DOI: 10.15201/hungeobull.74.3.4 Hungarian Geographical Bulletin 74 (2025) (3) 285–299.

Context as ontology and epistemic infrastructure: Rethinking explanation in economic geography

József BENEDEK[1,2] and Andreea ȚOIU[1]

Abstract

This paper clarifies how mechanism-based explanation can work in economic geography when digital spatial methods are routine. We outline a critical realist orientation that treats socio-spatial context in two linked ways: as an ontological condition that enables or constrains causal powers, and as an epistemic infrastructure that organises the categories through which mechanisms become visible. On this basis, explanation involves specifying mechanisms, scope conditions, and likely empirical traces, while attending to how data systems shape what can be observed. We illustrate the approach with two short cases from Romania. First, spatial models of COVID-19 vaccine uptake identify clustering and diffusion, but explanation arises only when these patterns are situated within a layered health regime shaped by socialist legacies, market reforms, and transnational guidance. Second, typologies of peri-urban change derived from demographic and satellite data are read as traces of spatial figurations generated by property restitution, fragmented planning, and capital flows. In both cases, the same variables can sustain divergent ontological commitments: mechanisms treated as regularities, or mechanisms identified as generative structures with stated conditions of activation. The paper's contribution is practical. It offers a clear statement of the framework, two heuristic illustrations that connect patterns to mechanisms, and a set of design suggestions: state mechanisms and scope before methods; use digital tools to locate and evaluate traces rather than to stand in for mechanisms; combine quantitative outputs with institutional and historical evidence; and document the fit of travelling categories to regional ontologies. We do not claim to settle the debate. Our aim is to show how explanation can proceed in a way that is transparent about assumptions and proportional in its claims. Viewed this way, the paper provides a tractable starting point for cumulative, comparative, theory-building research in and beyond Central and Eastern Europe.

Keywords: mechanism-based explanation, critical realism, geography of knowledge, digital spatial technologies, Central and Eastern Europe

Received June 2025, accepted September 2025.

Introduction

Explanation has long been a central concern in economic geography. Since the critiques of the quantitative revolution, scholars have questioned whether correlations between variables can provide sufficient grounds for causal understanding (Harvey, D. 1969; Sayer, A. 1984). The debate has re-emerged in recent years as big data, spatial econometrics, and machine learning have been mobilised to identify patterns of clustering, diffusion, or association (Kitchin, R. 2014; Shelton, T. *et al*. 2015; Arribas-Bel, D. and Reades, J. 2018). These tools provide new descriptive and predictive capacities, but they also risk reducing explanation to statistically robust regularities. It is now widely recognised across the social sciences that statistical correlation does not by itself provide causal explanation. The challenge, as emphasised by Hedström, P. and Swedberg, R. (1998) and Elster, J. (2015), lies

[1] Faculty of Geography, Babeș-Bolyai University. 5–7 Clinicilor Street, 400006 Cluj-Napoca, Romania. E-mails: jozsef.benedek@ubbcluj.ro; andreea.toiu@ubbcluj.ro
[2] Budapest Metropolitan University. Nagy Lajos király útja 1–9. 1148 Budapest, Hungary.

in identifying the mechanisms that generate the observed associations.

Critical realism has been one of the most sustained philosophical resources for rethinking explanation in geography, emphasising that mechanisms are real causal powers which operate contingently under enabling and constraining conditions (Bhaskar, R. 1979; Sayer, R.A. 1992). From Bhaskar's foundational claims about a stratified ontology (1975, 1979) to Sayer's influential work in geography (1992, 2010), critical realism has emphasised that mechanisms are real causal powers which operate contingently, depending on enabling and constraining conditions. Early interventions introduced this orientation into economic geography (Johnston, R. 1992; Pratt, A.C. 1995; Yeung, H.W. 1997), insisting that explanatory depth could not be achieved by correlation alone. More recent contributions, such as Yeung, H.W. (2019, 2023), have reformulated this agenda as an explanatory realism, where mid-range theorising specifies mechanisms, scope conditions, and empirical traces while accommodating epistemic pluralism.

A central implication of this approach is that ontological commitments shape epistemological categories and methodological practices. Structures at the level of the real generate practical ontologies, which in turn condition how actors and scientists perceive problems and mobilise categories of investigation (Bhaskar, R. 1979; Yeung, H.W. 2023). The geography of knowledge tradition has long emphasised that categories of analysis travel across regions, often obscuring local generative structures (Livingstone, D.N. 2013; Meusburger, P. *et al.* 2018). For example, Anglo-American concepts of governance, neoliberalisation, or urban resilience have often been imported into Central and Eastern Europe (CEE), where they flatten a stratified regional ontology into empirical anomalies or derivative cases (Stenning, A. 2005; Müller, M. 2019; Nagy, E. 2025). This recursive relation between ontology, epistemology, and methodology is essential for producing adequate explanations.

At the same time, debates about digital spatial technologies have further complicated the relationship between theory, ontology, and method. Kitchin, R. (2014, 2022) challenged claims about the "end of theory" in big data, showing that data are always theory-laden and embedded in socio-technical infrastructures. Thatcher, J. *et al.* (2016) conceptualised "data colonialism," highlighting how digital infrastructures extract, commodify, and centralise data in ways that reproduce long-standing inequalities. More recent work has shown how artificial intelligence, machine learning, and remote sensing embed epistemic assumptions that shape what is visible, measurable, and explainable in space (Dalton, C.M. and Thatcher, J. 2015; Lynch, M. 2022). These critiques converge with critical realist concerns: data infrastructures are not neutral but condition explanatory claims by embedding power relations and epistemic categories.

This article contributes to the latest academic discourse on the role of theory in geographical explanation launched by the recently published contribution of Henry Yeung. More exactly the paper addresses a key issue of Yeung's conception on theory building, namely the role of context. Our arguments are novel and original in the sense that we address the question of context from a twofold perspective: one is offered by the latest technological advancements in data processing (geospatial technologies) and the second is represented by the specific central-eastern European perspective. The paper argues that socio-spatial context should be conceptualised in economic geography not only as an ontological condition for mechanism activation but also as an epistemic infrastructure. Ontologically, mechanisms operate only in stratified contexts shaped by institutional legacies, multi-scalar governance, and material infrastructures. Epistemically, the categories used to identify mechanisms are themselves conditioned by regional ontologies and by the circulation of epistemologies across academic communities. Without attending to both dimensions, mechanism-based explanation risks falling

into two extremes: abstract universalism, which assumes mechanisms travel everywhere without modification, or local exceptionalism, which isolates cases without theorising their generative mechanisms.

