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METAPHYSICAL ASSUMPTIONS AND THEORETICAL STRUCTURES IN NATURAL SCIENCES: A SYSTEMATIC LITERATURE REVIEW ANALYSIS OF THE ONTOLOGICAL FOUNDATIONS OF NATURAL AND SOCIAL SCIENCES

Dewi Astuti[1a]*, Insih Wilujeng[2b], Woro Sri Hastuti[3c], Ifan Awanda[4d]

[1,3,4]Basic Education, Faculty of Education and Psychology, Universitas Negeri Yogyakarta, Indonesia
[2]Science Education Study Program, Faculty of Mathematics and Natural Sciences, Universitas Negeri Yogyakarta, Indonesia

[a]*E-mail: dewiastuti.2025@student.uny.ac.id*

(*) Corresponding Author
dewiastuti.2025@student.uny.ac.id

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ABSTRACT
This study aims to identify and synthesize the metaphysical assumptions underlying the theoretical structure of Natural and Social Sciences (IPAS), especially at the ontological level. Using a Systematic Literature Review approach guided by PRISMA 2020, searches were conducted in Scopus, SpringerLink, Taylor & Francis, PhilPapers, and MDPI (2015–2026), resulting in 29 key literatures analyzed thematically-narratively. Four main ontological themes were found: (1) natural sciences are based on metaphysical naturalism that relies on an ordered external reality; (2) social sciences have ontological diversity, including critical realism, social constructivism, and agency-structure ontology; (3) ontological tensions in interdisciplinary research can be bridged by critical realism and methodological pluralism; (4) an integrated, model-based naturalistic metaphysics serves as a connecting framework for natural and social ontologies. The novelty of this research lies in providing a conceptual map of the metaphysical assumptions of IPAS that facilitates more reflective cross-disciplinary collaboration, thereby strengthening the development of IPAS as an interdisciplinary field.

INTRODUCTION

Understanding metaphysical assumptions, particularly ontological foundations, is crucial in the Natural and Social Sciences (IPAS). Chakravartty (2017), asserts that a convincing ontological explanation must respect how science integrates metaphysical assumptions with empirical dimensions. These basic assumptions about the nature of reality implicitly guide the entire research process from hypothesis formulation to the interpretation of findings yet often escape critical reflection by researchers, even though they determine the legitimacy of scientific activity. In IPAS, which unites the traditions of the natural and social sciences, an understanding of metaphysics is the foundation for successful cross-disciplinary integration.

Interdisciplinary research practices face serious challenges due to ontological incompatibilities. Persson

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dkk., (2018) show that sustainability research often underestimates the differences in ontological assumptions between the natural and social sciences, resulting in flawed integration strategies. A comparison of eight interdisciplinary efforts from environmental economics to actor network theory concludes that none has succeeded in providing a satisfactory integrated understanding (Wong, 2016). This finding confirms that integration issues are not merely technical-methodological, but rooted in fundamental differences in understanding the nature of reality. Without adequate reflection, both existing interdisciplinary approaches are equally risky: unification can trigger scientific imperialism, while poorly managed pluralism actually hinders knowledge integration due to the lack of conceptual bridges. Furthermore, Bryant, (2025) notes skepticism about the naturalization of social metaphysics due to its perceived failure to meet realist criteria such as unity and predictive power, often positioning social sciences as "second-class," hindering equal collaboration with the natural sciences.

Although the literature on ontology of the natural and social sciences has grown, systematic studies comparing and synthesizing their foundations within a social science framework remain scarce. Bumatay (2022), notes that much of the work on social ontology has been conducted without a close connection to the practice of social science itself. The call for a naturalistic metaphysics based on the best social sciences suggests an urgent need, but the definition of "best social science" is less clear than in the physical sciences. The absence of a comprehensive Systematic Literature Review (SLR) on this topic leaves a complete conceptual map of the metaphysical assumptions of social sciences unavailable.

Theoretical Framework: Mapping the Ontological Landscpe

Metaphysical Naturalism and Its Discontents

In the natural sciences, metaphysical naturalism constitutes the dominant foundation. Sambrotta (2023), defines naturalism as the ontological thesis that the world is what the natural sciences say it is, and that anything outside this domain does not interact with objects, events, and processes in our world. This view implies an orderly, external reality governed by universal laws and accessible through systematic empirical methods. However, recent developments have unsettled this monolithic picture. Mitchell (2023), critically dismantles reductionist claims of the unity of science, arguing that actual scientific practice reveals a plurality of ontological frameworks that resist convergence into a single fundamental level. Ferrari (2024), extends this critique by proposing a processual ontology that emphasizes relationality, interdependence, and contingency, thereby avoiding both reductionist fundamentalism and dualistic fragmentation. These contributions signal a shift from a singular naturalistic ontology toward an ontological pluralism that remains tethered to a minimal realism a commitment to a mindindependent world (Tewers, 2024).

