of 11 European regions that only two regions (i.e. Baden-Württemberg and North Brabant) had a well-functioning regional IS. Does this finding falsify the hypothesis that 'all regions have some kind of a regional innovation system' (Doloreux and Parto, 2005, p.142)? Put differently, the observation that one or a few technologically locked-in ISs exhibit one of the highest input-output efficiency ratios when compared with the remaining ISs (Niosi, 2002, p.293) is not enough on its own to falsify the rule that technological lock-ins are associated with significant inefficiencies in ISs (Narula, 2002, Woolthuis et al., 2005). Thus, since case study research investigates a very small number of cases, one or even a few falsifying cases are not enough to reject a widely-accepted theory or hypothesis unless the scientific community is willing, at some point, to accept the results of falsified case studies as reliable and generalisable. As Harre (1972) put it, '[c]ontrary evidence must accumulate before a hypothesis is agreed to be false'(Harre, 1972, p.60).

3. **Corroborationism** is the third main variant of the HDME. According to corroborationism, explanatory research on ISs constructs and corroborates empirically theoretical statements rather than by verifying their truthfulness (Harre, 1972, Popper, 2014). Although case study research on ISs can exclusively be conducted in quantitative terms (see, for instance, Vilanova and Leydesdorff, 2001, Jackson et al., 2016), its ability to test a theory in a generalisable manner lies, from the standpoint of corroborationism, in studying the most representative (average) case(s) (Yin, 2009, p. 41).Since every IS has a unique social division of labour (Nelson, 1993, Braczyk et al., 1998, Malerba, 2004, Cirillo et al., 2019), there is no such thing as the most representative (average) IS. In addition, Mattsson et al. (2005) point out, in their multiple case studies of eight ISs in the tourism sector, that 'it is very difficult to ascertain hard facts' (Mattsson et al., 2005, p.378) through case study research. This severely limits the ability of case study research to corroborate a theoretical proposition in a manner that is perfectly compatible with the corroborative variant of the HDME.

4. **Inductive deductivism** is the last, most recent and popular variant of the HDME in the social sciences. Although it may sound like an oxymoron as induction (which proceeds from the particular to the general) and deduction (which moves from the general to particular) have traditionally been regarded as two antagonistic modes of scientific inference (Harvey, 1969, Harre, 1972, Chalmers, 2009, Popper, 2014). The inductive variant is the most case study-friendly of all four variants. According to this variant, case study research on ISs is primarily an exploratory (rather than an explanatory) type of analysis, ideal for developing new concepts and testable theoretical propositions (Eisenhardt, 1989, Eisenhardt and Graebner, 2007, Yin, 2009). Moussavi and Kermanshah (2018) summarise the importance of inductive case study research on ISs in the following manner:

   > "*[t]he first function of cases [on ISs] is...[to] feed induction processes: instances in this research tradition help to form empirical generalizations in the form of propositions. They also support the evolution of new empirical concepts*"
   >
   > (Moussavi and Kermanshah, 2018, p.62).

   Implicit in the above passage is that case study research on ISs cannot discern what is general about causality unless its inductively developed concepts and theoretical statements are corroborated by a formal, large-N analysis. Such a view currently prevails in the literature on national ISs (see, for instance, Chapter 5 in Chaminade et al., 2018). While the early research on national ISs was undertaken as a critical (to neoclassical economics) inductive grounded theory[10] (Lundvall, 2007, p.98), the more recent research on national ISs proceeds by formulating and testing theoretical propositions based on the findings of case study research on ISs (see, for instance, Herrmann and Peine, 2011, Allard et al., 2012, Castellacci and Natera, 2013, Proksch et al., 2019).

The HDME has several crucial implications for the scientific image and design of case

[10]For instance, in his excellent summary of the early research on ISs, Edquist (2005) lamented that the ISs approach 'has not been used to formulate hypotheses to be confronted with empirical observations'(p.202).

study research on ISs, and the ISs approach in general. By placing recurrent observations among empirical events across the largest number of cases observable as the only legitimate inferential criterion (Hempel and Oppenheim, 1948, Harvey, 1969), the HDME forces IS scholars to conceive and practice case study research as a purely inductive type of research. Correspondingly, accepting the HDME as the primary model of scientific explanation in ISs research inevitably leads to the conclusion that deductive theorising (e.g. hypothesis testing, mathematical modelling and equations) and large-scale formal research will make the ISs approach more 'scientific'. In contrast, case studies are highly unlikely to do so.

However, as will be shown shortly, from the standpoint of the retroductive model of explanation, neither the deductive thesis nor the key methodological stipulations and implications of the HDME are valid. On the contrary, they are highly misguided and detrimental to both ISs approach and policy practice; hence, they need to be abandoned.

4.2 Retroductive Antithesis: Case Study Research on ISs Can Study Causality and Generality

4.2.1 Retroductive Model of Science

Rooted in the work of notable philosophers (e.g. Aristotle and Charles Chander Pierce), as well as in the writings of the founders of several fields of science (e.g. Adam Smith, Karl Marx, Charles Darwin), the retroductive model of explanation (RME) constitutes the primary antagonist to the HDME in both natural and social sciences (Harre, 1972, Lawson, 1997, Bhaskar, 2008*b*, Pratten, 2009, Blaikie and Priest, 2019, Danermark et al., 2019, Jagosh, 2020, Ritz, 2020). Despite having a long intellectual lineage, the systematisation of the RME into a coherent model of scientific explanation is a relatively recent development (Blaikie and Priest, 2019, Danermark et al., 2019), in particular associated with the emergence of *critical realism*[11] as one of the main philosophies of social science (Archer et al., 1998, Baert, 2005, Benton and Craib, 2010, Blaikie and Priest, 2019, Jagosh, 2020, Ritz, 2020).

As the name suggests, central to the RME is the inferential logic of *retroduction*[12]

[11]Emanating from a synthesis of Roy Bhaskar's work on *transcendental realism* (Bhaskar, 2008*b*) and *critical naturalism* (Bhaskar, 1979), critical realism (CR) is a variant of scientific realism in the social sciences (Baert, 2005, Benton and Craib, 2010). As is the case with every realist philosophy of science, CR endorses the realist thesis that our knowledge of causality – and reality in general – does not exhaust their existence (Bhaskar, 2008*b*, Danermark et al., 2019). Bhaskar's (1979, 2008*b*) philosophical analysis of both the natural and social sciences has shown that, despite their ontological differences, the ultimate objects of explanatory research in both fields of science are not empirical regularities (cf. positivist philosophy of science), but the causal powers (i.e., inherently-possessed abilities to do certain things and not others) of structures (i.e., a set of necessary related elements). For a succinct, yet relevant to the field of innovation studies, introduction to critical realism, see Sorrell (2018).

