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Case study research on innovation systems: Paradox, dialectical analysis and resolution

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ABSTRACT

This paper addresses a largely unnoticed methodological paradox regarding the scientific status of case study research on innovation systems (ISs). Case study research has been the methodological catalyst for 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. However, many ISs scholars believe that this type of research is not scientific enough. To deepen our understanding of the case study paradox, this paper utilises the dialectical method (also known as dialectics); in particular, the analytical triad of thesis (affirmation), antithesis (negation), and synthesis (transformation). It is shown that a dialectical resolution to the case study paradox involves a three-phase process. First, the analysis introduces the ***deductive thesis***, which, based on the hypothetico-deductive model of science, posits that case study research on ISs cannot investigate causality and generality. The second step formulates the ***retroductive antithesis***, which, based on the retroductive model of science, holds that case study research inherently possesses the ability to infer causality and generality. The third and final phase transforms the contradiction between the deductive thesis and the retroductive antithesis into a new methodological perspective, the ***detroductive synthesis***, wherein – depending on the model of scientific explanation – case study research is both incapable (deductive thesis) and capable (retroductive antithesis) of inferring causality and generality. Overall, the analysis enables IS scholars to conduct case study research in a paradox-free, stand-alone, causal-explanatory, and generalisable way. The paper ends by discussing thought-provoking implications for research practice, the peer-review process, and the evaluation of innovation policies.

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)

Innovation systems (ISs) are understood as a 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). They constitute an essential structural condition for achieving and sustaining a high level of (Schumpeterian) growth and development in modern-day capitalist societies (Freeman, 2002; Filippetti and Archibugi, 2011; Radosevic and Yoruk, 2013). Since the early 1990s, ISs have been a popular object of extensive research and policy action across the world (Nielsen, 2003; Sharif, 2006; Rakas and Hain, 2019; Fernandes et al., 2021). Over time, this has led to the emergence of the IS approach (Edquist, 2005; Sharif, 2006), which has now become one of the most widely utilised theoretical perspectives on innovation (Fagerberg et al., 2012; Rakas and Hain, 2019).

This paper is among the first to systematically scrutinise the deeper assumptions that inevitably underpin research on ISs. As such, both the analysis and findings of this paper complement recent stock-taking contributions to ISs research (Teixeira, 2014; Chaminade et al., 2018; Asheim et al., 2019; Rakas and Hain, 2019; Fernandes et al., 2021; Lundvall, 2024). 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.

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On the one hand, the groundbreaking 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 that case study research is not scientific enough. The underlying argument can be summarised as follows: since the principal aim of scientific research is to produce generalisable causal knowledge about the phenomena under investigation (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 research is highly unlikely to generate findings that extend beyond the case study context.

In propagating such a view (either intentionally or unintentionally), ISs scholars have 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 IS studies (Carlsson, 2007; Teixeira, 2014; Doloreux and Porto Gomez, 2017)? Furthermore, since the current stock of knowledge on ISs is mainly based on 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; Edquist, 2019) – are of dubious scientific quality? It is these largely unexamined methodological contradictions that constitute the heart of the *case study paradox* in the field of ISs studies.[2]

To heighten our understanding of the paradox in question, this paper employs the dialectical method (also known as dialectics); in particular, the 'dialectical triad' (Popper, 1940, p.325) consisting of thesis (affirmation), antithesis (negation), and synthesis (transformation) (Hegel, 1977, 2010; Hargrave and Van de Ven, 2017). It is shown that a dialectical resolution to the case study paradox unfolds in three main phases. First, the analysis establishes the ***deductive thesis***, which is grounded on the hypothetico-deductive model of science (Hempel and Oppenheim, 1948), and posits that case study research on ISs cannot study causality and generality. In the second phase, the analysis formulates the ***retroductive antithesis***, wherein, based on the retroductive model of science (Bhaskar, 2008*b*; Danermark et al., 2019), case study research inherently possesses the ability to study causality and generality. In the third and last phase of the analysis, the mutually reinforcing contradiction between the deductive thesis and the retroductive antithesis culminates in the ***detroductive synthesis***, wherein case study research, depending on the model of science that informs the analysis, is incapable (deductive thesis) and capable (retroductive antithesis) of inferring causality and generality.

A dialectical analysis of the case study paradox makes several novel contributions to comprehending the methodology and explanatory potential of IS research. For instance, by debunking the methodological supremacy of the deductive perspective on case study research, the paper clears the methodological ground for a new type of causal-explanatory analysis based on the retroductive model of science, whilst unveiling a number of novel, yet practical methodological lessons (see Section 4.3.2 in this paper). This enables ISs 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; Lundvall, 2024): (a) to study the emergence of new ISs and the ongoing transformation of existing ones; (b) to broaden the scope of ISs research (e.g. artificially intelligent technologies, digital innovation and inclusive entrepreneurship); and (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 present paper makes it possible to address the aforementioned research challenges by means of 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 three decades of research on ISs. Special attention is given to the paradoxical status of case study research. Section 3 introduces the dialectical method, while Section 4 articulates, compares, and distinguishes the three central theses (namely, the deductive thesis, retroductive antithesis, and detroductive synthesis) that constitute the analytical core of this paper. Section 4 concludes the paper: it summarises the findings and discusses thought-provoking implications for the peer-review process and policy evaluation studies.

2. Case study research on ISs: methodological overview and paradox

2.1. Case study research on ISs – a curious case?

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 Neo-schumpeterian economists (Fagerberg, 2003): in particular, Christopher Freeman, Bengt-Ake Lundvall, Dick Nelson, Carlota Perez, and Nathan Rosenberg (Eparvier, 2005; Sharif, 2006; Fagerberg and Sapprasert, 2011). For instance, in his seminal study on Japan, Freeman (1987, 1988) demonstrated that the Japanese economic catch-up in the post-war period, and the subsequent technological leadership in electronics in the 1970s and 1980s, was built on 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), particularly 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 organization, such as in cities, regions, sectors, technologies 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

[1] There are various definitions of 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).

[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 BCE), an ancient Cretan philosopher who repeatedly stated that 'All Cretans are liars'. The paradox is that Epimenides was a Cretan!

studies (Fagerberg et al., 2012; Rakas and Hain, 2019).

In line with Joseph Schumpeter's (1954/2006*b*) methodologically eclectic approach to socioeconomic 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, in their systematic review of two decades of research on regional ISs, Doloreux and Porto Gomez (2017) found that 61 % (or 182 studies) of all published studies (n = 292) were case studies.

Table 1 lists a selection 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 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 in early 2022, corresponding to 2191 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 indications, one might assume 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 should have provided ample methodological inspiration and instruction on how to conduct highly influential yet policy-relevant case studies. Surprisingly, neither of these occurs.

Specifically, in their studies on ISs in Asia, Dodgson (2009) and Dodgson et al. (2008) point out 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.). Similarly, in a policy report on innovation and growth in the United Kingdom, Smith and Estibals (2011) emphasise 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.).

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

Like Oliveira and Natario (2016), whose case study analysis focuses on the agro-food IS in the Tagus Valley, Trippl (2011) states that her case study findings regarding the Vienna food IS 'cannot and should not be generalised' (p.1606). While Trippl (2011) associates the question of external validity with the breadth of case study data, others seem to imply that collecting additional data does not mitigate the question of external validity in case study research. For example, Hung and Whittington (2011) conducted more than 160 interviews with IT firm managers, journalists and technical experts; they also triangulated the interview data with insights obtained from archival materials (e.g. company annual reports, analysts' coverage, and articles from the specialised and more general business press). Despite collecting a wealth of data, Hung and Whittington (2011) state that the findings derived from their case study on the Taiwanese IS are 'unlikely to generalise in a simple fashion to larger, more pluralistic countries' (p. 537).

All in all, despite having given birth to, established and popularised the ISs approach in the domains of both academe and policy, ISs scholars very often tend to uphold the view that case study research is mainly a descriptive-exploratory type of analysis, the findings of which cannot be extrapolated to other ISs. It is this methodological consensus that has engendered the case study paradox in the field of ISs.

2.2. Case study paradox: essence, the formal turn, and its discontents

2.2.1. Paradox and the formal turn

As with every paradox, central to the case study paradox 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 for the emergence and success of the ISs approach in the domains of both academia and policy (i.e. $Element_1$). 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 (Bhaskar, 2008*a*; Chalmers, 2009): namely, causal explanation and generalisation ($Element_2$).