Critical Realism and Stratified Ontology

A particularly influential framework that spans both natural and social science is critical realism, developed originally by Roy Bhaskar. Stavrianos (2025), articulates its core: reality exists independently of human perception and is organized into three distinct ontological domains—the empirical (subjective experience), the actual (events and outcomes), and the real (underlying structures, mechanisms, and causal powers). This stratified ontology acknowledges that causal mechanisms may operate without being directly observed and that reality possesses depth. Crucially, critical realism also recognizes that social structures are emergent entities with their own causal powers, irreducible to individual actions. Longo et al., (2025) argue that this framework can facilitate the bridging of natural and social sciences by providing an ontology that treats both ecological and social structures as real, without privileging one level as more fundamental.

Ontological Pluralism in the Social Sciences

In contrast to the natural sciences, the social sciences exhibit far greater ontological diversity. Buch-Hansen, (2023)) offers a flexible typology distinguishing between strong and weak versions of three philosophical stances: positivism, constructivism, and critical realism. This typology reveals that in actual research practice, the boundaries between these positions are often blurred, and researchers may combine elements from multiple traditions . Kolasï (2018,) demonstrates the tension between intersubjectivist and objectivist ontologies in International Relations, arguing that reducing social ontology entirely to intersubjective meanings ignores objective features of social reality such as hierarchies and dependencies that possess causal force independently of

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actors' acknowledgment (Trundle & Phillips, 2023). Porpora (2015), reinforces this by defending the existence of social structure as a distinct metaphysical category, neither reducible to individual agency nor to mere aggregations of actions.

Naturalized Social Metaphysics

Finally, the project of naturalizing social metaphysics provides a bridge between the ontological concerns of philosophy and the empirical practices of social science. Ross (2023), defines naturalistic metaphysics as a metaphysics that employs no transcendental concepts or categories not explicitly appearing in firstorder scientific theories, models, or explanations. Two methodological approaches have emerged: a modelbased approach, which emphasizes theoretical modeling as central to ontological inquiry (Sarkia, 2022), and inference to the best explanation (IBE), which seeks to ground ontological claims in explanatory power (Shevchenko, 2023). Accroding to (Bryant, 2025; Saunders, 2020) provide empirical justification that social sciences such as epidemiology and archaeology can yield reliable evidence for metaphysical claims without needing to meet the predictive standards of physics. These debates underscore the viability of a methodological pluralism in which multiple naturalistic paths can legitimately inform ontology.

Based on the above description, the formulation of the research problem is: (1) What are the fundamental ontological assumptions underlying the theoretical structure of natural science? (2) What are the fundamental ontological assumptions underlying the theoretical structure of social science? (3) How is the ontological tension between the two mediated in interdisciplinary research practices? (4) What metaphysical framework can bridge these ontological differences? The aim of this research is to conduct a systematic synthesis of the literature to identify, map, and analyze the ontological foundations of both domains in science and technology. Theoretically, this research is expected to produce a conceptual map as a basis for developing a more coherent interdisciplinary theory; practically, it will serve as a reflective guide for science and technology researchers in designing cross-disciplinary research that considers the implications of the metaphysical assumptions adopted.

METHOD

This study uses a Systematic Literature Review (SLR) approach with reference to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 protocol. The selection of this approach is based on its ability to systematically identify, evaluate, and synthesize all literature relevant to the established research questions. The validity of the PRISMA 2020 protocol as a reliable methodological framework for systematic literature reviews has been confirmed through various studies (Dadas et al., 2026). The SLR approach is considered most suitable for answering philosophical-theoretical research questions, such as the exploration of metaphysical assumptions in the Natural and Social Sciences (IPAS), because this approach allows researchers to track, map, and critically compare various scattered ontological positions.