[12]Due to space considerations, this section discusses a condensed, idealised version of the two main approaches to retroductive research: the *Describe-Retroduce-Eliminate-Identify (DREI)* analysis and the *Resolve-Redescribe-Retrodict-Eliminate-Identify* (RRREI) analysis. For an overview of these two approaches to retroduction, see Collier (1994), Mingers and Standing (2017), Hu (2018), Danermark et al. (2019).

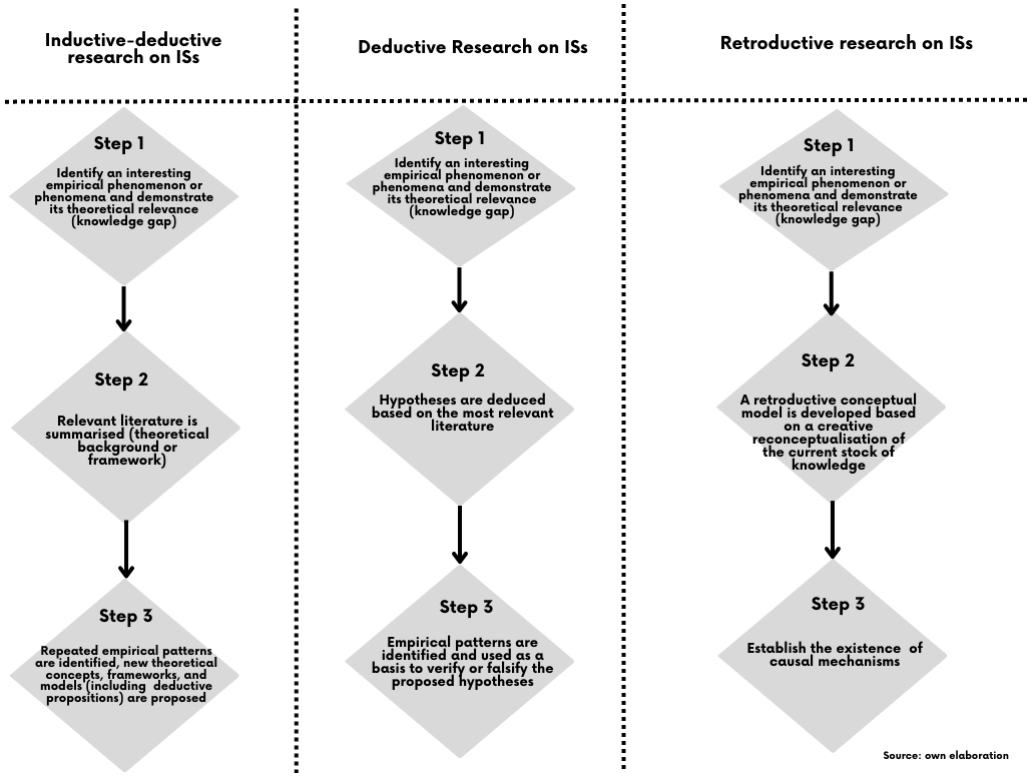
(Downward and Mearman, 2007, Bhaskar, 2008*b*, Belfrage and Hauf, 2017, Jagosh, 2020, Ritz, 2020). In a nutshell, retroduction refers to the process of identifying, by means of a creative reconceptualisation of the current stock of knowledge and systematic empirical research, *causal mechanisms* capable of producing the phenomena under investigation(Lawson, 1997, Bhaskar, 2008*b*, Danermark et al., 2019). Thus, in contrast to deduction, which is a formal mode of inference in the sense that conclusions must always derive from the premises (testable hypotheses), retroduction is a creative 'thought operation' (Danermark et al., 2019, p.113) where the analysis moves iteratively from the *known* (i.e. existing concepts, theories, empirical events, anomalies, discourses, experiences, hints, etc.) to the *unknown* (i.e. causal mechanisms) (Lawson, 1997, Jagosh, 2020). Hence, retroductive research is ultimately a search for causal mechanisms.

Figure 3 summarises in a highly-abstract way the key steps in inductive, deductive and retroductive research on ISs. There are fundamental differences, in terms of both logic and practice, among the three archetype approaches to research. For instance, in deductive research, the explanans consist of testable (mathematically amenable) hypotheses (Step 2), whereas, in inductive research, the explanans emerge, in the form of inductively-generated concepts and models, at the end of the analysis (Step 3) (Chalmers, 2009, Blaikie and Priest, 2019). In contrast, in retroductive research, the explanans take the form of retroductive conceptual models of hypothesised causal mechanisms (Tsang, 2014, Danermark et al., 2019, Fragkandreas, 2021). Relatedly, in Step 3, retroductive research seeks neither to corroborate (or falsify) a set of hypotheses nor to identify small-scale empirical patterns as a means by which to develop inductive concepts and empirical models. Instead, it is primarily concerned with causal mechanisms, namely what makes 'things' happen in the world (Mingers and Standing, 2017, Danermark et al., 2019, Fragkandreas, 2021). As Sayer (2000) put it,

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

To investigate causal mechanisms, retroductive research makes use of both *extensive research designs* (e.g. econometrics, regression analysis, structural equation modelling, etc.) and *intensive research designs* (e.g. case study research, grounded theory ethnography, etc.), thus also qualitative and quantitative data (Sayer, 2000, Mingers, 2001, 2006, Downward and Mearman, 2007, Olsen, 2010, Papachristos and Adamides, 2016, Danermark et al., 2019). However, in contrast to both inductive and deductive research, both of which end up – although for different reasons – to place extensive research designs at the centre of causal explanatory research (Lawson, 1997, Blaikie and Priest, 2019, Danermark et al., 2019), retroductive research does the exact opposite: *it is through intensive research (e.g. case studies, ethnography, etc.) that the IS scholar is able to produce causal explanatory and externally valid knowledge about ISs* (Tsoukas, 1989, Sayer, 2000, Danermark et al., 2019, Morais, 2011, Wynn and Williams, 2012, Tsang, 2014). To understand why this is the case in retroductive, but not deductive (including inductive), research on ISs requires a closer look into causal mechanisms both as agents of change and analytical devices.