The argument develops in dialogue with Yeung, H.W. (2023) call for explanatory realism but extends it in two ways. First, we emphasise that practical ontologies emerging from social structures can transform the epistemic categories of actors, including scientists. This recursive relation between ontology and epistemology changes both categories of perception and categories of investigation. Second, we draw on the geography of knowledge tradition to argue that the circulation of concepts across regions can obscure or reveal local generative structures, thereby producing emergent epistemic effects (Livingstone, D.N. and Withers, C.W.J. 2011; Meusburger, P. *et al.* 2018; Paasi, A. 2025). In this sense, context is both ontological and epistemic: it shapes the activation of mechanisms and the categories through which mechanisms are rendered intelligible.

The implications of this perspective can be demonstrated through Central and Eastern Europe, a region that has repeatedly been cast as derivative or exceptional in economic geography. Post-socialist transformations have produced structured variation in institutional capacity, governance models, and socio-spatial outcomes. Countries across the region liberalised markets, decentralised governance, and integrated into European and global economies, yet outcomes diverged markedly in areas such as foreign investment, innovation, and urban development (Pickles, J. 2010; Smith, A. and Timár, J. 2010). More recent work has argued that these divergences reflect not anomalies but the operation of hybrid and layered mechanisms that combine socialist legacies, neoliberal reforms, and global institutional pressures (Pucherová, D. and Gáfrik, R. 2015; Müller, M. 2019; McElroy, E. and Chelcea, L. 2025). Treating CEE as an ontologically stratified region therefore reveals how socio-spatial context generates mechanisms of wider theoretical significance.

This perspective also carries implications for how digital spatial technologies are incorporated into research design. While GIS (Geographic information system), remote sensing, and spatial econometrics can enrich explanation by identifying clusters, spillovers, or diffusion effects, their contribution depends on whether they are embedded in theory-led approaches. Without theoretical framing, they risk collapsing into correlationism, treating observed regularities as mechanisms in themselves. With theoretical framing, they can provide empirical traces that help identify generative structures. As Wyly, E. (2011) and Dodgson, M. *et al.* (2014) argue, quantitative methods can be repurposed for realist ends if they are aligned with ontological commitments and used to specify scope conditions.

To substantiate this argument, the paper presents two empirical illustrations. The first concerns vaccine uptake in Romania, where the same dataset has been mobilised in two different ways: once through spatial econometric modelling of clustering and diffusion Mare, C. *et al.* (2024) and once through theorisation of hybrid health regimes combining socialist legacies, neoliberal reforms, and global governance Petrovici, N. *et al.* (2023). The second concerns peri-urbanisation, where demographic and satellite data have been used to typologise post-socialist cities as cases of growth and decline (Sandu, A. 2024), but also to theorise "spatial figurations" as stratified outcomes of institutional layering and capital flows (Petrovici, N. and Poenaru, F. 2025). In both cases, the same variables yield flat, correlationist explanations under a positivist ontology, or stratified, mechanism-based explanations under a critical realist ontology.

The contribution of the paper is threefold. Conceptually, we clarify and operationalise a mechanism-based approach that treats socio-spatial context as both an ontological condition and an epistemic infrastructure. Methodologically, we set out research-design principles for integrating digital spatial methods into mechanism-oriented inquiry

by specifying mechanisms and scope conditions in advance, using digital outputs as empirical traces, and documenting the fit of travelling categories to regional ontologies. Empirically, we show that Central and Eastern Europe is not a residue of anomalous data but a region where hybrid institutions and epistemic effects make visible the recursive relation between ontology and knowledge production. More broadly, the paper contributes to debates on the role of theory in economic geography (Barnes, T.J. and Christophers, B. 2018; Rodríguez-Pose, A. 2021), the continuing relevance of post-socialist studies (Müller, M. 2019; McElroy, E. and Chelcea, L. 2025), and the integration of digital spatial technologies into explanatory research (Arribas-Bel, D. and Reades, J. 2018; Ash, J. *et al.* 2018; Kitchin, R. 2022).

The paper proceeds as follows. Section 2 traces the genealogies of mechanism-based explanation in geography, from early critiques of positivism to recent calls for explanatory realism. Section 3 develops the dual framing of socio-spatial context as both ontological condition and epistemic infrastructure. Section 4 considers how digital spatial technologies can be integrated into theory-led mechanism design. Section 5 presents empirical illustrations from CEE. Section 6 concludes with implications for advancing context-sensitive, mechanism-based explanation in economic geography.

Genealogies of mechanism-based explanation in geography

The search for causal explanation in geography has unfolded through successive phases of critique, reformulation, and methodological experimentation. The first decisive break came with the critique of the quantitative revolution. David Harvey's *Explanation in Geography* (1969) reflected the ambition to construct nomothetic science through statistical laws, but it also revealed the fragility of reducing explanation to correlations. By the late 1970s, critical interventions (Harvey, D. 1969; Wisner, B. 1978; Soja, E.W. 1980) highlighted how spatial-economic patterns could not be understood without reference to political economy, class relations, and power. These early critiques already anticipated the call for mechanism-based reasoning, since they questioned whether universal laws were feasible in open social systems.

Realist philosophy provided a systematic alternative. Bhaskar, R. (1975) introduced the notion of a stratified ontology, distinguishing the real (generative structures), the actual (events), and the empirical (observations). Sayer, R.A. (1984, 1992) adapted these insights into geography, insisting that explanation required uncovering mechanisms operating under contingent conditions, not just observable regularities. Johnston, R. (1992) pressed this critique further by emphasising that the closure assumed in positivist models was incompatible with the openness of social systems. Pratt, A.C. (1995) and Yeung, H.W. (1997) made these philosophical principles operational for economic geography: mechanisms should be traced through comparative strategies, mixed methods, and multi-scalar analysis.

During the 2000s, empirical work demonstrated the potential of this approach. Glasmeier, A.K. and Farrigan, T.L. (2007) showed how urban segregation and economic isolation emerge from the contingent interplay of labour markets, housing institutions, and racialised practices, rather than from single-variable correlations. Evolutionary economic geography (Boschma, R.A. and Frenken, K. 2006; Boschma, R.A. and Martin, R. 2010; Clark, G.L. *et al.* 2018) proposed a mechanism-oriented account of regional development, where related variety, branching, and path dependence were not abstract models but causal processes embedded in institutional contexts. These contributions also aligned with broader methodological debates in social science, where Hedström, P. and Swedberg, R. (1998) and Elster, J. (2015) promoted mechanism-based explanation and mid-range theorising.

A recurrent ambiguity has concerned the relation between mechanisms and processes.