When the two elements are in isolation, they appear innocuous and somewhat in harmony. However, when juxtaposed, they are utterly contradictory, which bears significant implications for the scientificity of the ISs approach. For instance, embracing $Element_2$ 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), for instance, 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 puts 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 scientific rigour of ISs research, a growing number of studies have adopted 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 trendsetting, journal in innovation studies (Fagerberg et al., 2012; Rakas and Hain, 2019). The table illustrates that the proportion of formal studies in

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	3858
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	2267
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	2129
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	2080
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	1441
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	1196
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	1105
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'	Single case study	Analysis of life science firms in the region of Emilia Romagna in Itally	Survey of firms	Article	Research Policy	376

(*continued on next page*)

Table 1 (*continued*)

	Author	Year	Title	Type of case study	Unit of analysis	Data collection and analysis	Book/ Article	Journal/publisher	Citations (*)
			innovation strategies in the Emilia Romagna life science industry						
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	2191
								Total	43,819

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.

comparison to other types of papers (such as conceptual, case studies, and descriptive quantitative studies) has significantly risen, from 13 % in the 2000s to 50 % in 2010, and reaches 100 % in the early 2020s. In essence, the field of ISs is experiencing a *formal turn*, where 'soft' (qualitative) studies have gradually been replaced by 'hard' (quantitative) ones (see also Martin, 2016; Chaminade et al., 2018).

The formal turn signals to social scientists of a particular type (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 a 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. Consider, for instance, the fact that formal research is often justified on the ground that, since the existing literature on ISs 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 undermines the methodological monopoly of formal analysis as the only essential means of inferring causality and generality in ISs.

The present paper takes a different perspective: it maintains that resolving the case study paradox requires IS scholars to take a step back from actual research and critically reflect on the more profound and taken-for-granted assumptions which have engendered the paradox in question. In a way, this paper embraces, in a more explicit manner than hitherto, Schumpeter's (1954/2006*b*) invaluable methodological observation that philosophy, theory and research are always intertwined.[4] Following this Schumpeterian insight, 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 – particularly the triad of thesis (affirmation), antithesis (negation), and

[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' (cited in Skidelsky, 2010, p.10).

synthesis (transformation), which forms the methodological foundation of the analysis.

However, before delving into the logic and core elements of the dialectical method, it is important to offer some critical insights regarding the formal turn. This is not intended to present a comprehensive critique of formal research on ISs, *nor does it claim that this type of research has no place in IS research.*[5] Instead, through critical reflection, it seeks to introduce the relevant concepts, pose appropriate questions, and set the stage for the dialectical analysis that follows in this paper.

2.2.2. The formal turn and its discontents

The formal turn raises a multitude of methodological questions, most of which have been notoriously overlooked. Consider, for instance, the question of naturalism (Bhaskar, 1979; Flyvbjerg, 2001): specifically, the extent to which the methods of natural sciences (e.g. physics) – which positivist social scientists (most notably neoclassical economists[6]) have long regarded as the most legitimate methods for investigating social phenomena – are a feasible methodological avenue for research on ISs. Put differently, if we agree with the notion that reality constitutes an open system composed of diverse strata, each with its own unique array of emergent powers, why should the ISs scholar regard the methods of lower strata (e.g. physics, biology, chemistry, physiology) as the optimal choice for comprehending the causal powers of upper strata, such as human beings and society?[7]

These concerns are not only in line with Schumpeter's (1954/2006*b*) overall methodological outlook[8]; they also pertain to actual research practice. In particular, regardless of the type (e.g. regression, econometrics, simulation, etc.), formal studies suffer from two critical problems: oversimplified assumptions, and a dearth of adequate data. Crescenzi (2005), for instance, has built 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 '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' (Crescenzi, 2005, p.477) regarding the 'complexity of the underlying mechanism[s]' (ibid.).

Moreover, innovation is, by definition, a qualitatively new yet constantly evolving phenomenon (Schumpeter, 1911/1983; Freeman and Louçã, 2001). Consequently, formal studies on innovation 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). On the one hand, the systemic character of innovation is 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 other hand, these studies analyse ISs in a 'narrow' way, by focusing exclusively on science and technology indicators (e.g. patents and R&D statistics) (see, for instance, Crescenzi, 2005; Proksch et al., 2019). This, among other issues, suggests that formal studies may often fail to meet the *construct validity* criterion, or '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 formal research. Pearl and Mackenzie (2018) remind us that formal analysis is, by design, bias-prone.[9] For example, by introducing new confounding variables, the formal scholar also adds new biases to the analysis. To overcome such inherent methodological weaknesses in formal research, 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 (Lawson, 1997; Fleetwood, 2017). This methodological practice makes one wonder whether the closed system logic that underpins most (if not all) types of formal research can produce useful knowledge about an inherently dynamic (open-system), context-specific phenomenon – such as the interactive and constantly evolving character of innovation.

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 (e.g. De Vaus, 2014). Yet, formal research very often treats the absence of a statistically significant relationship among variables as conclusive evidence for the absence of 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, and as is the case with case study research on ISs, formal research on such system-like entities is, in principle, a narrative-rhetorical analysis.

Given that formal research is also fraught with severe methodological weaknesses and limitations, the following questions must be asked. First, *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 (Carlsson, 2007; Doloreux and Porto Gomez, 2017), how many more case studies do ISs scholars need to conduct until such findings are seen as being as scientifically legitimate as those of 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 not, 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 dialectical method originates in the work of Ancient Greek philosophers such as Socrates, Plato and Aristotle (Adorno, 2017; Clegg and Cunha, 2017; Maybee, 2019).According to Plato, dialectics involves 'the art of conversation' – i.e. a dynamic exchange or debate between

[5] To avoid misunderstandings, including unnecessary critique, this paper does not oppose the use of formal analyses of ISs. Instead, it rejects the conventional methodological wisdom that quantification and mathematical formalisation are necessary to investigate 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).

[7] Drawing on Kuhn's (1962/2012) seminal work on scientific paradigms, one might also add here that it is the methods of upper-strata sciences that significantly enrich our understanding of the underlying layers of reality. The same holds for phenomena such as environmental pollution, whose underlying causes originate and act in a top-down manner (i.e. downward causation) in the upper strata (e.g. economy) (Elder-Vass, 2010; Sorrell, 2018).

[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 ever wrote [… Schumpeter] 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).

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

interlocutors (Cooper et al., 2002). Dialectics, as Plato's work demonstrates, is a discursive process that enables us to structure and refine our views on a particular subject (Russell, 2008; Maybee, 2019). Subsequent contributions, particularly by prominent philosophers (e.g. Immanuel Kant, Johan Gottlieb Fichte, Georg Wilhelm Friedrich Hegel, Søren Kierkegaard, and Karl Marx), yielded a more systematic interpretation of dialectics (Russell, 2008; Clegg and Cunha, 2017). According to these philosophers, dialectics constitutes a logical approach to addressing contradictions in the domains of both matter and intellect (Slaatte, 1968; Elster, 1986; Adorno, 2017; Hargrave and Van de Ven, 2017; Smith et al., 2017; Maybee, 2019).

Hegel (1977, 2010), for instance, who is widely recognised as the most influential dialectician of all times, comprehended dialectics as a three-phase process (Mueller, 1958; Singer, 2001; Maybee, 2019). The first phase is characterised by 'fixity', where concepts and forms possess seemingly stable determinations. The second phase involves instability – a 'negatively rational' stage where the first phase is 'negated'. The third phase is the 'speculative' moment – a 'positively rational' juncture where the 'unity of opposites' between the first two moments is established, leading to a new fixity. By systematising these three pivotal moments, Hegel strove to elevate the dialectical method from a Socratic conversational technique to the science of logic (Popper, 1940; Mueller, 1958; Singer, 2001; Maybee, 2019).

Today, the dialectic method constitutes a methodological paradigm (dialectics), rather than a homogenous (Hegelian) method. It encompasses a variety of approaches and perspectives (for an accessible overview, see Clegg and Cunha, 2017). Nevertheless, a shared characteristic among all dialectical variants is the interaction between opposing elements, such as the *thesis* (also referred to as affirmation), its *antithesis* (also known as negation), and *synthesis* (also called transformation) (Popper, 1940; Bhaskar, 2008*a*; Adorno, 2017; Hargrave and Van de Ven, 2017). Hargrave and Van de Ven (2017) summarise the key components of the dialectical method as follows:

> In dialectics [...] the relationship of contradictory elements [thesis and antithesis] plays out through a process in which actors espousing one element, the affirmation [thesis], engage in conflict with actors promoting the opposed element, the negation [antithesis]. This conflict releases the tension between the contradictory elements and produces a new set of arrangements and practices, the transformation [synthesis]. (Hargrave and Van de Ven, 2017, p.325, emphasis added)

To illustrate briefly how the dialectical method works in practice, the following utilises Schumpeter's (1944/2006*a*) (Nietzschian) conceptualisation of innovation as a 'creative-destructive' process (Reinert and Reinert, 2006). The *thesis* is that innovation is a creative activity, adding new skills, competencies, jobs, knowledge, new products and services into the economic system; the *antithesis* is that innovation destroys existing skills, jobs, competencies and knowledge; and the *synthesis* is that innovation does both simultaneously – thus, it is a creative-destructive process (Fig. 1). 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 dialectical triad of thesis (affirmation), antithesis (negation), and synthesis (transformation). 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 approach followed in this paper draws inspiration from the work of Roy Bhaskar (2008*a*). Bhaskar's dialectics allows for an examination not only of the existence of a thesis (affirmation), but also of the absence of an antithesis (negation) (for an accessible introduction to Bhakar's work, see Collier, 1994; Norrie, 2009). According to Bhaskar (2014):

> 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 holds significant implications for our understanding and resolution of the case study paradox. It implies that the absence of an antithesis (negation) holds as much importance as the presence of a thesis (affirmation). In essence, a Bhaskarian dialectical perspective indicates that *without negating the thesis that case studies cannot study causality and generality, the case study paradox cannot be resolved*.The remainder of this paper explores the above methodological implication. The analysis establishes the *deductive thesis*, which is grounded on the hypothetico-deductive model of science (Hempel and Oppenheim, 1948), and posits that case study research on ISs lacks the capacity to scrutinise causality and generality. Subsequently, it progresses to formulate the *retroductive antithesis*, which contends that, based on the retroductive model of science (Bhaskar, 2008*b*), case study research can indeed infer the general aspects of causality. Finally, the tension between the deductive thesis and the retroductive antithesis begets the *detroductive synthesis*, which constitutes the final stage in the dialectical analysis of the case study paradox.