Figure 3: Key Steps in Inductive-Deductive, Deductive and Retroductive Research



4.2.2 Causal Mechanisms and Generality in ISs

Retroductive research is often grounded on the critical realist conception of causal mechanisms[13] (Fleetwood, 2001, Bhaskar, 2008*b*, Mingers and Standing, 2017). According to this perspective, causal mechanisms consist of *dynamic configurations* of two main components (Pawson and Tilley, 1997, Fleetwood, 2001, Mingers and Standing, 2017, Fragkandreas, 2021): the inherent abilities of a structured entity (i.e. its *causal powers*) which enable it to do certain things, not others, and a set of *relevant conditions* that facilitates (or triggers) the causal powers to produce an *empirical event or outcome*. For instance, due to its underlying chemical composition, dynamite possesses the *causal power* to explode (*empirical outcome*), especially when it is brought into contact with fire (*relevant condition*). Similarly, due to its underlying structural composition, the Japanese IS is capable of facilitating (*causal power*) the development and diffusion of constant flows of innovative activities (*empirical outcome*), especially when focal (triple helix) make long-term investments in the structural components (e.g. knowledge bases, soft and hard infrastructure, etc.) of the IS in question (*relevant conditions*) (Freeman, 1987, 1988)[14]. Hence, causal mechanisms can be understood in the following way (Fragkandreas, 2021, p.8):

Causal Power (CP) + Relevant Conditions (RCs) = Empirical Outcomes (EOs)

[13]For an overview on the different views and perspectives on causal mechanisms in the social sciences, see Ylikoski and Hedström (2010), Gorski (2015), Geels (2022).

[14]Although, and to the best of my knowledge, Christopher Freeman (1921-2010) never refereed to his work on ISs as retroductive, his seminal study on Japan's national IS (Freeman, 1987) resembles the retroductive model of science.

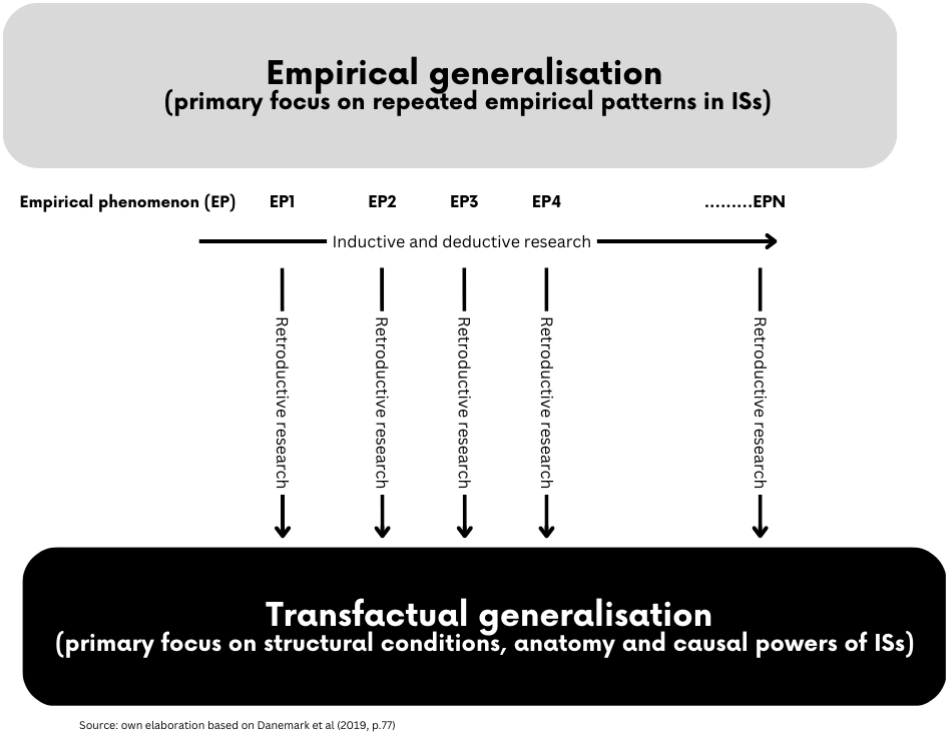
Based on the above 'causal formula', it is futile to expect that empirical regularities to be pure, pervasive and persistent over time in ISs (Lawson, 1997, Castellacci, 2006, Sorrell, 2018). Since ISs are structurally, and thus causally, heterogeneous, it follows that every IS is bestowed with a unique set of causal powers (Chaminade et al., 2018, Asheim et al., 2019, Cirillo et al., 2019, Wang et al., 2021). By facilitating the innovation process, although at varying paces and degrees (Nelson, 1993, Freeman, 2002), ISs are generally prone to structural transformation (Storz, 2008, Isaksen et al., 2022). However, ISs are also liable to path-dependence and structural inertia due to, among other factors, technological lock-ins, institutional rigidity, political instability and power struggles among focal actors (Narula, 2002, Niosi, 2002, Dodgson et al., 2008, Bergek et al., 2008, Fagerberg et al., 2009, Allard et al., 2012). Due to the above, empirical regularities in ISs are *demi-regularities* (Lawson, 1997), namely spatio-temporally confined, rough, yet unstable (due to the creative-destructive nature of innovation), empirical continuities and discontinuities (Freeman and Louçã, 2001, Perez, 2010). Thus, as is the case with every open socio-economic system (Lawson, 1997, Fleetwood, 2017), demi-regularities, rather than pure empirical regularities, are pervasive in ISs (Carlsson et al., 2002, Stamboulis, 2007, Lundvall, 2007).

However, in contrast to deductivist research, where demi-regularities are seen as a strong indication of weak and absent causality, and thus not scientifically relevant (Lawson, 1997, McCloskey, 1998, Fleetwood, 2017), in retroductive research, demi-regularities constitute an opportunity to identify the causal mechanisms that produce them (Downward and Mearman, 2007, Jackson et al., 2016, Sorrell, 2018). As Danermark et al. (2019) put it, '[t]hings do not happen by chance or without reason. Behind events and courses of events, there are powers generating them' (p.199). For instance, in their retroductive study on the Australian IS, Jackson et al. (2016) analysed data from statistical databases and reports (e.g. Cornell University and OECD) to verify the demi-regularity that the Australian IS failing to transform relatively high innovation inputs into equivalent outputs. These authors identified six causal mechanisms responsible for Australia's poor innovation performance, such as (1) lack of funding, (2) shortage of analytical skills, (3) low managerial capability, (4) low value-adding specialisation, (5) weak collaboration, and (6) entrepreneurial culture. As the study above demonstrates, a retroductive causal explanation is not a matter of identifying how strong or weak demi-regularities are. Instead, it involves identifying which causal capacities of ISs are active and whether they have been implicated in the production of the observed empirical outcomes.