While often used interchangeably, critical realist accounts distinguish between them. Processes denote sequences of events observable at the empirical and actual levels, while mechanisms refer to the generative structures that make such processes possible (Sayer, A. 2002; Yeung, H.W. (1997). For example, "*urban sprawl*" may appear as a general process across contexts, but the mechanisms producing it differ in the United States through suburban property regimes, in post-socialist Europe through restitution policies and fragmented planning systems (Stenning, A. 2005; Hirt, S.A, 2012). Mechanism-based explanation, thus, requires moving beyond descriptive process-tracing to the identification of causal powers activated under specific socio-spatial conditions.

The 2010s brought confrontation with the digital turn. Wyly, E. (2011) asked whether quantitative tools could be repurposed for radical ends when re-embedded in realist ontology. Kitchin, R. (2014) dismantled the rhetoric of the "*end of theory*" showing how data are always theory-laden and embedded in socio-technical infrastructures. Thatcher, J. *et al.* (2016) conceptualised "*data colonialism*" as a mode of dispossession, linking the epistemic power of digital infrastructures to broader geographies of inequality. Critical GIS scholarship reinforced these insights: Pickles, J. (1995), Schuurman, N. (2000), Goodchild, M.F. (2007), and Ash, J. *et al.* (2018) demonstrated that spatial data infrastructures are not neutral but privilege certain ways of knowing, thereby shaping which mechanisms can be rendered visible.

More recent debates have returned explicitly to the methodological core. MacLeavy, J. (2019) argued that in open systems the distinction between mechanisms, processes, and contexts cannot be neatly separated. Crespi, F. and Quatraro, F. (2015) insisted that mechanisms are never universal but conditional on institutional and spatial settings. Dodgson, M. *et al.* (2014) applied this reasoning to innovation ecosystems, where non-linear and multi-scalar interactions require mechanism-based explanations attentive to complexity. Yeung, H.W. (2019, 2023), reformulated this orientation as "*explanatory realism*" a pragmatic stance where mid-range theories identify mechanisms and scope conditions, while recognising epistemic pluralism.

Since 2020, further contributions have underscored both the opportunities and the risks of mechanism-based explanation. Ash, J. *et al.* (2018) called for moving beyond critique to reconstruct explanatory practices, while Lynch, M. (2022) examined how data infrastructures codify particular epistemologies of space. Paasi, A. (2025) extended these debates into regional theory, showing that spatial categories themselves are ontological constructions shaping how mechanisms are identified. At the same time, the geography of knowledge tradition (Livingstone, D.N. 2013; Meusburger, P. *et al.* 2018) highlights the recursive relation between ontology, epistemology, and methodology: real structures generate practical ontologies that condition how actors and scientists perceive problems and mobilise categories of investigation (Bhaskar, R. 1979; Yeung, H.W. 2023).

This issue is particularly salient in post-socialist studies. Imported epistemologies often flatten stratified regional ontologies into derivative anomalies, reducing CEE to a site of empirical irregularities rather than a source of theory (Pucherová, D. and Gáfrik, R. 2015; Müller, M. 2019; Nagy, E. 2025; McElroy, E. and Chelcea, L. 2025). By contrast, mechanism-based reasoning allows treating the region as a generative site of theory production, where institutional hybridity and layered sovereignties create mechanisms of wider relevance (Stenning, A. 2005; Petrovici, N. 2012).

Taken together, this genealogy charts a trajectory from the critique of positivism, through the adoption of realist philosophy, to methodological embedding and contemporary debates about digital epistemologies. The unifying thread is a persistent concern with context: mechanisms operate contingently in open systems, and explanatory adequacy requires both ontological specification and epistemic reflexivity

Socio-spatial context as ontological condition and epistemic infrastructure

In order to advance mechanism-based explanation, socio-spatial context must be analysed in two complementary ways: as an ontological condition that enables or constrains the operation of mechanisms, and as an epistemic infrastructure that frames the categories through which mechanisms are identified. Both perspectives are necessary if causal explanation in economic geography is to move beyond the limits of either abstract universalism or local exceptionalism.

Ontological conditions refer to the institutional, political, and material structures that shape the environments in which mechanisms are activated. Critical realism emphasises that mechanisms are real causal powers, but their effects depend on the stratified contexts in which they are embedded (Bhaskar, R. 1975; Sayer, R.A. 1992). Comparative research has shown how similar processes yield divergent outcomes under different institutional arrangements. For example, foreign direct investment generates distinct developmental trajectories depending on whether states exercise strategic coordination or rely on liberal market regimes (Pickles, J. 2010; Smith, A. and Timár, J. 2010). Evolutionary economic geography has further demonstrated that path dependence, related variety, and branching operate through concrete industrial structures and governance systems rather than as universal processes (Boschma, R.A. and Martin, R. 2010; Balland, P.-A. *et al.* 2019). These studies illustrate that the explanatory power of mechanisms derives not only from their existence but also from their embedding in particular socio-spatial conditions.

Epistemic infrastructures concern the frameworks of knowledge through which mechanisms are rendered visible. Categories of investigation are not neutral descriptors but emerge within scholarly traditions, data practices, and institutional routines (Livingstone, D.N. 2013; Meusburger, P. *et al.* 2018). What counts as a valid mechanism is shaped by epistemological assumptions embedded in these infrastructures. For example, the circulation of Anglo-American concepts of governance or neoliberalisation into post-socialist contexts has often obscured the specific institutional legacies of the region, reclassifying them as anomalies instead of potential sources of explanation (Stenning, A. 2005; Müller, M. 2019; Nagy, E. 2025). Recent debates highlight that epistemic infrastructures are themselves productive: they generate categories that shape empirical research and theory formation (Barnes, T.J. and Christophers, B. 2018; Paasi, A 2025). Recognising this role is crucial for assessing how knowledge practices enable or constrain mechanism identification.

The interaction between ontological and epistemic dimensions is recursive. Real structures generate practical ontologies that influence how social actors and scientists perceive and categorise problems (Bhaskar, R. 1979). These categories, once institutionalised in research practices, shape subsequent investigations, determining how mechanisms are conceptualised and tested. Yeung, H.W. (2023) reformulates this relationship within his framework of explanatory realism, arguing that mid-range theorising must remain reflexive about the epistemic assumptions that guide mechanism identification. Contributions from the geography of knowledge have reinforced this argument by showing that categories travelling across regions generate emergent epistemic effects when applied in new contexts (Livingstone, D.N. and Withers, C.W.J. 2011; Jessop, B. and Sum, N.-L. 2022). Adequate explanation therefore requires attention both to the structural conditions that activate mechanisms and to the epistemic infrastructures that make them intelligible.