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 syllogisms and formal reasoning; particularly, by deducing knowledge about the particular from the general (Hempel and Oppenheim, 1948; Harre, 1972; Blaikie and Priest, 2019). The hypothetico-deductive model of science (HDMS) has long been regarded as the most representative form of deductive reasoning and analysis in both the natural and social sciences (Hempel and Oppenheim, 1948; Gorski, 2004; Chalmers, 2009; Benton and Craib, 2010). Methodologically, the HDMS encompasses a three-stage, *formal analytical* process, which can be implemented either in a linear or iterative way (see Fig. 2).

- *Step 1: Explanandum* – An interesting empirical phenomenon/phenomena is/are 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 HDMS 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 comes in four main variants, each of which has several crucial implications for case study research on ISs.

1. **Deductive verification** refers to the standard version of the HDMS (Hempel and Oppenheim, 1948; Webb, 1995; Chalmers, 2009). According to the verification variant, causal explanatory research on ISs proceeds by verifying theoretical constructs (e.g. formal models and hypotheses) through the identification of large-scale empirical

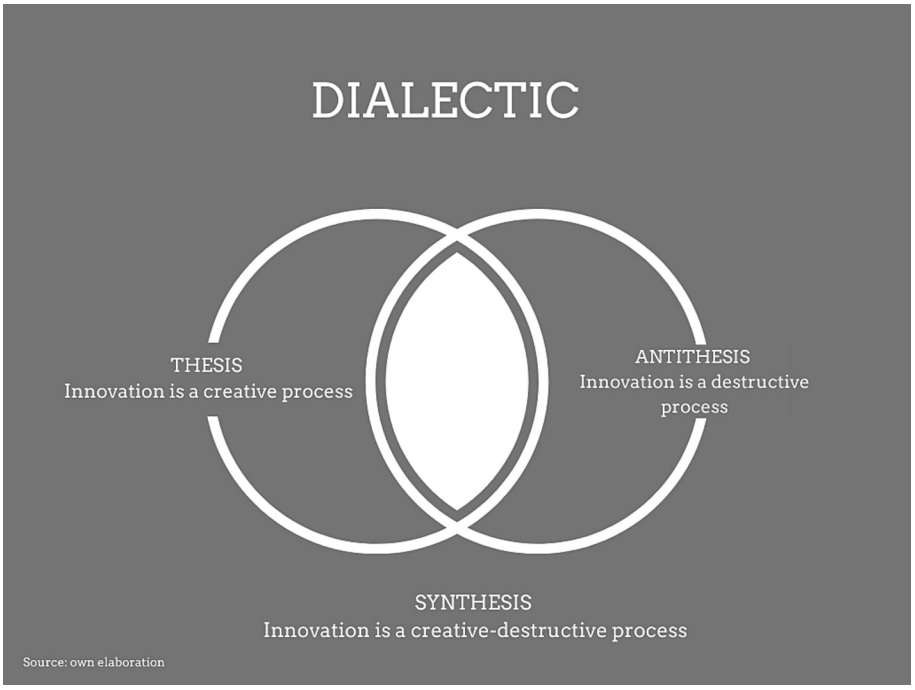

Fig. 1. The Schumpeterian Dialectic of Innovation.

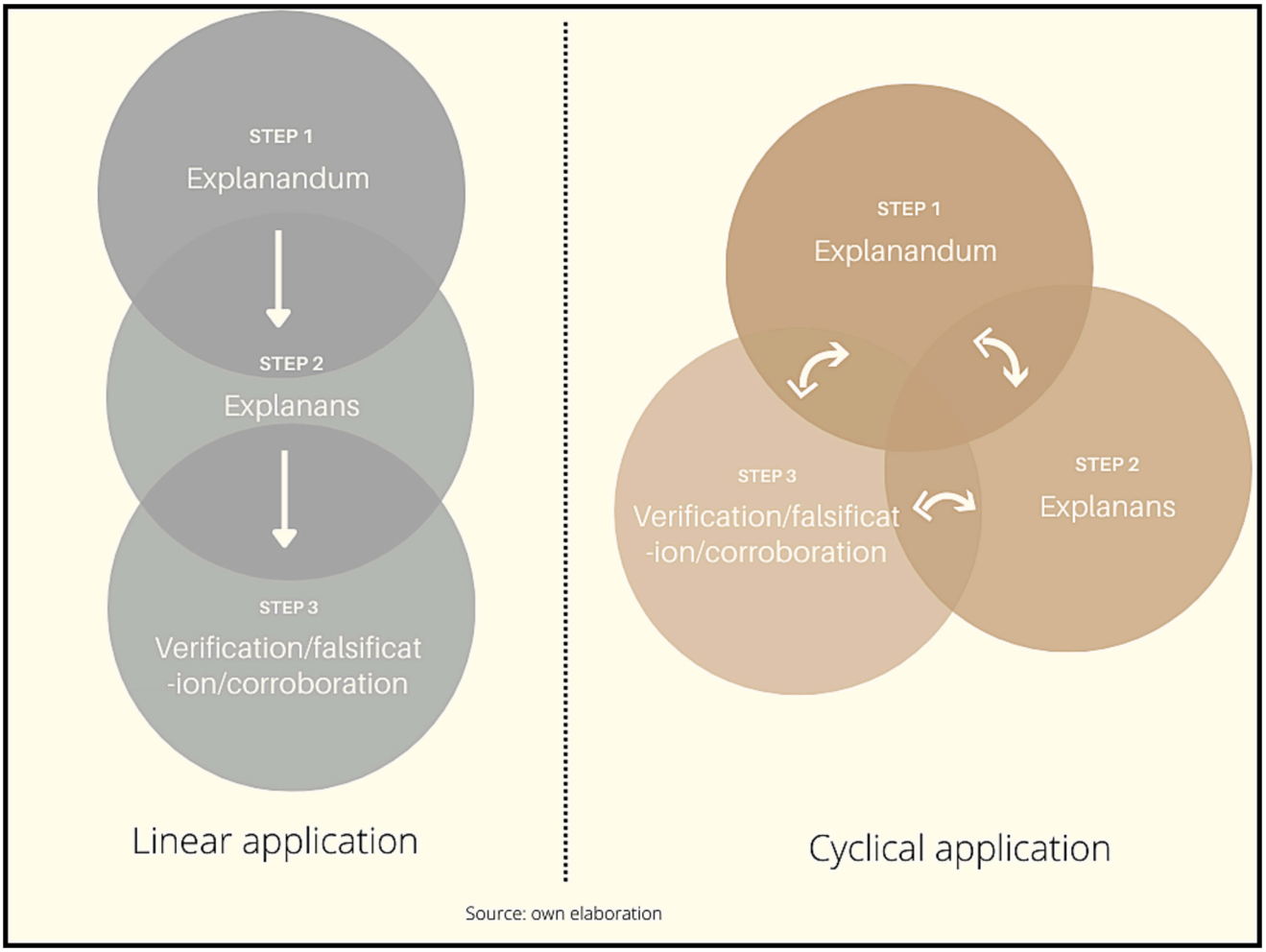

Fig. 2. HDMS: Linear and Cyclical Applications.

(law-like) regularities (Lawson, 1997; Sharif, 2006). Karl Hempel (1905–1997), one of the leading figures of deductivism (Hempel and Oppenheim, 1948), was fully aware of the flaws of this model (see, for instance, Gorski, 2004). Nonetheless, social scientists – most notably neoclassical economists (Lawson, 1997; Louçã, 2007) – have long regarded deductive verification as ideal for a social science that seeks to emulate the methods of natural science; especially the methodological apparatus of 19th-century physics (Bhaskar, 1979; Gorski, 2004). By placing significant emphasis on identifying law-like empirical regularities as the most reliable criterion for judging the analytical ability of explanatory research on ISs, the verification variant outrightly discards the possibility that case study research could yield trustworthy insights about the general aspects of causality in ISs.