According to the RME, externally valid knowledge about causality in ISs lies not in the empirical aspects (empirical generalisation) of such system-like entities but in their less empirical aspects of them (Bhaskar, 2008*b*, Koutsouris, 2012, Vega and Chiasson, 2019, Fragkandreas, 2021). As Bhaskar (2008*b*) puts it, '[s]cientifically significant generality does not lie on the face of the world, but in the hidden essences of things' (p.217). This approach to generalisation is known as *transfactual generalisation* (Tsoukas, 1989, Morais, 2011, Tsang, 2014, Danermark et al., 2019). It argues that the causal powers of ISs exist and act *transfactually*, regardless of what events ensue, and independently of our cognition, identification and measurement (Bhaskar, 2008*b*, Danermark et al., 2019). Thus, identifying sequences among empirical phenomena and events (empirical generalisation) is *not* the same as having externally valid knowledge of causality in ISs (see Figure 4). Otherwise, and if one argues that empirical generalisation is necessary to make externally

valid knowledge claims, she commits the *epistemic fallacy* (Bhaskar, 2008*b*), namely the reduction of our knowledge of the causal capabilities of ISs to what can be counted or be associated with recurrent empirical patterns and events. Making externally valid transfactual knowledge claims about ISs involves an understanding of the contingent ways in which the causal powers of ISs are intertwined with relevant conditions (Tsoukas, 1989, Wynn and Williams, 2012). In this regard, transfactual generalisation is simultaneously 'up in the clouds'(Tsoukas, 1989, p.558) and 'down to earth' (ibid.). Thus, in retroductive research, generalisation 'come[s] from identifying the deep processes [i.e. causal powers] at work under contingent conditions via particular mechanisms'(Easton, 2010, p.126).

Figure 4: Two Approaches to Generalisation in ISs Research



Source: own elaboration based on Danemark et al (2019, p.77)

4.2.3 Retroductive Case Study Research on ISs

Case study research is indispensable to retroductive research on ISs (Jackson et al., 2016, Papachristos and Adamides, 2016, Fragkandreas, 2021). As mainly an intensive form of analysis (Sayer, 2000, Easton, 2010), it is ideal for detecting and theorising the causal aspects of ISs and ascertaining which causal power(s) of ISs are involved in the production of empirical outcomes (Tsoukas, 1989, Wynn and Williams, 2012, Fragkandreas, 2022). It provides a 'contextually rich' explanation of the existence, composition and efficacy of the causal mechanisms in ISs. Due to its methodologically eclectic, open-ended and flexible nature (Eisenhardt, 1989, Eisenhardt and Graebner, 2007, Yin, 2009), it allows the analysis to utilise various data sources and forms of triangulation (Eisenhardt, 1989, Yin, 2009). This allows shuttling between empirical observations and creative re-conceptualisations regarding the causal powers of ISs (Wynn and Williams, 2012, Fragkandreas, 2021). In addition, case studies establish the extent to which the causal powers of ISs are, indeed,

connected with relevant conditions and empirical outcomes, as well as whether there is a disconnect between them which, given the uncertain and creative-destructive nature of innovation (Schumpeter, 1944/2006*a*, Kline and Rosenberg, 1986), should not be surprising (Freeman and Louçã, 2001, Perez, 2010). Finally, case study research is an in-depth, time-consuming and methodologically-challenging form of research. For instance, unlike a statistically-advanced analysis of ISs which – in principle – seeks to utilise only a very small number of variables, case study research deals with a 'technically distinctive situation' (Yin, 2009, p.22), i.e., there are more variables of interest than data points. Although for the deductivist scholar, this implies that case study research is unable to produce generalisable findings, for the retroductive researcher – as discussed above– the number of cases under investigation and the generalisability of findings are two completely different issues. Due to being an in-depth, data-rich approach to research, case study research eliminates the possibility of attributing causality to the least efficacious causal mechanisms, such as when a set of antagonistic causal mechanisms produce the same empirical (statistical) outcome (Sayer, 2000, Yin, 2009, Easton, 2010). Thus, given the causal complexities that imbue ISs as open social systems, an in depth small-N study is, in fact, more explanatory powerful than a large-N study (Tsoukas, 1989, Sorrell, 2018, Fragkandreas, 2022).

Fragkandreas (2021), for instance, in his retroductive study on ISs and inequality develops a conceptual model based on the RME and illustrates its explanatory power in a case study analysis of a regional IS in Germany. According to the proposed retroductive model, ISs shape the distribution either positively or negatively depending on how focal actors in ISs respond to key Schumpeterian (creative-destructive) challenges in the innovation process. Fragkandreas' (2021) in-depth analysis unearthes *seven causal mechanisms* through which the causal powers of the IS in question shape the distribution of income: *five mechanisms* leading to rising inequality (i.e. competence concentration, income hoarding, skill premiums, precarious employment, and old-age technological unemployment), and *two mechanisms* reducing inequality (i.e. gender-inclusive competence-building and employment).

On the one hand, the findings of the aforementioned study are externally valid to other innovative places exhibiting rising inequality (Lee, 2011, Breau et al., 2014) – one or more of the identified mechanisms are likely to contribute to rising inequality in other innovative regions. In this regard, Easton (2010) is right to argue that once a reasonable causal explanation has been produced in a single case study, 'the constituents of that explanation provide a basis for developing theory beyond that case'(Easton, 2010, p.127). On the other hand, Fragkandreas's (2021) study makes it possible to acquire generalisable knowledge about the deeper aspects of causality ISs in a manner that is impossible to achieve with the empirical approach to generalisation. For instance, the aforementioned study findings are transfactually generalisable in the sense that they imply that the causal powers of ISs exacerbate inequality when focal actors, either intentionally or unintentionally, devise and adopt a mix of inequality-friendly strategies as a means to address key problems and challenges that they encounter during the various stages of the innovation process.

All in all, under the RME, *case study research is metamorphosed from the Cinderella of deductivist research to the Queen of externally valid causal explanation in ISs*.

4.3 Detroductive Synthesis: Case Study Research on ISs Can (Not) Study Causality and Generality

4.3.1 Detroductive Synthesis

Having formulated the deductive thesis and the retroductive antithesis and established the dialectical tension between the two theses, it is now pertinent to ask the following question: *what do these opposing theses tell us about the case study paradox?* The short answer is that the case study paradox is the methodological corollary of the deductive thesis. Put differently, by embracing the deductive thesis, and thus also the HDME as the primary methodological foundation, IS scholars have inevitably engendered the case study paradox. In contrast, when the retroductive antithesis replaces the deductive thesis – particularly when the HDME is substituted with the RME, the paradox loses its logical coherence, let alone ceases to exist. Schematically, the argument goes as follows:

Deductive thesis $\Rightarrow$ HDME $\Rightarrow$ case study paradox
Retroductive antithesis $\Rightarrow$ RME $\Rightarrow$ no case study paradox

Since the retroductive antithesis dissolves the case study paradox, this paper could end here by claiming that the retroductive antithesis, particularly the retroductive model of science, offers a bright, paradox-free future for research on ISs. Doing so, however, entails a severe methodological danger – the deductive thesis will keep dominating the methodological thought, standards and practice in the field in the years to come.