This dual framing is particularly significant for post-socialist studies. The region has often been interpreted through concepts that position it as derivative of Western trajectories or as an empirical exception. Imported categories such as "*transition*" or "*convergence*" have sometimes flattened the stratified institutional landscape of Central

and Eastern Europe into anomalies, thereby obscuring the generative mechanisms at work (Pucherová, D. and Gáfrik, R. 2015; Müller, M. 2019; Nagy, E. 2025). Treating CEE instead as an ontologically stratified formation highlights how socialist legacies, neoliberal reforms, and global integration interact to create hybrid mechanisms that cannot be reduced to exceptions. At the same time, recognising the epistemic infrastructures through which categories travel sheds light on how external concepts shape the types of explanations that are legitimised. Recent interventions argue that post-socialism continues to serve as a site of theory production when analysed as an interaction between institutional layering and epistemic circulation rather than as a residual descriptive label (McElroy, E. and Chelcea, L. 2025; Kinossian, N. 2022). This perspective aligns with the broader call to treat regional ontologies as sources of explanatory innovation rather than as deviations from supposedly universal models.

Attention to both ontological and epistemic dimensions is also essential in relation to digital spatial technologies. Tools such as GIS, remote sensing, and spatial econometrics can provide valuable empirical traces of clustering, diffusion, or association. Yet these traces contribute to causal explanation only when interpreted within theory-led designs that identify the causal mechanisms involved (Wyly, E. 2011; Dodgson, M. *et al*. 2014; Kitchen, R. 2022). Without such embedding, digital methods risk reproducing correlationism, treating observed regularities as mechanisms in themselves. With theoretical framing, however, they can support mechanism-based explanation by situating empirical observations within stratified socio-spatial contexts. Recent work on artificial intelligence and machine learning demonstrates this tension: while these methods can uncover patterns at multiple scales, their explanatory value depends on whether results are incorporated into mechanism-oriented accounts of spatial processes (Ash, J. *et al.* 2018; Shelton, T. 2024). Digital infrastructures therefore exemplify how ontological and epistemic dimensions intersect: the data they produce are conditioned by socio-technical structures, while the categories through which they are mobilised shape explanatory outcomes.

Taken together, these points indicate that socio-spatial context must be treated along two linked dimensions. As an ontological condition, it sets the enabling and constraining environment in which mechanisms operate. As an epistemic infrastructure, it organises the categories and practices through which mechanisms are made legible. Attending to both avoids the twin errors of universalism and exceptionalism. For Central and Eastern Europe, this means tracing how institutional legacies meet circulating epistemologies and how this encounter shapes the identification of mechanisms whose scope and limits can be specified beyond the region.

Digital spatial technologies and mechanism-based explanation

The expansion of digital spatial technologies has altered both the empirical possibilities and the epistemological challenges of explanation in economic geography. GIS, spatial econometrics, remote sensing, and, more recently, artificial intelligence and machine learning, have been promoted as offering unprecedented capacity to capture spatial regularities, identify clusters, and model diffusion processes (Goodchild, M.F. 2007; Kitchen, R. 2014, 2022; Arribas-Bel, D. and Reades, J. 2018). These tools provide descriptive power at large scales and across multiple dimensions of socio-spatial life. Yet their contribution to causal explanation depends on whether they are embedded within theory-led research designs. Without theoretical framing, they risk reproducing correlationism in a new guise, substituting pattern detection for identification of generative mechanisms (Wyly, E. 2011).

Critical realist perspectives highlight that data do not speak for themselves but must be situated within an ontology that distin-

guishes between events, mechanisms, and structures (Bhaskar, R. 1975; Sayer, R.A. 1992). From this standpoint, digital traces can serve as empirical evidence of causal processes, but they cannot define those processes without theory. Data infrastructures also embed assumptions about what counts as a valid observation. Lynch, M. (2022) further argues that the digitalisation of geography embeds new power relations into explanatory practices by privileging what is visible and measurable over what is institutionally or socially latent. Mechanism-based reasoning requires treating these outputs as potential empirical traces of deeper structures rather than as explanations in themselves.

The tension is especially evident in applications of spatial econometrics and machine learning. Models of autocorrelation, clustering, or diffusion identify patterns across territorial units, but they do not by themselves reveal why certain outcomes occur. For example, clustering of foreign direct investment in specific regions may reflect the operation of multiple mechanisms, including state industrial policy, labour market institutions, and global production networks. Only comparative and historically grounded analysis can disentangle which mechanisms are activated under particular conditions (Boschma, R.A. and Martin, R. 2010; Pickles, J. 2010). Machine learning techniques that classify urban growth trajectories or predict household mobility likewise risk producing correlationist explanations unless their results are situated within mechanism-oriented accounts of urban governance, land regimes, or infrastructure development (Shelton, T. 2024).

Digital technologies also shape epistemic infrastructures by defining categories of analysis. Remote sensing data, for instance, classify land cover and land use according to global taxonomies, often obscuring local institutional meanings. Similarly, the use of "standard" econometric indicators of regional competitiveness imports categories developed in Western economies into post-socialist settings, potentially reinterpreting institutional hybridity as deviation or anomaly (Stenning, A. 2005; Müller, M. 2019; Nagy, E. 2025). In this sense, digital infrastructures exemplify how epistemological categories travel and are institutionalised, influencing which mechanisms can be identified. Paasi, A. (2025) has argued that spatial categories are themselves ontological constructions that condition explanatory reasoning; when embedded in digital platforms, these categories carry strong epistemic effects.

Central and Eastern Europe illustrates both the opportunities and the risks of digital methods for mechanism-based explanation. In the field of public health, spatial econometric models of vaccine uptake in Romania identified clustering and diffusion patterns across counties (Mare, C. *et al.* 2024). While such models capture empirical regularities, they do not specify why uptake diverged across similar institutional environments. A mechanism-based account situates these patterns within the layered health regime shaped by socialist legacies, neoliberal reforms, and transnational governance (Petrovici, N. *et al.* 2023). In this case, digital tools provide valuable traces, but explanation requires theorising the institutional mechanisms that generate the observed clusters.

A similar contrast is visible in urban studies. Satellite data and demographic statistics have been used to typologise post-socialist cities into trajectories of growth and decline (Sandu, A. 2024). While typologies describe variation, they risk reifying processes such as peri-urbanisation as homogeneous outcomes. By contrast, mechanism-based analysis treats peri-urbanisation as the contingent product of property restitution, fragmented planning, and capital inflows (Petrovici, N. and Poenaru, F. 2025). Here again, digital technologies supply essential empirical material, but explanatory adequacy depends on situating them within stratified socio-spatial contexts.

This recursive relation between digital methods and mechanism-based reasoning has broader implications for economic geography. First, it calls for methodological pluralism: quantitative models, qualitative evidence, and historical comparison must

be combined to identify the causal powers at work. Second, it highlights the importance of reflexivity about epistemic infrastructures: categories embedded in data collection and processing influence what becomes visible as a mechanism. Third, it shows the value of digital technologies is conditional: their explanatory power is realised only when used within theory-led research designs that account for institutional and spatial variation.