2. **Deductive falsification** is the second main variant of the HDMS. It mainly emanates from the work of Karl Popper (1902–1994), who famously argued that the feature that distinguishes a scientific theory from a non-scientific one is its ability to be falsified – i.e. the *falsification criterion* (Chalmers, 2009; Popper, 2014). According to deductive falsification, 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, in their study of 11 European regions, Cooke et al. (2000) found that only two regions (i.e. Baden-Wurttemberg 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). Since case study research examines a limited number of cases, one or a few instances of falsification are often insufficient to reject a widely accepted theory or hypothesis, unless the scientific community is willing to accept the results of falsified case studies as reliable and generalisable. As Harre (1972) put it, '[c]ontrary evidence must accumulate before a hypothesis is agreed to be false' (p.60).
3. **Deductive corroboration** is the third main variant of the HDMS. According to this variant, scientific progress occurs when research constructs and corroborates empirically theoretical statements, rather than by verifying their truthfulness (Harre, 1972; Popper, 2014). Since case study research mainly utilises qualitative data, it can only corroborate a theory in qualitative terms (Mattsson et al., 2005; Gilsing and Nooteboom, 2006). Mattsson et al. (2005), based on multiple case studies involving eight ISs in the tourism sector, highlighted that 'it is very difficult to ascertain hard facts' (p.378) through case study research. In addition, while case study research on ISs can be undertaken in quantitative terms (e.g. Vilanova and Leydesdorff, 2001; Jackson et al., 2016), its potential to test a theory in a generalisable manner hinges on investigating the most representative (average) cases (Yin, 2009, p. 41). However, since every IS has a unique social division of labour, and thus structure and properties (Nelson, 1993; Braczyk et al., 1998; Malerba, 2004; Cirillo et al., 2019), it follows that there is no such thing as the most representative (average) IS. This severely curtails case study research's ability to corroborate a theoretical proposition in a manner that is perfectly compatible with the corroborative variant of the HDMS.
4. **Inductive deduction** is the last, most recent and most popular variant of the HDMS in the social sciences. 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 (Harre, 1972; Chalmers, 2009; Popper, 2014). However, the inductive variant is the most case-study friendly of all variants of the HDMS; it posits that case study research on ISs is primarily an descriptive-exploratory 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 as follows:

> [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*) study. To a great extent, this methodological view is, currently, prevalent in the literature on national ISs. 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 national ISs research has proceeded 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; Chaminade et al., 2018; Proksch et al., 2019).

4.1.1. *Deductive thesis and the case study paradox*

The HDMS carries several crucial implications for our understanding of the case study paradox. By placing significant emphasis on recurrent empirical observations across the largest number of observable cases as the only genuinely legitimate inferential criterion, the HDMS forces us to comprehend and conduct case study research as a purely descriptive-exploratory type of analysis. Thus, accepting the HDMS as the primary model of scientific explanation inevitably gives birth to the *deductive thesis*, wherein formal theorising (e.g., hypothesis testing, mathematical modelling, and equations) and large-scale formal research will render the IS approach more 'scientific'. In contrast, case studies are highly unlikely to accomplish this.

However, there is a lot more to the deductive thesis. Surprisingly to the deductivist scholar, this thesis is fundamentally erroneous, flawed, and detrimental to the scientific progress of the IS approach. Consider, for instance, that for the deductive thesis to be held true, ISs must be replete with pure empirical regularities. In other words, sheer empirical regularities must be the defining feature of causality in ISs, at all scales and points of time.

However, as several decades of research on ISs have taught us (Edquist, 2005; Lundvall, 2007, 2013), constant empirical regularities, as presupposed by the deductive thesis, are an exception rather than the rule. In fact, innovation has the inherent ability to induce qualitative structural change in the economic system (Freeman and Louçã, 2001; Perez, 2010). Researchers have pointed to the creative (Schumpeterian) abilities of focal actors in ISs (Radosevic and Yoruk, 2013; Lawton Smith, 2018), the inherent structural diversity underpinning ISs (Nelson, 1993; Braczyk et al., 1998; Cirillo et al., 2019), and the context-specific dynamics of the agency–structure interplay in ISs (Hung and Whittington, 2011; Svensson and Nikoleris, 2018; Vetsikas and Stamboulis, 2023). Thus, the assumption that causality in ISs occurs, by necessity, in the form of undisturbed empirical regularities sounds like an occult fairytale.

Given that enduring empirical regularities within and across ISs are not, and cannot be, stable empirical instances (innovation, after all, is a creative-destructive process), it follows that deductivist research on ISs is also unable to study causality and generality; hence, as is the case with case study research, it cannot contribute to the scientificity of the IS approach. It is these inherent contradictions and fatally misleading

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

implications for the scientific potential and research practice of the IS approach that necessitate the negation of the deductive thesis. In the context of this paper, this negation is accomplished through the formulation of the *retroductive antithesis*.[11]

4.2. Retroductive antithesis: case study research on ISs can study infer causality and generality

4.2.1. Retroductive model of science

The retroductive model of science (RMS) constitutes the primary antagonist to the HDMS in both the natural and social sciences (Harre, 1972; Lawson, 1997; Bhaskar, 2008*b*; Pratten, 2009; Blaikie and Priest, 2019; Danermark et al., 2019; Ritz, 2020). It emanates from the work of notable philosophers (e.g. Aristotle and Charles Sanders Pierce), and the writings of the founders of several fields of science (e.g. Adam Smith, Karl Marx, Charles Darwin). Despite having a long intellectual lineage, the systematisation of the RMS into a coherent model of scientific explanation is a relatively recent development (Blaikie and Priest, 2019; Danermark et al., 2019); this is particularly associated with the emergence of *critical realism*[12] as one of the main philosophies of social science (Benton and Craib, 2010; Blaikie and Priest, 2019; Jagosh, 2020; Ritz, 2020).

As the name suggests, central to the RMS is the inferential logic of *retroduction*[13] (Downward and Mearman, 2007; Bhaskar, 2008*b*; Belfrage and Hauf, 2017). 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* that are capable of producing the phenomena under investigation (Lawson, 1997; Bhaskar, 2008*b*; Danermark et al., 2019). In contrast to deduction, which is a formal mode of inference in the sense that conclusions must always derive from the premises (i.e. testable hypotheses), retroduction is a creative 'thought operation' (Danermark et al., 2019, p.113). The analysis moves iteratively from the *known* (i.e. existing concepts, theories, empirical events, anomalies, discourses, experiences, hints, etc.) to the *unknown* or the *lesser known* (i.e. causal mechanisms) (Lawson, 1997; Danermark et al., 2019). Hence, retroductive research is ultimately a search for causal mechanisms. As Sayer (2000) puts it:

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

Fig. 3 presents a stylised summary of 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 archetypal approaches to research on ISs. 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, statements and models) at the end of the analysis (Step 3) (Chalmers, 2009; Blaikie and Priest, 2019). In retroductive research, the explanans take the form of *retroductive conceptual models*[14] of hypothesised causal mechanisms (Tsang, 2014; Danermark et al., 2019). 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 – i.e. what makes 'things' happen in the world (Bhaskar, 2008*b*; Mingers and Standing, 2017; Danermark et al., 2019).

To investigate causal mechanisms, retroductive research makes use of either/both *extensive research designs*, such as econometrics, regression analysis, structural equation modelling, etc., and *intensive research designs*, such as case study research, grounded theory ethnography, etc. (Sayer, 2000; Mingers, 2001, 2006; Downward and Mearman, 2007; Olsen, 2010; Papachristos and Adamides, 2016; Danermark et al., 2019). However, whereas both inductive and deductive research (although for different reasons) end up placing extensive research designs at the centre of causal explanatory research (Lawson, 1997; Blaikie and Priest, 2019; Danermark et al., 2019), in retroductive research, *it is through intensive research* (e.g. *case studies, ethnography,* etc.*) that the IS*

[11] Indeed, as an anonymous reviewer has pointed out, the deductive thesis can be negated without resorting to dialectics. For instance, one can argue that the thesis in question stems from the (neo-) positivist philosophy of science (Benton and Craib, 2010); while from the standpoint of an alternative philosophical perspective (e.g. interpretivism, critical theory, critical realism, pragmatism, postmodernism), the deductive thesis is flawed and mistaken. Although philosophical perspectives provide guidelines and implications regarding what constitutes appropriate scientific practice, they fall short in relation to offering a systematic method capable of resolving paradoxes. In contrast, dialectics offers such a method (Hargrave and Van de Ven, 2017). Surprisingly, critics of dialectics such as Sir Karl Popper praised dialectics for its ability to 'study […] the methods of science' (Popper, 1940, p. 426).

[12] 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 (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 of 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 are not empirical regularities (cf. the 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 introduction to critical realism that is also relevant to the field of innovation studies, see Castellacci (2006), Svensson and Nikoleris (2018), Sorrell (2018), and Vega and Chiasson (2019).