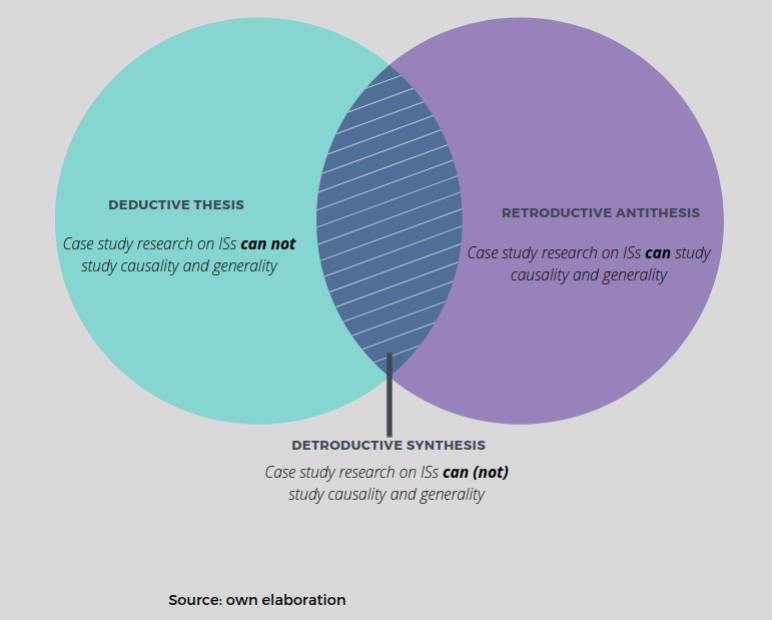
Several developments attest to this possibility. First, spurred on by the increasing digital availability of large chunks of numerical data (i.e. 'big data'), a rising number of innovation scholars seem to believe, though somewhat implicitly, that incorporating big data in our research will help us uncover the 'big truths' about the complex aspects of causality in ISs (Cirillo et al., 2019, Yin et al., 2019, Sena et al., 2021, Rikap, 2022). Second, coupled with the pressing need to publish (especially on the part of young scholars) as many papers as possible in high-ranked journals, this puts a significant methodological premium on easily accessible secondary data and thus, on formal research, rather than on time-consuming and methodologically-challenging types of research such as case studies. Lastly, given the above, it is hardly surprising that an increasing proportion of innovation studies (especially the ones conducted by young researchers) are formal 'even econometric, often exhibiting a naive positivism'(Martin, 2016, p.440).

In such a methodological landscape, where innovation researchers seem to have joined, albeit belatedly, the cheerleaders club of deductivism in the social sciences, the retroductive case study scholar has two major options: (a) either to surrender to deductivism due to peer pressure; or (b) to embark upon a heated methodological controversy (a sort of *Methodenstreit*), such as the one experienced by Joseph Schumpeter (1954/2006*b*) in his early academic years between the German historical school (often associated with inductivism) and the Austrian school of economics (often associated with deductivism) (Fagerberg, 2003, Shionoya, 2004). However, neither option seems promising for the field of

innovation studies. The history of science (Kuhn, 1962/2012) has taught us that power struggles in scientific fields are often associated with missed knowledge opportunities, wastage of scarce resources (e.g. talent), and eventually declining social relevance.

To free case study research from the methodological shackles of deductivism, the paper advances the ***detroductive synthesis***. In line with the logic of dialectics, the proposed thesis builds, transcends and emerges from the dialectical space between the deductive thesis and the retroductive antithesis (see Figure 5). The synthesis in question establishes in the most explicit manner possible that the scientificity of case study research can not be accessed independently of the model of scientific explanation. Put differently, *what is case study research capable of doing has very little to do with the number of cases under investigation, type, depth and breadth of data; instead, it has mainly to do with the model of science that informs the analysis*. This is a significant methodological revelation that has, to date, evaded the attention of both innovation scholars and, surprisingly, notable case study experts (Eisenhardt, 1989, Flyvbjerg, 2001, 2006, Yin, 2009)[15].

Figure 5: The Methodological Dialectic of Case Study Research on ISs



4.3.2 Practical Implications

The detroductive synthesis has several far-reaching implications for designing, undertaking and assessing the quality case study research on ISs. Following the work of Yin (2009) and other notable case study experts (Eisenhardt, 1989, Flyvbjerg, 2006, Eisenhardt and Graebner, 2007, Gehman et al., 2018), the remaining discusses how the detroductive synthesis casts a fresh perspective on six key practical aspects of case study research on ISs.

1. **Research purpose**. According to the HDME, case study research is, in principle, a descriptive-exploratory research design being primarily suitable to the initial stages

[15]Flyvbjerg (2001), for instance, states that generalising from case study research 'depends upon...how it [the case] is chosen' (p.74), no mention of the model of science.

of scientific inquiry rather than in the later, and more mature, stages which, according to the HDME, deal with what is causal and general (Hempel and Oppenheim, 1948, Eisenhardt, 1989, Flyvbjerg, 2006). In contrast, the RME regards case study research on ISs as, by default, a causal-explanatory research design (Tsoukas, 1989, Easton, 2010), ideal for identifying and teasing out a complex of causal mechanisms through which the 'overall function' (Edquist, 2005) in ISs produces several theory-relevant, yet often contradictory empirical outcomes (Jackson et al., 2016, Fragkandreas, 2021).

> ***1st detroductive implication*** *– Categorising case study research on ISs as merely exploratory, descriptive, qualitative type of analysis is severely misleading because it fails to acknowledge that it is the model of scientific explanation which, in principle, moulds the research purpose (exploratory or explanatory) and empirical content (qualitative and/or quantitative) of this type of research.*

2. **Theoretical purpose**. According to the HDME, case study analysis of ISs is best conducted as an inductive theory-building exercise (Eisenhardt, 1989, Moussavi and Kermanshah, 2018), as well as – and where possible (e.g. when an average or critical case is identified) – as a theory-testing form of research (Flyvbjerg, 2006, Yin, 2009). From the standpoint of the RME, central to an explanatory analysis of ISs is a ceaseless process of re-conceptualising and collecting data about the structural composition, causal powers and mechanisms of ISs (Sayer, 2000, Easton, 2010, Tsang, 2014). As Edwards et al. (2014, p.22) nicely put it, '[w]hat concepts do I need to understand and explore more fully the causal mechanisms under investigation?'(Edwards et al., 2014, p.22). This is, in a nutshell, one of the central methodological questions in retroductive research. Thus, in retroductive research, theory building and testing are two mutually reinforcing steps that need always go hand in hand (Easton, 2010, Tsang, 2014, Danermark et al., 2019).