Recent work supports this perspective. Dodgson, M. *et al.* (2014) show that innovation ecosystems require mechanism-based accounts that integrate digital data with institutional analysis. Jessop, B. and Sum, N.-L. (2022) stress that epistemic reflexivity is central to avoiding the reification of categories produced by digital infrastructures. Shelton, T. (2024) demonstrates that machine learning models in urban geography generate useful empirical insights only when interpreted through theories of governance and inequality. Together, these contributions underscore that digital technologies are neither neutral instruments nor autonomous explanatory devices; they are epistemic infrastructures whose value depends on their integration into mechanism-oriented research designs.

For post-socialist studies, this dual framing is especially important. Imported digital categories, such as "*transition economies*" or "*emerging markets*" can flatten regional ontologies and obscure hybrid institutional mechanisms (McElroy, E. and Chelcea, L. 2025). Yet when contextualised within local histories and comparative frameworks, digital data can illuminate how socialist legacies interact with global pressures to produce novel causal configurations. In this way, Central and Eastern Europe is not merely a site of empirical testing but a region where digital infrastructures and mechanism-based reasoning together reveal processes of wider theoretical significance.

Read in this way, digital spatial technologies extend the empirical reach of geography but do not by themselves provide explanation. Their outputs should be read as traces of causal mechanisms situated in socio-technical infrastructures and filtered through specific analytic categories. Coupled with a critical realist ontology and a reflexive epistemology, these tools can help connect patterns to structures and events to generative powers. Without such embedding, they risk reinstalling a thin positivism through computation. For economic geography, and for Central and Eastern Europe in particular, the task is to use digital infrastructures as components of theory-led, mechanism-oriented designs rather than as self-standing explanatory devices.

Empirical illustrations from Central and Eastern Europe

The argument can be grounded in two short illustrations from Romania that work with the same families of variables but produce different kinds of explanation. The first concerns vaccine uptake and shows how spatial models identify robust patterns that require institutional specification to count as explanation. The second concerns peri-urban change and shows how typologies drawn from demographic and satellite data can be reinterpreted as traces of generative mechanisms that vary across metropolitan settings. In both cases the move from pattern to explanation depends on the dual view of context developed above and on the mid-range orientation in explanatory realism (Yeung, H.W. 2019, 2023; Paasi, A. 2025).

Vaccine uptake in Romania

Mare, C. *et al.* (2024) analyse county and local data on COVID-19 vaccination together with socio-economic covariates. Spatial econometric specifications identify positive spatial autocorrelation and diffusion effects. These results show that vaccine uptake clusters and that neighbouring units co-vary in a systematic way. Poverty, settlement structure and religious composition are correlated with the outcome and some effects propagate across administrative boundaries. Read

at the level of the actual and the empirical, these findings support a model in which mechanisms are treated as regularities that may travel to similar settings subject to further testing. The account is predictive and precise, but the causal powers that produce the observed clusters remain unspecified.

Petrovici, N. *et al.* (2023) re-embed the same empirical patterns in a stratified ontology of hybrid health regimes. The analysis reconstructs how socialist legacies of primary care and access, post-1990s market reforms, and transnational governance produced distinct organisational arrangements for vaccination logistics, information and trust. In this reading the mechanisms are generative structures. They include institutional layering in family medicine and public health, the organisation of professional authority and distrust, and the circulation of clinical and managerial guidelines across national and international bodies. Spatial clusters are treated as empirical traces of these mechanisms rather than as explanations in themselves. The models remain useful because they indicate where the mechanisms are likely to be active and how their effects are distributed. Explanation requires stating the scope conditions under which particular combinations of mechanisms operate, for example the joint presence of fragmented primary care, targeted private provision and strong vertical guidance.

This illustration clarifies the role of digital and statistical tools within mechanism-oriented research. Spatial econometrics shows where and how outcomes co-vary. It does not identify causal powers independently of theory and institutional evidence. The realist account provides that identification by linking traces to structures and by specifying conditions of activation. The result is consistent with a pragmatic explanatory realism that evaluates explanation by its capacity to uncover context-dependent mechanisms with stated scope rather than by predictive fit alone (Yeung, H.W. 2019, 2023). It also aligns with recent work on data infrastructures and epistemic effects, which cautions that model outputs codify assumptions about observables and therefore require reflexive interpretation (Ash, J. *et al.* 2018; Kitchin, R. 2022; Lynch, M. 2022).

Peri-urban change in Romania

Sandu, A. (2024) combines demographic indicators with satellite-derived measures of built-up area to classify post-socialist cities into trajectories of growth and decline. The typology is clear and comparable across many cases. If taken as sufficient for explanation, however, the mechanism behind peri-urban expansion during demographic decline is the correlation itself. The city appears as a bounded unit that moves across states defined by the data. The causal powers remain implicit.

Petrovici, N. and Poenaru, F. (2025) work with the same kinds of variables but interpret them within a framework that treats peri-urban morphologies as spatial figurations. The analysis reconstructs how property restitution, fragmented planning, state and private capital in land and infrastructure markets, and the labour-housing nexus interact across metropolitan regions. In this reading the mechanisms are again generative and multi-scalar. Built-up change and demographic decline are empirical traces of these mechanisms. The concept of spatial figuration specifies how particular configurations of institutional and economic relations generate distinct peri-urban outcomes and it states when these mechanisms are likely to combine. The focus shifts from the typology of outcomes to the identification of causal powers and to the conditions under which they operate.

As in the health case, digital sources are indispensable for identifying patterns at scale, but they require theoretical embedding to yield explanation. Remote sensing classifications and demographic indicators supply the patterns. Mechanism-based analysis supplies the link to structures and to scope conditions. This approach avoids treating Central and Eastern Europe as a set of anomalies and instead treats it as a region in which hybrid mechanisms are analytically visible and travel under specified conditions (Grubbauer, M.

and Kusiak, J. 2012; Paasi, A. 2025). It also responds to concerns about imported categories in post-socialist research by showing how regional ontologies shape what counts as a mechanism and how categories must be inspected for fit before they are used for explanation (Müller, M. 2019; McElroy, E. and Chelcea, L. 2025; Nagy, E. 2025).