[13] Although some scholars treat retroduction and abduction as two nearly identical inferential processes (Lawson, 1997), in more recent contributions, the two are regarded as two distinct modes of inference (Blaikie and Priest, 2019; Danermark et al., 2019). Abduction, which can be understood as either a formal process or a thought operation, re-describes and recontextualises a phenomenon by moving 'from a conception of something to a different, possibly more developed or deeper conception of it' (Danermark et al., 2019, p.91). In a similar yet different manner, retroduction conceptualises and identifies structural conditions and causal mechanisms capable of producing the phenomena under investigation (Lawson, 1997; Danermark et al., 2019; Ritz, 2020).

[14] Unlike the deductive scholar, who utilises the current stock of knowledge in a formal way (i.e. to deduce a set of testable hypotheses, the explanans), and the inductive scholar, who develops the explanans at the end of the analysis in the form of inductively generated concepts, theories and models (Glaser and Strauss, 1967/2017; Eisenhardt, 1989; Eisenhardt and Graebner, 2007), the retroductive scholar utilises the current stock of knowledge in a creative (rather than in a formal) way, to develop a provisional (fallible) conceptual model about the necessary (structural) preconditions that must exist, at least in theory, for causal mechanisms to be held accountable for the explanandum. To develop such conceptual models, the retroductive scholar deals with certain realist questions (Sayer, 2000; Bhaskar, 2008b; Danermark et al., 2019) such as: 'What does the existence of this phenomenon/practice/event presuppose?'; 'What are its preconditions?'; 'Can/could phenomenon A exist without structure B, C or D?'; and 'What is it about a structured object (e.g. an IS in liberal market economies) that enables it to do certain things (e.g. facilitate radical innovation)?' By conceptually addressing realist questions, retroductive research is constantly engaged in a process of reconceptualisation, where existing and new concepts and theories are re-developed before, during, and after the data collection stage (Sayer, 2010; Wynn and Williams, 2012; Danermark et al., 2019). However, whereas the deductive scholar sees ongoing reconceptualisation as a sign of scientific immaturity, reconceptualisation is a highly desirable scientific quality in retroductive research that deals with constantly changing open social systems such as ISs (Sayer, 2000; Danermark et al., 2019).

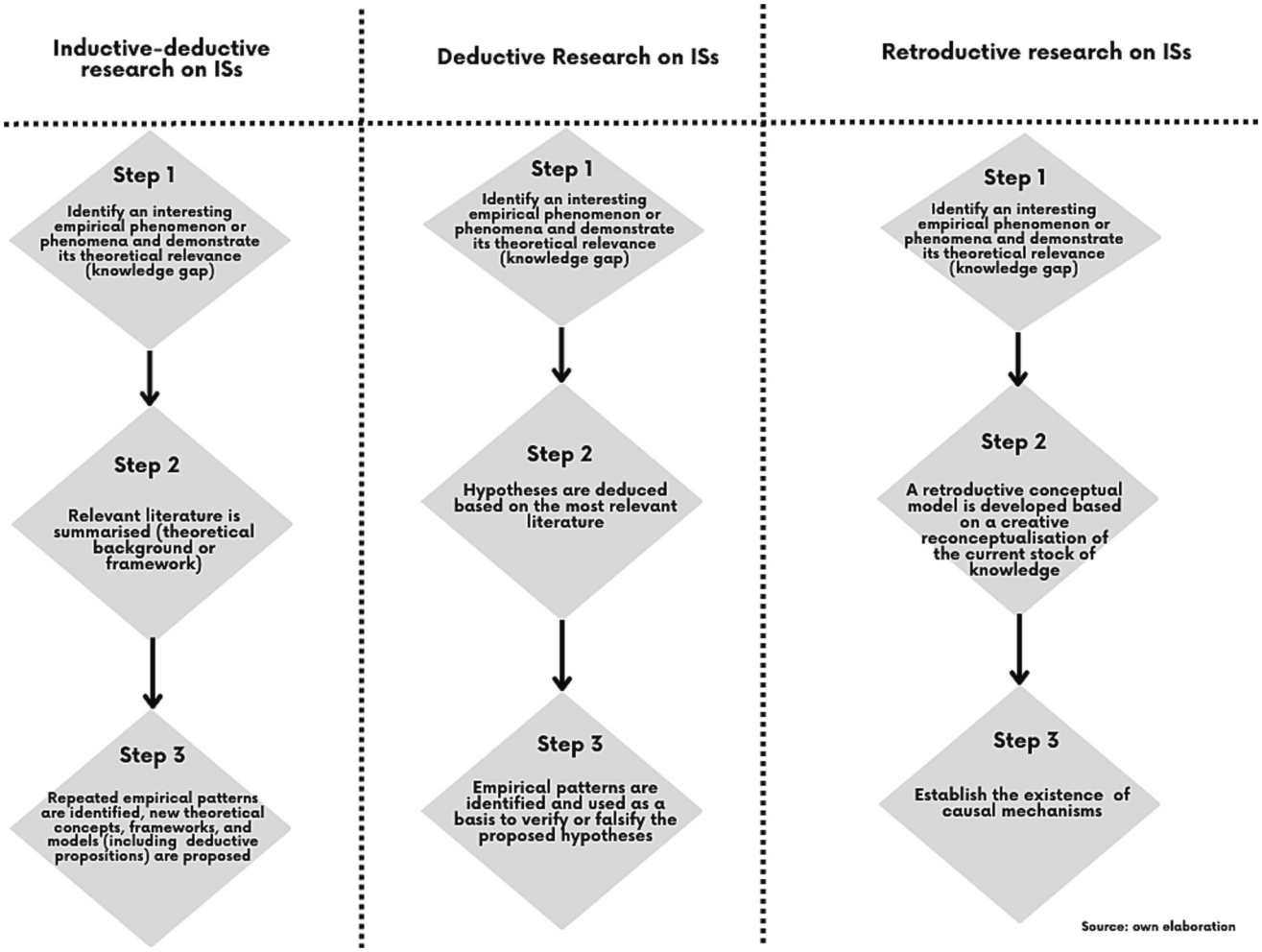

Fig. 3. Key Steps in Inductive-Deductive, Deductive and Retroductive Research on ISs.

scholar is able to produce causal explanatory and externally valid knowledge about ISs[15] (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 research, but not in deductive or inductive research on ISs, it requires a closer look into the notions of *causal mechanisms* and *transfactual generalisation*.

4.2.2. Causal mechanisms

Retroductive research is often grounded in the critical realist conception of causal mechanisms[16] (Fleetwood, 2001; 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): the inherent abilities of a structured entity (i.e. its *causal powers*), which enable it to do certain things but 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).[17] In critical realist terms, causal mechanisms can be understood in the following way (Fragkandreas, 2021, p.8):

Causal Power (CP) → Relevant Conditions (RCs) → Empirical Phenomena (EP)

Based on the above 'critical realist formula', it is futile to expect 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 prone to structural transformation (Storz, 2008; Isaksen et al., 2022), while being liable to path-

[15] This is not to say that the retroductive scholar does not make use of advanced statistical methods (Downward and Mearman, 2007; Olsen, 2010). Rather, from the standpoint of the RMS, it is through well-crafted case studies that the retroductive scholar expects to learn the most about the causal mechanisms through which ISs produce the empirical phenomena under investigation.

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

[17] It is interesting to note that while Chris Freeman (1921–2010) has, to the best of my knowledge, never referred to his work as being retroductive, his seminal study on Japan's IS (Freeman, 1987) resembles, to a considerable extent, the retroductive model of science.

dependence and structural inertia (Narula, 2002; Niosi, 2002; Dodgson et al., 2008; Bergek et al., 2008; Fagerberg et al., 2009). Accordingly, empirical regularities in ISs are, at best, *demi-regularities* (Lawson, 1997) – in other words, spatiotemporally confined, 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 (cf. the deductive thesis), are pervasive in ISs (Carlsson et al., 2002; Stamboulis, 2007; Lundvall, 2007).

However, whereas in deductive research, demi-regularities are seen as a strong indication of weak and absent causality, and are thus scientifically irrelevant (Hempel and Oppenheim, 1948; Popper, 1940), in retroductive research, demi-regularities constitute an opportunity to identify the causal mechanisms that produce them (Lawson, 1997; Downward and Mearman, 2007; Jackson et al., 2016; Sorrell, 2018). For instance, in their retroductive study, Jackson et al. (2016) analysed statistical data and reports (e.g. Cornell University and OECD) to verify the demi-regularity that the Australian IS was failing to transform relatively high innovation inputs into equivalent outputs. These authors identified six causal mechanisms responsible for Australia's poor innovation performance: (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, retroductive research on ISs is not concerned with how strong or weak empirical regularities are. Instead, it involves identifying which causal capacities of ISs are active, and whether they have been implicated in producing the observed empirical phenomena under investigation.