The literature search strategy was implemented from January to April 2026 using seven major electronic databases: Scopus, SpringerLink, Taylor & Francis Online, PhilPapers, MDPI, Sage Publications, and Google Scholar as a supplementary database. This database selection aligns with the principle that more than one database is generally needed in a systematic review. Multidisciplinary databases such as Scopus should be included because they cover literature across all disciplines (humanities, social sciences, and sciences). Although subject-specific databases should be prioritized over publisher-specific platforms (such as Taylor & Francis, SpringerLink), whose content may already be indexed elsewhere, it is still important to search all major journals within a discipline. Scopus itself is the world's largest abstract and citation database for peer-reviewed literature, covering research topics across all technical and scientific disciplines, from medicine and the social sciences to the arts and humanities (Baas et al., 2020; Pranckutė, 2021).

Search keywords were grouped into three clusters. The first cluster (metaphysical assumptions) included the terms metaphysical assumptions, ontological assumptions, metaphysical foundations, ontological foundations, and metaphysics of science. The second cluster (natural and social sciences) included natural science, social science, natural sciences, social sciences, natural and social sciences, Natural and Social Sciences, and Natural Sciences. The third cluster (theoretical focus) included ontology, epistemology, theoretical foundations,

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theoretical structure, philosophy of science, critical realism, scientific metaphysics, and naturalized metaphysics. These keyword combinations were applied with Boolean operators (AND, OR) to the title, abstract, and keywords of the articles. This practice is common across various databases to construct effective search strings. This keyword identification process is crucial for thoroughly documenting the methodology (Abusaada & Elshater, 2024; Firoozeh et al., 2020).

The inclusion criteria were as follows: (1) peer-reviewed journal articles, books, or book chapters indexed by Scopus or published by leading academic publishers (such as Springer, Routledge, Oxford University Press); (2) published between 2015 and 2026; (3) in English or Indonesian; (4) explicitly discussing metaphysical, ontological, or epistemological assumptions in the natural and/or social sciences; (5) available in full access or at least an abstract sufficient for analysis. Meanwhile, the exclusion criteria included: (1) articles that only discuss methodological aspects without an explicit metaphysical foundation; (2) opinion articles or editorials without an adequate literature review; (3) dissertations or theses that have not been published as monographs; (4) articles that have no direct connection to the ontological foundations of science.

The study selection procedure was conducted in stages following the PRISMA flowchart. The first stage was identification through database searches, which yielded 847 records. The second stage was duplication removal, which left 621 records. The third stage was title and abstract screening, which excluded 473 records as irrelevant to the research question, leaving 148 records. The fourth stage was full-text eligibility assessment, which excluded 119 records for the following reasons: lack of full access (n=47), inadequate discussion of metaphysical assumptions (n=38), and solely methodological focus (n=34). The final stage yielded 29 papers that met all inclusion criteria for analysis.

Data extraction was conducted using a standardized form that included six types of information: (1) publication identity (author, year, title, source, DOI); (2) research focus (natural sciences, social sciences, or integration); (3) ontological assumptions discussed; (4) metaphysical framework used; (5) key findings related to ontological foundations; and (6) implications for science and technology. Data synthesis was conducted using a thematic narrative synthesis approach. Various approaches to synthesizing qualitative and quantitative evidence in systematic reviews have been developed, including narrative synthesis with the more methodologically explicit thematic analysis method. This process involves identifying thematic patterns across the literature, grouping findings based on conceptual similarities, and developing an integrated interpretive framework (Ahmed et al., 2025). Thematic synthesis has the greatest potential for hypothesis generation (Flemming & Noyes, 2021). To ensure consistency of interpretation, the synthesis process also involves cross-checking between researchers.

The quality of the included literature was assessed using criteria adapted from the Critical Appraisal Skills Programme (CASP) for theoretical and philosophical studies. These criteria include: (1) clarity of purpose statement and problem formulation; (2) appropriate use of sources and references; (3) depth of conceptual analysis; (4) originality of theoretical contribution; (5) transparency of argumentation; and (6) relevance to the research question. No literature was excluded solely on the basis of quality assessment, but literature scoring low on these criteria was given less weight in the final synthesis to maintain a balance between inclusiveness and validity of findings.

RESULTS AND DISCUSSIONS

This study successfully identified and analyzed 29 key literatures that substantially discuss the ontological foundations of natural science and social science. Based on a systematic search through the databases of Scopus, SpringerLink, PhilPapers, and other reputable sources, it was found that the distribution of the literature is divided into several main categories. Approximately 38 percent of the literature (11 articles) focuses on the ontology of social science, 31 percent (9 articles) discusses the integration between natural science and social science, 17 percent (5 articles) examines the ontology of natural science, and 14 percent (4 articles) discusses general metaphysical issues and the philosophy of science. The majority of publications were published by leading academic publishers such as Springer, Routledge/Taylor & Francis, and Oxford University Press, with a fairly diverse range of years from 2015 to 2026. The highest concentration of publications occurred in the period 2020-

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2025, reflecting the increasing attention to metaphysical issues in the context of interdisciplinary research in the past decade.