Synthesis

The two illustrations support three claims that follow directly from the theoretical argument. First, the same data can sustain different ontological commitments. If mechanisms are defined as regularities, explanation remains at the level of the actual and the empirical. If mechanisms are defined as generative structures, explanation requires institutional and historical specification and a statement of scope. Second, digital spatial technologies are best treated as epistemic infrastructures that produce empirical traces to be linked to mechanisms. Their value for explanation rises when model outputs are read through theory-led designs and when categories embedded in data collection and processing are made explicit (Ash, J. *et al.* 2018; Kitchin, R. 2022; Lynch, M. 2022). Third, treating Central and Eastern Europe as an ontologically stratified region changes the research questions we ask and the categories we use. Explanation depends on how socialist legacies, post-socialist reforms and transnational pressures interact to produce outcomes. This perspective avoids universalism and exceptionalism and supports comparative work in which mechanisms travel only under clearly stated conditions (Yeung, H.W. 2019, 2023; Paasi, A. 2025).

These illustrations therefore meet the empirical expectations that follow from the rest of the paper. They move from patterns to mechanisms with explicit scope conditions. They integrate digital methods without conflating pattern with explanation. They show how a regional ontology shapes epistemic categories and, in turn, explanatory claims.

Implications for mechanism-based research design

The analysis above has two practical implications for how we design studies in economic geography. First, explanation should proceed by specifying mechanisms and scope conditions before the choice of methods. Second, digital spatial technologies should be treated as epistemic infrastructures that yield empirical traces to be interpreted within a stratified ontology. In what follows we set out design principles that follow from these claims and indicate how they relate to recent work in the field.

A mechanism-oriented design begins with a clear statement of the causal powers that are hypothesised to operate, the socio-spatial conditions under which they are activated, and the empirical traces they are expected to leave. This framing translates the realist distinction between structures, events and observations into research practice (Bhaskar, R, 1975; Sayer, R.A. 1992). It is also consistent with explanatory realism, which evaluates theories by their ability to recover context-dependent mechanisms rather than by predictive fit alone (Yeung, H.W. 2019, 2023). In empirical terms this means formulating propositions that link a set of institutional arrangements to a pattern that can be observed and then stating the conditions under which the link should hold. For example, a claim about related variety and branching in regional development must identify the industrial and governance configurations through which that mechanism operates and the range of contexts in which it is expected to travel (Boschma, R.A. and Martin, R. 2010; Balland, P.-A. *et al.* 2019).

Comparative strategy follows from this orientation. Cases should be selected to vary the conditions that are thought to enable or constrain a mechanism so that we can test its operation across settings. This can be done within a country, across countries within a region, or across regions where institutional architectures are comparable. The point is to avoid both abstract universalism and local exceptionalism by stating where the mecha-

nism is likely to work and where it is not. In Central and Eastern Europe, for instance, the interaction between socialist legacies and market reforms can be treated as a structured source of variation rather than as a residual context, which allows mechanism-based claims to be examined across different institutional mixes (Kinossian, N. 2022; McElroy, E. and Chelcea, L. 2025; Paasi, A. 2025).

The use of digital spatial technologies should be aligned with these aims. Spatial econometrics, remote sensing and machine learning can identify clusters, discontinuities and co-variations at scale, but these outputs do not by themselves specify causal powers. Their role in a mechanism-oriented design is to locate and describe empirical traces and to help adjudicate between rival mechanism claims. This requires transparent reporting of model choices, variable construction and classification schemes, alongside a discussion of the epistemic assumptions embedded in data infrastructures (Ash, J. *et al*. 2018; Kitchin, R. 2022; Lynch, M. 2022). It also requires combining quantitative outputs with historical and institutional evidence that bears directly on the proposed mechanisms. The goal is not method triangulation for its own sake but the use of diverse materials to identify and test the action of causal powers in stratified contexts (Wyly, E. 2011). A further implication concerns categories. Because categories travel with data infrastructures and scholarly traditions, researchers should document how key constructs are defined and whether they fit the regional ontology under study. This is particularly important when standard indicators and taxonomies originate in settings with different institutional architectures. Reflexive treatment of categories is part of the research design rather than an afterthought, since misfit can generate spurious regularities or hide relevant mechanisms (Barnes, T.J. and Christophers, B. 2018; Jessop, B. and Sum, N.-L. 2022; Paasi, A. 2025). In practical terms, this entails justifying the transfer of constructs, adjusting them where needed, and indicating how these decisions affect the identification of mechanisms.

Evaluation criteria also follow from the foregoing. We propose four that can be applied to mechanism-based studies in economic geography. First, ontological clarity: are the mechanisms, structures and scope conditions explicitly stated and distinguished from the empirical patterns they are meant to explain. Second, evidential fit: do the empirical traces produced by digital and non-digital methods correspond to the expected signs of the proposed mechanisms. Third, contextual specificity: are the institutional and spatial conditions under which the mechanism operates described in sufficient detail to allow comparison and limited generalisation. Fourth, epistemic reflexivity: are the categories and data infrastructures that structure observation made explicit and assessed for fit with the regional ontology (Ash, J. *et al*. 2018; Yeung, H.W. 2019; Kitchin, R. 2022; Paasi, A. 2025).

These principles have consequences for field-building. They encourage cumulative work in which mechanisms are carried across studies together with their scope conditions, rather than being replaced whenever new data become available. They favour designs that combine digital traces with institutional analysis and comparative evidence so that results can be interpreted as more than surface regularities. They also support the status of Central and Eastern Europe as a site for concept formation, since hybrid institutional arrangements in the region make certain mechanisms analytically visible and therefore useful for theory beyond the region when scope is stated clearly (Kinossian, N. 2022; McElroy, E. and Chelcea, L. 2025).

Finally, the approach outlined here has limits that should be recognised. Mechanisms in open systems rarely operate in isolation, which makes identification and adjudication demanding. Digital infrastructures change rapidly and carry evolving epistemic effects that must be tracked. Not all mechanisms will leave traces that can be captured by current data. These constraints do not weaken the case for mechanism-based explanation. They indicate the need for careful design, transpar-

ent reporting and cumulative comparison so that claims about causal powers remain tied to the contexts in which they operate and the categories through which they are known.

Conclusions

This paper has argued that explanation in economic geography requires treating socio-spatial context as both an ontological condition and an epistemic infrastructure. Mechanisms operate in stratified settings shaped by institutions, politics and material arrangements (Bhaskar, R. 1975; Sayer, R.A. 1992). At the same time, the categories through which we recognise mechanisms are produced within data systems and scholarly traditions that travel unevenly across regions (Livingstone, D.N. 2013; Meusburger, P. *et al*. 2018; Lynch, M. 2022). When these two dimensions are addressed together, we can avoid the twin errors of abstract universalism and local exceptionalism. The paper developed this claim in dialogue with explanatory realism. We adopted Yeung's call to judge theories by their capacity to recover context-dependent mechanisms and to state scope conditions, and extended it by foregrounding how practical ontologies shape the epistemic categories of both social actors and researchers (Bhaskar, R. 1979; Yeung, H.W. 2019, 2023). We showed that digital spatial technologies are valuable when used to locate empirical traces for theory-led inquiry but do not by themselves supply causal powers (Wyly, E. 2011; Ash, J. *et al*. 2018; Kitchin, R. 2022). The two illustrations from Central and Eastern Europe made this point concrete. The same datasets can yield correlationist accounts or mechanism-based explanations depending on how they are embedded in institutional histories and regional ontologies.