> ***2nd detroductive implication*** *– Whether case study research on ISs should, in principle, aim at either/both devising new concepts and theories (theory-building) or/and testing existing concepts, insights and models (theory-testing) is subject to the model of science that informs one's views.*

3. **Case selection**. Case study research on ISs follows a strategic approach to sampling that fundamentally differs from the sampling logic in survey research (Yin, 2009, De Vaus, 2014). Yin (2009), for instance, discusses five sampling strategies for case study research (i.e. average, critical, extreme, longitudinal and revelatory), one of which (i.e. the average case) would be regarded as the most reliable in survey research (De Vaus, 2014). Unlike the HDME, which, in principle, regards the average case as the most appropriate sampling strategy, the RME assigns methodological value to extreme, deviant and critical cases (Bhaskar, 1979, Flyvbjerg, 2006, Danermark et al., 2019). In addition, contrasting cases (i.e. cases exhibiting contradictory empirical outcomes) are ideal for retroductive explanatory research that seeks to ascertain why the same causal power(s) of ISs produce(s) differential empirical outcomes in one case but not in the other(s) (Lawson, 1997, Danermark et al., 2019).

3rd detroductive implication *– Which sampling strategy is ideal for conducting explanatory case research on ISs is intrinsically linked to the model of scientific explanation that informs the analysis.*

4. **Triangulation**. One of the distinguishing strengths of case study research on ISs is its ability to utilise multiple theoretical perspectives and sources of evidence – i.e. triangulation (Eisenhardt, 1989, Eisenhardt and Graebner, 2007, Yin, 2009). Although the HDME does not oppose nor preclude the use of multiple perspectives and data sources is IS research (see, for instance, Tsouri et al., 2021), triangulation makes no actual contribution to the overall quality of the research findings. This, among other things, is due to the fact that at the centre of the HDME lies the belief that the identification of empirical regularities across the largest number of observations constitutes the most reliable indicator of a causal relationship (Hempel and Oppenheim, 1948, Harre, 1972, Bhaskar, 2008*b*). In contrast, the RME regards triangulation as a necessary procedure for detecting and learning the most about the composition and efficacy of causal mechanisms in ISs (Downward and Mearman, 2007, Wynn and Williams, 2012, Papachristos and Adamides, 2016). Combining multiple perspectives and sources of evidence allows the retroductive researcher to investigate the anatomy and efficacy of causal mechanisms in concrete, yet dynamic settings (Papachristos and Adamides, 2016, Danermark et al., 2019, Fragkandreas, 2021). In this regard, the RME concurs that '[m]ost interesting [causal explanatory] studies on...innovation systems combine quantitative and qualitative methods' (Chaminade et al., 2018, p.43).

   4th detroductive implication *– The extent to which triangulation is essential in inferring causality in ISs research depends upon the model of scientific explanation that informs the analysis.*

5. **Quality criteria**. The HDME implies that the quality of case study research on ISs always needs to be assessed by following the standard (positivist) quality criteria (i.e. internal, construct, external validity and reliability), which are also used to assess the findings of deductivist and formal studies on ISs (Gibbert et al., 2008, Yin, 2009). However, from the standpoint of the RME, such criteria are inadequate to judge the quality of retroductive case study research on ISs (Healy and Perry, 2000, Wynn and Williams, 2012). For instance, none of the standard quality criteria assesses whether case study research on ISs has identified the contextual factors that impede or facilitate the causal abilities of ISs to induce certain empirical events (Healy and Perry, 2000, p.124). Similarly, issues of ontological appropriateness (i.e. whether the choice of research problem and methods is in line with the structurally-heterogeneous, open system and fuzzy nature of ISs) are seen as auxiliary methodological issues in deductive research. In contrast they, whereas they are of utmost significance in retroductive research (Tsoukas, 1989, Sayer, 2000, Danermark et al., 2019). Relatedly, and while the HDME implies that causal explanatory research on ISs needs to be detached from actors' views in order to retain its objectivity (Chalmers, 2009, Blaikie and Priest, 2019), the RME entails that without registering actors' views – the 'proto-theories', as Collier (1994) calls them – explanatory research on ISs lacks methodological trustworthiness and construct validity (Healy and Perry, 2000, Wynn and Williams, 2012).

5th detroductive implication *– What criteria are the most appropriate to assess the quality of explanatory research on ISs can not be decided without paying due consideration to the model of scientific explanation that informs the analysis.*

6. **Generalisation**. The question of 'how many cases?' has often been regarded as identical to the question of external validity or generalisation, i.e., 'the problem of knowledge whether a study's findings are generalizable beyond the immediate case study'(Yin, 2009, p.49). According to the HDME, it is difficult, if not impossible, to draw reliable general knowledge on ISs from small-N research, especially single-case research. To paraphrase Easton (2010), what can a single-case study tell you about the general aspects of causality in ISs? The answer is very clear: very little indeed[16]. In contrast, the RME implies that the findings of single case studies on ISs are as reliable as those of multiple case studies, including those produced by large-scale quantitative studies (Tsoukas, 1989, Easton, 2010). The RME is grounded on an ontological perspective on generalisation known as *transfactual generalisation* (Morais, 2011, Tsang, 2014, Danermark et al., 2019). Thus, generalisable knowledge lies not in empirical patterns (empirical generalisation) but in their deeper (non-empirical) aspects (i.e. causal powers) of ISs (transfactual generalisation).

   6th detroductive implication *– The question of whether the findings of case study research on ISs are transferable beyond the case study context is, in principle, not a question of sample size but subject to the model of scientific explanation that informs our views.*