4.2.3. *Transfactual generalisation*

According to the RMS, externally valid knowledge about ISs lies not in the empirical aspects of such system-like entities (*empirical generalisation*), but in their less empirical aspects (Bhaskar, 2008*b*; Koutsouris, 2012; Vega and Chiasson, 2019). 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* (Danermark et al., 2019; Tsang, 2014). It maintains that the causal capacities of ISs exist and act *transfactually* – i.e. independently of our cognition, identification and measurement, and regardless of what empirical events ensue (Tsoukas, 1989; Morais, 2011; Tsang, 2014; Danermark et al., 2019). Thus, identifying constant sequences among empirical phenomena and events (empirical generalisation) is *not* the same as having externally valid knowledge of causality in ISs (see Fig. 4). Otherwise, and if one maintains that empirical generalisation is necessary to make externally valid knowledge claims (cf. the deductive thesis), one commits the *epistemic fallacy* (Bhaskar, 2008*b*, p.26) – in other words, reducing our knowledge of ISs' causal capabilities to what can be counted or associated with recurrent empirical patterns and events.

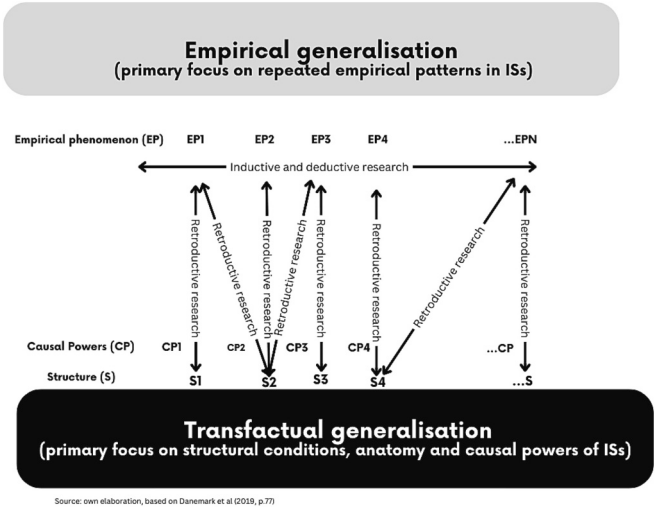

Fig. 4. Approaches to Generalisation in ISs Research.

From the standpoint of the RMS, making externally valid knowledge claims involves understanding the contingent ways in which the causal powers of ISs are intertwined with relevant conditions (Tsoukas, 1989; Wynn and Williams, 2012). In retroductive research, externally valid knowledge 'come[s] from identifying the deep processes [i.e. causal powers] at work under contingent conditions via particular mechanisms' (Easton, 2010, p.126). Thus, transfactual generalisation is achieved when retroductive research is simultaneously 'up in the clouds' (Tsoukas, 1989, p.558) and 'down to earth' (ibid.). To paraphrase Keynes, transfactual generalisation 'contemplates the particular, in terms of the general, and touches [the] abstract and concrete in the same flight of thought' (cited in Skidelsky, 2010, p.10).

Having discussed the notions of causal mechanisms and transfactual generalisation, it is now pertinent to consider why case study research is ideal, if not indispensable, for undertaking retroductive research on ISs.

4.2.4. *Retroductive case study research on ISs*

Due to their methodologically eclectic, open-ended and flexible nature (Eisenhardt, 1989; Yin, 2009), case studies allow an in-depth, contextually rich explanation of the existence, composition and efficacy of the causal mechanisms in ISs (Tsoukas, 1989; Easton, 2010; Fragkandreas, 2021). This enables the research process to distinguish which causal powers of ISs relate to relevant conditions, as well as whether there is a disconnect between them (Tsoukas, 1989; Easton, 2010) – which should not be surprising, given the uncertain and creative-destructive nature of innovation (Freeman and Louçã, 2001; Perez, 2010). By being analytically flexible, case studies are capable of detecting and theorising the causal powers of ISs and ascertaining which power(s) is (are) involved in the production of the empirical phenomena under investigation (Tsoukas, 1989; Wynn and Williams, 2012; Fragkandreas, 2021).

Furthermore – and unlike a formal analysis, which, in principle, must utilise a small number of variables (De Vaus, 2014; Pearl and Mackenzie, 2018) – case study research on ISs 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, the number of cases under investigation and the generalisability of findings are two completely different issues (Tsoukas, 1989; Easton, 2010). Due to being an in-depth, data-rich approach to research (Yin, 2009; Eisenhardt, 1989), case study research eliminates the possibility of (mis-)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; Easton, 2010). Thus, given the causal complexities that pervade ISs as highly heterogenous open social systems, an in-depth small-*N* study on ISs is, from the RMS standpoint, often more explanatory and powerful than a large-*N* formal study.

Fragkandreas (2021), for instance, conducted a retroductive case study on a regional IS in Germany. Prompted by formal studies showing that innovative regions tend to exhibit higher on average rates of income inequality (e.g. Lee, 2011; Breau et al., 2014), as well as by the lack of IS research on inequality (Martin, 2016), Fragkandreas' (2021) case study analysis demonstrates how the organisational strategies of focal actors (e.g. innovative firms, universities, research institutes, policy organisations) combine with the structural components, causal powers and liabilities of the IS under investigation to form *seven causal mechanisms*. These comprise *five inequality-inducing causal mechanisms* (i.e. core–periphery competence concentration, dependent income extraction, skill premiums, flexible precarious employment, and absent old-age

technological unemployment) and *two inequality-reducing causal mechanisms* (i.e. gender-inclusive competence building and employment). The findings of this study extend our knowledge of the causal capacities of ISs beyond the case study context. They are transfactually generalisable, as they imply that ISs exacerbate inequality when focal actors, intentionally or unintentionally, adopt inequality-friendly organisational strategies to address key (Schumpeterian) challenges in the innovation process.

Fig. 5 breaks down the key steps and procedures in retroductive case study research. In contrast to the inductive approach, retroductive case studies are significantly more intricate, messy, challenging, iterative and demanding. In retrdouctive case studies, the research process unfolds from Step 1 to Step 3, with Step 2 acting as a bridge. In these steps, the retroductive researcher aims to identify and theorise the causal mechanisms (Step 3) responsible for generating the empirical phenomena under examination (Step 1). This process relies on *iterative abstraction* rather than on *iterative analysis* – the latter is typically employed in inductive and deductive research on ISs. Iterative abstraction encompasses an ongoing, open-ended and creative analytical interplay between a retroductive conceptual model (Step 2) and causal mechanisms (Step 3) (Yeung, 1997; Danermark et al., 2019). Thus, as shown in Fig. 5, retroductive case research is an open-ended, highly complex, yet painstaking type of causal explanatory analysis.

4.2.5. Retroductive antithesis and the case study paradox

Having established the significance of case study research for studying causality and generality in retroductive research on ISs, it is pertinent to ask the following question: What does the retroductive antithesis tell us about the case study paradox? The short answer is that the case study paradox appears to be the sole methodological corollary of the deductive thesis. Schematically, the argument runs as follows:

Deductive thesis → Case study paradox

Retroductive thesis → No paradox

While the articulation of the retroductive antithesis makes it clear that the root cause of the case study paradox is the deductive thesis, a consistent resolution to the paradox, however, requires going a step further in the dialectical process, in order to transform the dialectical tension between the deductive thesis and retroductive antithesis into a new synthesis – namely, a new methodological fixity. From a dialectical standpoint, this is necessary, as the primary (if not existential) purpose of the retroductive antithesis is to dialectically oppose the deductive thesis rather than resolve the case study paradox. Consider, for instance, that the dialectical tension between the two theses does not logically compel the deductive scholar to abandon the deductive thesis in favour of the retroductive antithesis. The deductive scholar can at any time reject the retroductive antithesis on the ground that it is incompatible with the HDMS.

This leaves the retroductive scholar with two major options: (a) surrender to the deductive thesis due to peer pressure; or (b) embark upon a heated methodological controversy – a sort of *Methodenstreit* – such as that 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 linked to deductivism) (Fagerberg, 2003; Shionoya, 2004). However, even if (b) is the preferred option, it seems highly unlikely that in the near future the retroductive antithesis can build the momentum necessary to significantly challenge and overcome the dominance of the deductive thesis.

Several developments attest to this possibility. On the one hand, there exists the formal turn in the field of IS studies (see, for instance, Section 2 in this paper). This, among other issues, implies that the peer review process (especially in high-ranked journals) has already been moulded in deductivist (if not positivist) terms. On the other hand, the increasing digital availability of large chunks of numerical data has given the false impression that incorporating such 'big data' in our research will help us uncover the 'grant truths' about the complex aspects of causality in ISs[18] (Yin et al., 2019; Sena et al., 2021; Rikap, 2022). Coupled with the pressing need (especially among young scholars) to publish as many papers as possible in high-ranked journals, this puts a significant methodological premium on deductivist (if not positivist) research, rather than on methodologically challenging and time-intensive retroductive case studies. In such a deductivist-dominated environment, it is somewhat naïve to expect that a *Methodenstreit* between the deductive and the retroductive scholar will allow the latter to build the power needed to arrive at the dialectical resolution of the case study paradox.