The contribution is threefold. First, the paper clarifies how mechanism-based explanation in geography depends on both ontological specification and epistemic reflexivity. Second, it offers design principles for mechanism-oriented research that link causal claims, scope conditions and empirical traces, and that align digital methods with comparative and historical evidence. Third, it reframes Central and Eastern Europe as a productive site for concept formation rather than a repository of anomalies, consistent with recent reconsiderations of post-socialist studies (Grubbauer, M. and Kusiak, J. 2012; Kinossian, N. 2022; McElroy, E. and Chelcea, L. 2025; Paasi, A. 2025).

The analysis points to a short research agenda. Future studies should code institutional and governance features alongside standard quantitative indicators so that proposed mechanisms can be tested across clearly stated conditions (Boschma, R.A. and Martin, R. 2010; Balland, P.-A. *et al.* 2019). Reporting should document category choices and data lineage to make the epistemic effects of digital infrastructures visible and assessable by readers (Barnes, T.J. and Christophers, B. 2018; Kitchin, R. 2022). Comparative designs in CEE and beyond should vary enabling and constraining conditions deliberately so that results speak to limited generalisation rather than to universal laws.

Mechanisms in open systems rarely act alone and traces are often noisy. These limits are real, but they are also the reason to adopt designs that bring together theory, history and digital observation. If explanation is to remain central to economic geography, it must connect patterns to structures and events to causal powers under specified conditions. Treating context as both ontological and epistemic provides one practical route to that end.

REFERENCES

Arribas-Bel, D. and Reades, J. 2018. Geography and computers: Past, present, and future. *Geography Compass* 12. (10): e12403. https://doi.org/10.1111/gec3.12403

Ash, J., Kitchin, R. and Leszczynski, A. 2018. Digital turn, digital geographies? *Progress in Human Geography* 42. (1): 25–43. https://doi.org/10.1177/0309132516664800

Balland, P.-A., Boschma, R., Crespo, J. and Rigby, D.L. 2019. Smart specialization policy in the European Union: Relatedness, knowledge complexity and regional diversification. *Regional Studies* 53. (9): 1252–1268. https://doi.org/10.1080/00343404.2018.1437900

Barnes, T.J. and Christophers, B. 2018. *Economic Geography: A Critical Introduction*. Hoboken, NJ, Wiley Blackwell.

Bhaskar, R. 1975. *A Realist Theory of Science*. York, Books.

Bhaskar, R. 1979. *The Possibility of Naturalism: A Philosophical Critique of the Contemporary Human Sciences*. Atlantic Highlands, NJ, Humanities Press.

Boschma, R.A. and Frenken, K. 2006. Why is economic geography not an evolutionary science? Towards an evolutionary economic geography. *Journal of Economic Geography* 6. (3): 273–302. https://doi.org/10.1093/jeg/lbi022

Boschma, R.A. and Martin, R. (eds.). 2010. *The Handbook of Evolutionary Economic Geography*. Cheltenham, UK–Northampton, MA, Edward Elgar. https://doi.org/10.4337/9781849806497

Clark, G.L., Feldman, M.P., Gertler, M.S., Wójcik, D. and Kaiser, A. (eds.) 2018. *The New Oxford Handbook of Economic Geography*. Oxford, Oxford University Press. https://doi.org/10.1093/oxfordhb/9780198755609.001.0001

Crespi, F. and Quatraro, F. (eds.) 2015. *The Economics of Knowledge, Innovation and Systemic Technology Policy*. London–New York, Routledge. https://doi.org/10.4324/9780203795071

Dalton, C.M. and Thatcher, J. 2015. Inflated granularity: Spatial "Big Data" and geodemographics. *Big Data & Society* 2. (2): 1–15. https://doi.org/10.1177/2053951715601144

Dodgson, M., Gann, D. and Phillips, N. (eds.). 2014. *The Oxford Handbook of Innovation Management*. Oxford, UK, Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199694945.001.0001

Elster, J. 2015. *Explaining Social Behaviour: More Nuts and Bolts for the Social Sciences*. Cambridge, UK, Cambridge University Press. https://doi.org/10.1017/CBO9781107763111

Glasmeier, A.K. and Farrigan, T.L. 2007. Landscapes of inequality: Spatial segregation, economic isolation, and contingent residential locations. *Economic Geography* 83. (3): 221–229. https://doi.org/10.1111/j.1944-8287.2007.tb00352.x

Goodchild, M.F. 2007. Citizens as sensors: The world of volunteered geography. *GeoJournal* 69. (4): 211–221. https://doi.org/10.1007/s10708-007-9111-y

Grubbauer, M. and Kusiak, J. 2012. *Chasing Warsaw: Socio-material Dynamics of Urban Change Since 1990*. Frankfurt–New York, Campus-Verlag.

Harvey, D. 1969. *Explanation in Geography*. London, Edward Arnold.

Hedström, P. and Swedberg, R. (eds.). 1998. *Social Mechanisms: An Analytical Approach to Social Theory*. Cambridge, UK, Cambridge University Press. https://doi.org/10.1017/CBO9780511663901

Hirt, S.A. 2012. *Iron Curtains: Gates, Suburbs and Privatization of Space in the Post-Socialist City*. Chichester, Wiley Blackwell. https://doi.org/10.1002/9781118295922

Jessop, B. and Sum, N.-L. 2022. Cultural political economy. In *Handbook of Alternative Theories of Political Economy*. Eds.: Stilwell, F., Primrose, D. and Thornton, T., Cheltenham, Edward Elgar Publishing, 355–370. https://doi.org/10.4337/9781789909067.00034

Johnston, R. (ed.) 1992. *The Dictionary of Human Geography*. Oxford, Blackwell.

Kinossian, N. 2022. Rethinking the post-socialist city. *Urban Geography* 43. (8): 1240–1251. https://doi.org/10.1080/02723638.2022.2102332

Kitchin, R. 2014. *The Data Revolution: Big Data, Open Data, Data Infrastructures & Their Consequences*. London, SAGE. https://doi.org/10.4135/9781473909472

Kitchin, R. 2022. *The Data Revolution: A Critical Analysis of Big Data, Open Data & Data Infrastructures*. Los Angeles–London–New Delhi–Singapore–Washington D. C.–Melbourne, SAGE.