4.3.3 Metatheoretical Implications

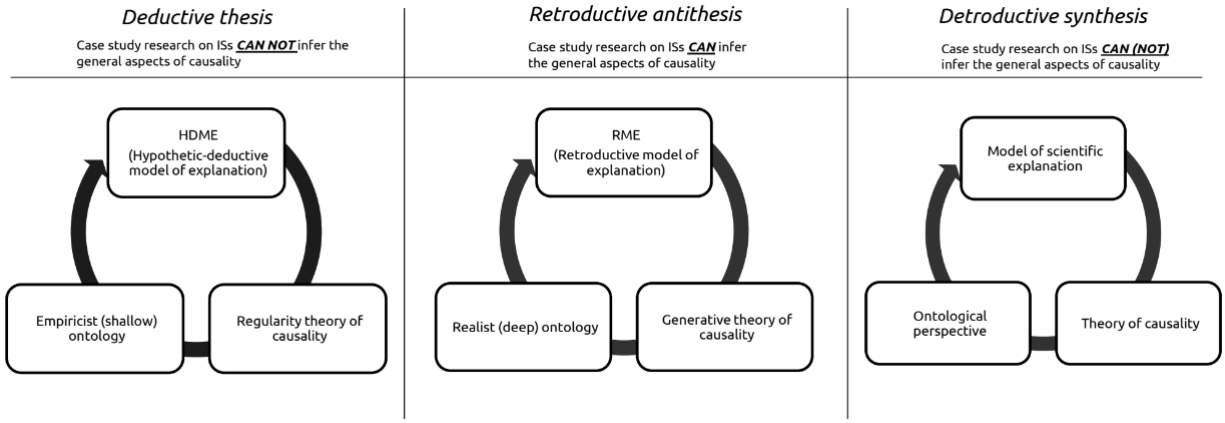
In addition to practical implications, the detroductive synthesis has a few crucial metatheoretical implications. Table 3 summarises the methodological implications of a dialectical analysis of the case study paradox. As is shown, the deductive and retroductive theses have fundamentally different implications for what constitutes proper case study practice on ISs. Such striking differences attain their substance and coherence from a particular set of metatheoretical assumptions, such as epistemological and ontological assumptions. For instance, when one subscribes to the deductive thesis, she not only endorses the HDME as the most appropriate model of causal explanation but also she embraces the *regularity theory of causality* (Harre, 1972, Bhaskar, 2008*b*), wherein causality in ISs occurs in the form of recurrent empirical constancies such as if Event A is present, Event B follows or tends to do so in all or most ISs. As a result, the deductivist scholar endorses an *empiricist* (shallow) ontological perspective on ISs (Blaikie and Priest, 2019, pp.89-118), according to which, the most scientifically relevant aspects of ISs are empirical events. In contrast, when one argues for the retroductive thesis, not only she embraces the RME but also accepts the *generative theory of causality* wherein causality in ISs resides in 'powerful particulars'(Harre, 1972, Bhaskar, 2008*b*), namely in the causal powers of ISs (Koutsouris, 2012, Vega and Chiasson, 2019, Fragkandreas, 2021). Correspondingly, the retroductive

[16] 'What can one case tell you?...The answer is very clear: very little, indeed' (Easton, 2010, p.213).

scholar adopts a *realist* (deep) ontological perspective (Blaikie and Priest, 2019, pp.89-118) wherein the most essential aspects of causality lie in the structural (less empirical) causal capacities of ISs (Bhaskar, 2008*b*, Castellacci, 2006, Svensson and Nikoleris, 2018, Fragkandreas, 2021).

> ***7th detroductive implication*** *– Central to our views on the scientificity of case study research on ISs lies the metatheoretical interdependence between (a) a particular model of science, (b) its underlying theory of causality (epistemology) and (c) its corresponding worldview (ontology)* (see Figure 6).

Figure 6: Metatheoretical Interdependencies



Source: own elaboration

While the metatheoretical assumptions underpinning the retroductive antithesis are in line with what we know about ISs (Edquist, 2005, Lundvall, 2013), the metatheoretical assumptions supporting the deductive thesis are certainly not. For instance, accepting the deductive thesis presupposes 'the ubiquity of spontaneous event regularities'(Lawson, 1997, p.25) in ISs. Put differently, for the deductivist thesis to be true, ISs must be replete with pure empirical regularities of the form Event X leads to Event Y. However, several decades of research on ISs have taught us that because each ISs has a unique structure, and thus possesses a unique set of causal powers, empirical regularities are, at best, partial and unstable in ISs, surprisingly even when focal actors, such as policy-makers, are purposefully seeking to sustain demi-regularities (Schot and Steinmueller, 2018, Edquist, 2019). Innovation is a creative-destructive force (Schumpeter, 1911/1983), meaning that it is liable to constantly transform the structural composition and causal abilities of ISs, and as an extension of this, the entire capitalist system (Freeman and Louçã, 2001, Perez, 2010), including its national and regional institutional varieties (Hall and Soskice, 2001, Asheim and Gertler, 2005, Herrmann and Peine, 2011). Here, and in line with the retroductive thesis, the detroductive thesis turns the deductive thesis on its head by revealing that at the centre of the deductive thesis, including formal (deductivist) research on ISs, lies a scandalous 'theory-methodology' inconsistency.

> ***8th detroductive implication*** *– The deductive thesis rests upon a set of metatheoretical assumptions which are fundamentally at odds with key stylised facts of knowledge on innovation and ISs.*

Table 3: Case Study Research on ISs: Key Methodological Implications

Implications	Type of implication	Deductive thesis (HDME)				Retroductive (RME) antithesis	Detroductive synthesis
		Verificationism	Falsificationism	Corroborationism	Inductivism		
Causality	Epistemological	Empirical regularities	Empirical regularities	Empirical regularities	Empirical regularities	Causal powers and mechanisms	Subject to the model of scientific explanation
Form of theory	Epistemological	Formal deductive hypotheses	Formal deductive hypotheses	Formal deductive hypotheses	Inductively-generated concepts and hypotheses	Conceptual models	Subject to the model of scientific explanation
Logic of inference	Methodological	Deduction (formal)	Deduction (formal)	Deduction (formal)	Inductive-deduction (formal)	Retroduction (creative)	Subject to the model of scientific explanation
Generalisation	Epistemological	Analytical generalisation based on empirical generalisation	Analytical generalisation based on empirical generalisation	Analytical generalisation based on empirical generalisation	Analytical generalisation based on empirical generalisation	Analytical generalisation based on transfactual generalisation	Subject to the model of scientific explanation
Sampling strategy	Methodological	Average case(s)	Critical case(s)	Average case(s)	Multiple cases	Critical, extreme and contrasting cases	Subject to the model of scientific explanation
Primary research focus	Epistemological	Empirical events	Empirical events	Empirical events	Empirical events in Iss	Structural anatomy and causal powers of Iss	Subject to the model of scientific explanation
Quality criteria	Methodological	Validity and reliability	Validity and reliability	Validity and reliability	Validity and reliability	Realist (ontological, epistemological and methodological) criteria	Subject to the model of scientific explanation
Research goal	Methodological	Illustration	Illustration	Illustration	Exploration	Thick explanation	Subject to the model of scientific explanation
Theoretical purpose	Methodological	Rich description	Theory-testing	Theory-corroboration	Theory-building	Concurrent theory-building and testing	Subject to the model of scientific explanation
Type of triangulation	Methodological	Data triangulation	Data triangulation	Data triangulation	Data triangulation	Data and theoretical triangulation	Subject to the model of scientific explanation
Worldview	Ontological	Empiricist	Empiricist	Empiricist	Empiricist	Realist	Subject to the model of scientific explanation