However, from the standpoint of dialectics (especially Bhaskar's approach to dialectics: see Section 3 in this paper), it is not only power struggles and the politics of publication that prevent the retroductive scholar from resolving the case study paradox, but also *the absence of a synthesis capable of 'dialectically compelling' the deductive scholar to acknowledge the retroductive antithesis*. It is such a synthesis that can, in practice, logically and potentially settle the case study paradox.

4.3. Detroductive synthesis: case study research is (in)capable of studying causality and generality

4.3.1. Detroductive synthesis

According to Hegel (2010), the conflict between thesis (affirmation) and antithesis (negation) has the inherent, albeit unintended, power of bringing about a synthesis (transformation). The synthesis signifies the reconciliation of the contradiction between the (deductive) thesis and (retroductive) antithesis; it represents a moment of creative rationality where 'the unity of opposites' becomes apparent and understandable. In this paper, the unity of the two opposing theses becomes intelligible through the *detroductive synthesis*, wherein case study research on ISs is both incapable (deductive thesis) and capable (retroductive antithesis) of inferring causality and generality (see Fig. 6).

At first glance, the detroductive synthesis appears to have arrived at a methodological impasse: both the deductive thesis and the retroductive antithesis appear to be simultaneously true and false; hence, there can be no resolution to the case study paradox. Surprisingly, it is this apparent methodological dead-end that allows us to resolve the case study paradox.

This resolution stems from 'dialectical necessity' – particularly the fact that while the deductive scholar can dismiss the retroductive antithesis, she cannot reject the detroductive synthesis. The underlying reason is that detroductive synthesis unveils the interplay between models of science and the scientificity of case study research; in particular, a case study's ability to study causality and generality is intrinsically linked with the model of science that informs the analysis. Since the deductive thesis finds its intellectual mantle in the HDMS, the deductive scholar must also admit the soundness of the retroductive antithesis, particularly the interplay between the RMS and case study research; otherwise, she is left with no sound methodological foundation for her deductive thesis. It is this logical necessity within dialectics that compels the deductive scholar to inevitably embrace the retroductive antithesis in order to defend her thesis. In this regard, the detroductive synthesis transforms the deductive scholar from the root cause to the resolving agent of the case study paradox.

4.3.2. Methodological implications

A significant methodological implication that stems from the detroductive synthesis is that the explanatory capacities of case study research are either facilitated or curtailed by the model of scientific

[18] I would like to attribute this observation to Douglas Porpora (personal communication).

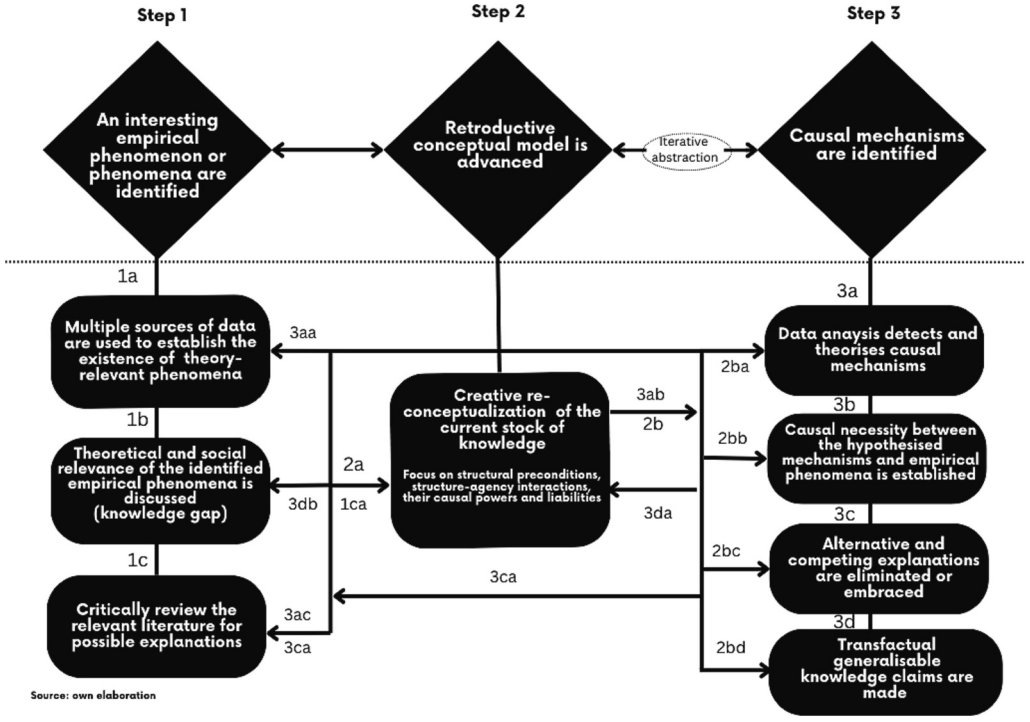

Fig. 5. Key Steps in Retroductive Research on ISs.

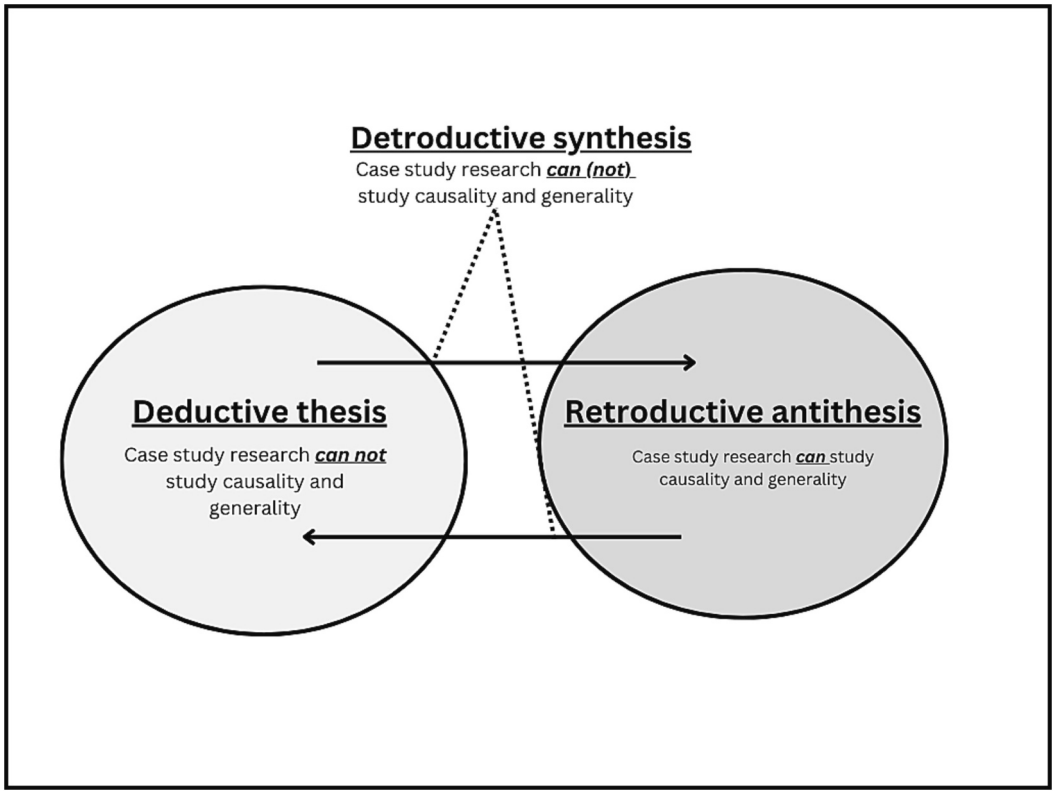

Fig. 6. Dialectic of the Case Study Paradox.

explanation that informs the analysis. However, such a methodological revelation has thus far eluded the attention of both innovation scholars and, surprisingly, notable case study experts.[19] Building on the work of Yin (2009) and other renowned case study experts (Eisenhardt, 1989; Flyvbjerg, 2006; Eisenhardt and Graebner, 2007; Gehman et al., 2018), the remainder of this section outlines how the central methodological implication of the detroductive synthesis offers a fresh perspective on six key practical aspects of case study research on ISs.

4.3.2.1. Research purpose. According to the HDMS, case study research is, in principle, a descriptive exploratory research design suitable for the initial stages of scientific inquiry, rather than the later and more mature stages of research – which, according to the model in question, deal with what is causal and general in ISs (Hempel and Oppenheim, 1948; Eisenhardt, 1989; Flyvbjerg, 2006). In contrast, the RMS regards case study research on ISs as, by default, a causal-explanatory type of analysis (Tsoukas, 1989; Easton, 2010). This method is 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).

> *Categorising case study research as merely exploratory, descriptive, a type of analysis is misleading because it fails to acknowledge that it is the model of science which, in principle, moulds the research purpose (exploratory or explanatory) and empirical content (qualitative and/or quantitative) of case study research.*

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

> *The question of whether case study research should 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 the analysis.*

4.3.2.3. 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 HDMS, which, in principle, regards the average case as the most appropriate sampling strategy, the RMS 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).