Livingstone, D.N. and Withers, C.W.J. 2011. *Geographies of Nineteenth-Century Science*. Chicago, University of Chicago Press. https://doi.org/10.7208/chicago/9780226487298.001.0001

Livingstone, D.N. 2013. *Putting Science in its Place: Geographies of Scientific Knowledge*. Chicago, The University of Chicago Press.

Lynch, M. 2022. *Data Lives: How Data Are Made and Shape Our World: Rob Kitchin*. Bristol, UK, Bristol University Press. https://doi.org/10.1080/2325548X.2022.2036546

MacLeavy, J. 2019. Mechanism, process and the wider context of economic geography. *Dialogues in Human Geography* 9. (3): 273–279. https://doi.org/10.1177/2043820619875332

Mare, C., Belbe, S. and Petrovici, N. 2024. Exploring the spatial clustering and spill-over effects of COVID-19 vaccination uptake in Romania: An analysis at municipality level. *AStA Advances in Statistical Analysis* Online publication. https://doi.org/10.1007/s10182-024-00520-3

McElroy, E. and Chelcea, L. 2025. Who's afraid of post-socialist theory? *Eurasian Geography and Economics* 66. (6): 719–731. https://doi.org/10.1080/15387216.2025.2510352

Meusburger, P., Heffernan, M. and Suarsana, L. (eds.) 2018. *Geographies of the University*. Cham, Springer International Publishing. https://doi.org/10.1007/978-3-319-75593-9

Müller, M. 2019. Goodbye, Post-socialism! *Europe-Asia Studies* 71. (4): 533–550. https://doi.org/10.1080/09668136.2019.1578337

Nagy, E. 2025. Post-socialism: Still here? *Eurasian Geography and Economics* 66. (6): 689–696. https://doi.org/10.1080/15387216.2025.2510354

Paasi, A. 2025. Geopolitics of knowledge. In *The Wiley Blackwell Companion to Political Geography*. Eds.: Mamadouh, V., Koch, N., Woon, C.Y. and Agnew, J., Chichester, Wiley Blackwell, 56–72. https://doi.org/10.1002/9781119753995.ch4

Petrovici, N. 2012. Workers and the city: Rethinking the geographies of power in post-socialist urbanisation. *Urban Studies* 49. (11): 2377–2397. https://doi.org/10.1177/0042098011428175

Petrovici, N., Belbe, S., Mare, C. and Cotoi, C. 2023. Hybrid health regimes: Access to primary care physicians and COVID-19 vaccine uptake across municipalities in Romania. *Social Science & Medicine* 337. 116305. https://doi.org/10.1016/j.socscimed.2023.116305

Petrovici, N. and Poenaru, F. 2025. Uneven and divergent spatial figurations: A five-pronged typology of urban and periurban formations in Romania. *Cities* 156. (5): 105578. https://doi.org/10.1016/j.cities.2024.105578

Pickles, J. (ed.) 1995. *Ground Truth: The Social Implications of Geographic Information Systems*. New York, NY, Guilford Press.

Pickles, J. 2010. The spirit of post-socialism: Common spaces and the production of diversity. *European Urban and Regional Studies* 17. (2): 127–140. https://doi.org/10.1177/0969776409356492

Pratt, A.C. 1995. Putting critical realism to work: The practical implications for geographical research. *Progress in Human Geography* 19. (1): 61–74. https://doi.org/10.1177/030913259501900104

Pucherová, D. and Gáfrik, R. (eds.) 2015. *Postcolonial Europe? Essays on Post-Communist Literatures and Cultures*. Leiden–Boston, Brill Rodopi. https://doi.org/10.1163/9789004303850

Rodríguez-Pose, A. 2021. Costs, incentives, and institutions in bridging evolutionary economic geography and global production networks. *Regional Studies* 55. (6): 1011–1014. https://doi.org/10.1080/00343404.2021.1914833

Sandu, A. 2024. The post-socialist cities from Central and Eastern Europe: Between spatial growth and demographic decline. *Urban Studies* 61. (5): 821–833. https://doi.org/10.1177/00420980231189261

Sayer, R.A. 1984, 1992. *Method in Social Science: A Realist Approach*. Abingdon, UK, Taylor & Francis. https://doi.org/10.4324/9780203310762

Sayer, A. 2002, 2010. *Method in Social Science: A Realist Approach*. Revised second edition. London, Routledge. https://doi.org/10.4324/9780203850374

Schuurman, N. 2000. Trouble in the heartland: GIS and its critics in the 1990s. *Progress in Human Geography* 24. (4): 569–590. https://doi.org/10.1191/030913200100189111

Shelton, T., Poorthuis, A. and Zook, M. 2015. Social media and the city: Rethinking urban socio-spatial inequality using user-generated geographic information. *Landscape and Urban Planning* 142. 198–211. https://doi.org/10.1016/j.landurbplan.2015.02.020

Shelton, T. 2024. Challenging opacity, embracing fuzziness: Geographical thought and praxis in a post-truth age. *Dialogues in Human Geography* 14. (2): 352–356. https://doi.org/10.1177/20438206231157891

Smith, A. and Timár, J. 2010. Uneven transformations: Space, economy and society 20 years after the collapse of state socialism. *European Urban and Regional Studies* 17. (2): 115–126. https://doi.org/10.1177/0969776409358245

Soja, E.W. 1980. The socio-spatial dialectic. *Annals of the Association of American Geographers* 70. (2): 207–225. https://doi.org/10.1111/j.1467-8306.1980.tb01308.x

Stenning, A. 2005. Where is the post-socialist working class? Working-class lives in the spaces of (post-) socialism. *Sociology* 39. (5): 983–999. https://doi.org/10.1177/0038038505058382

Thatcher, J., O'Sullivan, D. and Mahmoudi, D. 2016. Data colonialism through accumulation by dispossession: New metaphors for daily data. *Environment and Planning D: Society and Space* 34. (6): 990–1006. https://doi.org/10.1177/0263775816633195

Wisner, B. 1978. Does radical geography lack an approach to environmental relations? *Antipode* 10. (1): 84–95. https://doi.org/10.1111/j.1467-8330.1978.tb00298.x

Wyly, E. 2011. Positively radical. *International Journal of Urban and Regional Research* 35. (5): 889–912. https://doi.org/10.1111/j.1468-2427.2011.01047.x

Yeung, H.W. 1997. Critical realism and realist research in human geography: A method or a philosophy in search of a method? *Progress in Human Geography* 21. (1): 51–74. https://doi.org/10.1191/030913297668207944

Yeung, H.W. 2019. Rethinking mechanism and process in the geographical analysis of uneven development. *Dialogues in Human Geography* 9. (3): 226–255. https://doi.org/10.1177/2043820619861861

Yeung, H.W. (ed.) 2023. *Theory and Explanation in Geography*. Chichester, Wiley. https://doi.org/10.1002/9781119845515