Source: own elaboration

5 Conclusion, Implications and Limitations

5.1 Summary

The present paper has analysed in a dialectical manner the paradoxical status of case study research in IS studies. The analysis revealed that the case study paradox stems from the prevailing deductivist belief that the hypothetico-deductive model of explanation (HDME) constitutes the most reliable yardstick to judge the scientific abilities of case study research on ISs and the ISs approach in general. Despite being widespread, such a methodological practice is erroneous and misleading because it conflates the key aspects of the HDME with the actual qualities and potential of case study research on ISs and the ISs approach in general. It is such a methodological misunderstanding which has led many ISs scholars to believe that case study research is, in principle, not a causal-explanatory form of scientific research, even though, as illustrated by the articulation of the retroductive thesis in this paper, case study research is ideal for studying causality in the form of causal mechanisms, as well as for acquiring (transfactual) general knowledge about the causal powers of ISs. Thus, this paper has resolved the case study paradox by dialectically juxtaposing the deductive thesis with the retroductive antithesis. Yet, developing the detroductive synthesis has revealed that our views on what constitutes proper research on ISs are always grounded, most often implicitly than explicitly, on a particular conception of science.

5.2 Peer-Review and Policy Implications

Since our methodological views are always subject to a particular model of scientific explanation, editors, reviewers, and case study researchers need to be significantly more transparent and reflexive than hitherto about the model of science that informs their views. This is especially true for the deductively-minded editors and reviewers who often reject or harshly critique the findings of case study research because they either divert significantly from the deductivist norm or they are incompatible with it. For instance, Kathleen Eisenhardt, who is with no doubt one of the leading case study experts in innovation and management studies (Eisenhardt, 1989, Eisenhardt and Graebner, 2007), has recently confessed that ‘my deductive editors often like propositions, and if so, I usually provide them’ (Gehman et al., 2018, p.296). The dialectical analysis in the present paper suggests that it is no longer the retroductive scholar but the deductive scholar who needs to convince us about the extent to which the underlying assumptions of deductivist research are, indeed, compatible with our knowledge and ontology of innovation as an open ended, creative-destructive process. Without doing so, the deductivist scholar can no longer self-determine the methodological terms in innovation studies.

The above extends to innovation policy evaluation, where deductivism is increasingly being seen as a methodological necessity when it comes to judging the effectiveness of innovation policies (see,e.g. Crespi et al., 2016, Knoll et al., 2021, Gangopadhyay and Homroy, 2023, Koh and Lee, 2023). What is at stake here is the fundamental tension between deductivism and innovation policy. The logic of deductivist research (which, in crude terms, seeks to identify stable empirical constancies across the largest number of

cases possible) contradicts the logic of innovation policy action (which, by nature, fosters innovation, hence disturbing rather than maintaining existing empirical patterns). In this regard, innovation policy is, by design, liable to undermine the explanatory success of deductivist research.

More importantly, a pure deductivist approach to policy evaluation may mislead policy action. Consider, for instance, the hypothetical case where an initiative seeking to enhance the adoption of artificial intelligent (AI) technologies in a peripheral, technologically locked-in IS triggered several positive mechanisms of change (e.g. induce a positive change in the attitude towards AI among focal actors in the IS in question) but, due to the absence of favourable conditions (e.g. lack of a critical mass, institutional capacity, financial resources, leadership, transparency etc.), no significant investments in AI technologies were made. Does this mean that the policy initiative in question is a failure? From the standpoint of deductivist research, the policy in question is a *failure* – no significant empirical regularity is observed between the policy initiative (event X) and investments in AI technologies (event Y). However, from the standpoint of retroductive research, the policy in question is a *partial success* – positive mechanisms were triggered, but due unfavourable (blocking) conditions, no empirical outcomes are observed.

This rather crude example reveals that a pure deductivist research agenda may, after all, be counterproductive when designing a new generation of innovation policies aimed at tackling grand societal challenges (Schot and Steinmueller, 2018, Lundvall, 2022). Designing such policies requires a system-specific, trial-and-error policy mindset, ongoing experimentation and cumulative policy learning (Mytelka and Smith, 2002, Tödtling and Trippl, 2005, Mazzucato, 2015, Lundvall, 2022). While these are perfectly compatible with the logic, including the metatheoretical assumptions, of the retroductive model of science[17], they are largely incompatible with the hypothetical-deductive model, including its metatheoretical baggage.

5.3 Limitations

As is the case with every type of research, this methodological study has some limitations. In the process of dialectically analysing the case study paradox on ISs, the discussion may have either superficially covered or overlooked key developments in the literature on both ISs and the case study method in the social sciences. However, to the best of the author's knowledge, the analysis in this paper has either referred to or touched upon several key methodological developments in the literature on both ISs and case study research.

Despite these possible limitations, the present paper has produced several novel methodological insights that make the case study research on ISs look even more methodologically attractive and consistent than previously. This is of significance to innovation re-

[17] Although the present paper has not touched upon the emancipatory potential of retroductive research (Sayer, 2000, Bhaskar, 2009), retroductive research can contribute vital 'mechanism-based' insights to policy design (Lawson, 1997, Pawson and Tilley, 1997). For instance, by identifying causal mechanisms that produce detrimental events and outcomes (e.g. environmental degradation, rising inequality, relative poverty, etc.), it provides policy-relevant knowledge of which mechanisms need to be blocked, altered or reinforced through innovation policy (see, for instance, Fragkandreas, 2021, 31-32).

searchers who, despite sharing Schumpeter's 1954/2006*b*) overall methodological outlook that socio-economic research is, by definition, an eclectic, yet systematic process of studying the most fundamental (qualitative) features and dynamic effects of the perennial gales of creative destruction in capitalist societies (Swedberg, 1991, Shionoya, 2004), find it extremely hard these days to justify why case study research is of utmost significance to innovation studies. Contemporary innovation researchers must not forget that, like Joseph Schumpeter, the early protagonists of the field of innovation studies (e.g. Chis Freeman, Dick Nelson, Bengt-Åke Lundvall, Carlota Perez and Nathan Rosenberg), neither embraced nor surrendered to the sirens of deductivism and mathematical formalism, despite conducting research at the height of positivism in the social sciences (Smith, 1998, Flyvbjerg, 2001, Benton and Craib, 2010). Their highly insightful work teaches us, among myriad issues, that it is the nature of innovation (ontology) that dictates the choice of methods (methodology), not the other way around (as the work of most contemporary innovation scholars seems to imply).

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