> *The question of which sampling strategy is ideal for conducting explanatory case research is intrinsically linked to the model of science that informs the analysis.*

4.3.2.4. Triangulation. One of the distinguishing strengths of case study research lies in its ability to utilise multiple theoretical perspectives and sources of evidence – namely, triangulation (Eisenhardt, 1989; Eisenhardt and Graebner, 2007; Yin, 2009). Although the HDMS does not oppose nor preclude the use of multiple perspectives and data sources in IS research (see, for instance, Tsouri et al., 2021), triangulation does not improve the external validity of the research findings. In contrast, the RMS 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 theoretical 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 RMS concurs that '[m]ost interesting [causal explanatory] studies on [...] innovation systems combine quantitative and qualitative methods' (Chaminade et al., 2018, p.43).

> *The extent to which triangulation is essential in inferring causality in ISs research depends upon the model of science that informs the analysis.*

4.3.2.5. Quality criteria. The HDMS 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 RMS standpoint, 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 ISs' causal abilities 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 – whereas they are of utmost significance in retroductive research (Tsoukas, 1989; Sayer, 2000; Danermark et al., 2019). Relatedly, while the HDMS 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 RMS 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).

> *The question of what criteria are the most appropriate to assess the quality of explanatory research cannot be addressed without considering the model of science that informs the analysis.*

4.3.2.6. 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 HDMS, it is difficult, if not impossible, to draw reliable general knowledge on ISs from small-*N* research, especially

[19] For instance, like Yin (2009), Flyvbjerg (2001) states that generalisation in case study research 'depends upon […] how it [the case] is chosen' (p.74) – with no mention of the model of science!

single-case research. In contrast, the RMS regards the findings of single case studies as being as reliable as those of multiple case studies, including those produced by large-scale quantitative studies (Tsoukas, 1989; Easton, 2010). The RMS is grounded on an ontological perspective on generalisation, known as *transfactual generalisation* (Morais, 2011; Tsang, 2014; Danermark et al., 2019), which posits that generalisable knowledge lies not in repeated empirical patterns, but in the deeper (non-empirical) aspects (i.e. causal powers) of ISs.

> *The question of whether the findings of case study research are extrapolatable beyond the case study context is, in principle, not a matter of sample size but subject to the model of science that informs the analysis.*

Table 3 summarises the methodological implications of a dialectical analysis of the case study paradox. It is shown that the deductive and retroductive theses have fundamentally different implications for what constitutes proper case study practice. Such striking differences attain their logical coherence from a particular set of metatheoretical (epistemological and ontological) assumptions. For instance, when one subscribes to the deductive thesis, one not only endorses the HDMS as the most appropriate model of causal explanation but also 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 (e.g. high R&D intensity) is present, Event B (e.g. high patenting activity) follows or tends to do so in all or most ISs. As a result, the deductive scholar endorses a *shallow empiricist* ontological perspective (Blaikie and Priest, 2019, pp.89–118), wherein the most scientifically relevant aspects of ISs are empirical events and observations. In contrast, when one argues for the retroductive thesis, one not only embraces the RMS, but also accepts the *generative theory of causality*, wherein causality in ISs resides in 'powerful particulars' (Harre, 1972; Bhaskar, 2008*b*) – specifically, in the causal powers of ISs (Koutsouris, 2012; Vega and Chiasson, 2019). Correspondingly, the retroductive scholar adopts an *ontologically deep* 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 (Papachristos and Adamides, 2016; Svensson and Nikoleris, 2018; Vega and Chiasson, 2019).

> *Central to our views on the scientific capacities of case study research lies a dense web of metatheoretical assumptions, such as a particular model of science, its underlying theory of causality (epistemology), and its corresponding worldview (ontology).*

In summary, the detroductive synthesis offers a dialectical resolution to the case study paradox, but it also allows us to comprehend and undertake causal explanatory research on ISs by means of case study research in ways that, based on the extant literature on ISs, were previously unimaginable and somewhat methodologically prohibited.

5. Conclusion, implications and limitations

5.1. Concluding summary

The present paper has attempted one of the first dialectical analyses of case study research on ISs. It has focused on and addressed, by means of dialectics, the paradoxical status of case study research in IS studies. The analysis revealed that the case study paradox stems from the *deductive thesis*, according to which case study research on ISs is, in principle, not a causal-explanatory form of scientific research. However,

Table 3
Dialectical Analysis: Key Methodological Implications

Implications	Type of implication	Deductive thesis implications				Retroductive antithesis implications	Detroductive synthesis implications
		Verificationism	Falsificationism	Corroborationism	Inductivism		
Causality	Epistemological	Empirical regularities	Empirical regularities	Empirical regularities	Empirical regularities	Causal powers and mechanisms	Subject to the model of science
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 science
Logic of inference	Methodological	Deduction (formal)	Deduction (formal)	Deduction (formal)	Inductive-deduction (formal)	Retroduction (creative)	Subject to the model of science
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 science
Sampling strategy	Methodological	Average case(s)	Critical case(s)	Average case(s)	Multiple cases	Critical, extreme and contrasting cases	Subject to the model of science
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 science
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 science
Research goal	Methodological	Illustration	Illustration	Illustration	Exploration	Thick explanation	Subject to the model of science
Theoretical purpose	Methodological	Rich description	Theory-testing	Theory-corroboration	Theory-building	Concurrent theory-building and testing	Subject to the model of science
Type of triangulation	Methodological	Data triangulation	Data triangulation	Data triangulation	Data triangulation	Data and theoretical triangulation	Subject to the model of science
Worldview	Ontological	Empiricist	Empiricist	Empiricist	Empiricist	Realist	Subject to the model of science

Source: own elaboration.

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, and for acquiring transfactually general knowledge about the causal abilities of IS. Nevertheless, from a dialectical standpoint, it is not the retroductive antithesis but the transformation of the tension between the deductive thesis and the retroductive antithesis (a process termed in this paper as the *detroductive synthesis*) that offers a consistent resolution to the case study paradox. Overall, the dialectical perspective followed in this paper has yielded several new methodological insights into the field of IS studies – particularly regarding case study research, which, despite being one of the most deployed research designs in the study of ISs, has been severely misunderstood and underutilised for causal explanatory purposes.

5.2. Thought-provoking implications

Although several implications concerning case study research were discussed throughout the paper (see, for instance, Section 4.3.2), an important point that requires particular mention is the following: *Our methodological views and assessments regarding case study research, and any type of research in general, are neither objective nor universal – instead, they are rather subject to a particular conception of science*. In fact, this is what makes our research, including methodological judgements, more or less coherent. This insight has far-reaching implications for how the scientificity of innovation research ought to be judged through the peer review process. Editors, reviewers and researchers need to be significantly more transparent and reflexive regarding the underlying conception of science that informs their views. Put differently, one must certainly lay one's methodological cards on the table before assessing the scientific merit of innovation research. This seems necessary in order to, on the one hand, ensure the transparency of the review process and, on the other, help innovation studies realise their true scientific potential.

The above implication extends to the realm of policy evaluation, where the deductivist conception of science is increasingly being regarded as the methodological standard for judging the effectiveness of innovation policies (e.g. Crespi et al., 2016; Knoll et al., 2021; Gangopadhyay and Homroy, 2023; Koh and Lee, 2023). What is at stake here is that contemporary policy evaluation studies seem to be entirely unaware of the following contradiction: 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 the creative-destructive properties of innovation, and hence constantly disturbs rather than maintains existing empirical patterns).

5.3. Limitations and suggestions

As is the case with every type of research, this methodological paper has some limitations. Despite advancing a specific configuration of (deductive) thesis, (retroductive) antithesis, and (detroductive) synthesis as a means of addressing the case study paradox, the present paper does not, and cannot, claim that it has arrived at 'the dialectical resolution' of this paradox. Rather, it has only attempted to provide 'a dialectical resolution' to the paradox in question. Future contributions may either seek to critique the dialectical formation in this paper or explore different dialectical formations in order to uncover fresh methodological insights about IS research. As shown in this paper, dialectics constitutes a promising underlabourer to resolving chronic methodological ironies and inconsistencies in our research.

Before the paper is brought to an end, it is necessary to draw a historical lesson regarding the methodological history of IS studies. Like Joseph Schumpeter, the early protagonists of the field (e.g. Chis Freeman, Dick Nelson, Bengt-Ake Lundvall, Carlota Perez, Nathan Rosenberg) did not succumb to the sirens of deductivism, despite conducting research at the height of this movement – including its philosophical master, namely positivism, in the social sciences. Their groundbreaking work has, among other issues, taught us that it is the nature of innovation (its ontology) that dictates the choice of methods (methodology), rather than vice versa. Hopefully, the present paper will inspire innovation researchers, especially young ones, to embrace and preserve the original methodological spirit that made IS studies one of the most exciting, interdisciplinary, yet policy- and socially relevant fields of social science.

CRediT authorship contribution statement

Thanos Fragkandreas: Writing – review & editing, Writing – original draft, Methodology, Investigation, Data curation, Conceptualization.

Declaration of competing interest

No conflict of interest reported in this paper.

Data availability

No data was used for the research described in the article.

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