A systematic search based on the PRISMA 2020 protocol in Scopus, SpringerLink, PhilPapers, and other databases yielded 29 key publications (Table 1). The highest concentration of publications in the 2020–2025 period (62%) reflects the increasing attention to metaphysical issues in interdisciplinary research, particularly due to the push to integrate the natural and social sciences in addressing global crises such as sustainability.

Table 1. Distribution of Literature based on Ontological Focus

Main focus	Number (n=29)	Percentage	Sample Source
Social Science Ontology	11	38%	Buch-Hansen (2023), Kolasi (2018), Porpora (2015)
Natural-Social Science Integration	9	31%	Persson et al., (2018), Longo et al., (2025)
Natural Science Ontology	5	17%	Sambrotta (2023), Mitchell (2023), Ferari (2024)
General Metaphysics/Philosophy of Science	4	14%	Ross (2023), Saunders (2020), Bryant (2025)

Meanwhile, the thematic analysis yielded four social ontological themes, and integration emphasized the urgency of social ontology, which is more debated due to the fluid nature of social reality, while integration efforts became the focus due to clashes between ontologies. The thematic analysis, meanwhile, yielded four main interconnected ontological themes. Table 2 maps subthemes, key authors' positions, and unresolved tensions, thus immediately indicating areas of debate that require further discussion.

Table 2. Map of Themes and Ontological Tensions in IPAS

Themes	Key Sub-Themes	Key Authors	Position/Consensus	Critical Tension/Debate
Natural Science Ontology	Metaphysical naturalism; reductionism vs.	Sambrotta (2023), Mitchell (2023), Ferari (2024),	Reality is external, orderly, and observable. Metaphysical naturalism is	Mitchell criticized reductionism and called for pluralism; Ferari proposed

Analyzing the Ontological Foundations of IPAS through Dialogue between Experts

Questioning the Single Foundation of Natural Science

The finding that the ontology of natural science is dominated by metaphysical naturalism (Sambrotta, 2023) and is simultaneously undermined by the insistence on pluralism (Ferrari, 2024; Mitchell, 2023) marks a significant shift in contemporary philosophy of science. Sambrotta formulated metaphysical naturalism as the ontological thesis that "the world is what natural science says it is," a position that negates non-physical entities interacting with our reality. However Mitchell (2023), dismantles the reductionist assumption often attached to it by showing that current scientific practices, from condensed matter physics to systems biology, operate with diverse ontologies that cannot be reduced to a single fundamental level. This failure of reductionism is not a weakness, but rather a reflection of a stratified reality. Contingency, thus avoiding fundamentalism without falling into dualistic fragmentation, parallels the critique of "physicalism," which is considered no longer adequate to explain the complexity found in the life and cognitive sciences.

Thus, the claim that the natural sciences possess a single ontology is now untenable. Instead, what emerges is a picture of ontological pluralism that remains tied to minimal realism—that is, a commitment to the existence of an external world independent of human consciousness. Both authors, however, have not provided concrete guidance on how this pluralism might be operationalized within an interdisciplinary project.

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Social Sciences: Between Structure and Theme

Unlike the natural sciences, the ontology of the social sciences lacks a single center of gravity. Three major currents critical realism, constructivism/interpretivism, and pragmatism coexist with competing metaphysical claims. The most pointed debate revolves around the status of social reality: is it merely a product of intersubjective meaning, or does it possess an independent objective dimension? Kolasï (2018), convincingly critiques the constructivist tendency in International Relations to reduce social ontology to "shared meaning." He argues that structures such as hierarchy and dependency possess causal powers that operate independently of actors' recognition, so reducing them to the intersubjective realm means missing half of reality. This argument directly

resonates with the thinking of (Porpora, 2015) who asserts that social structure is a metaphysical reality irreducible to the aggregate of individual actions, thus demanding an ontology that recognizes the dialectical relationship between agency and structure.

However, an approach that views social reality solely as objective is also inadequate. This is where typology (Buch-Hansen, 2023) becomes a valuable analytical tool. It maps "strong" and "weak" versions of positivism, constructivism, and critical realism, demonstrating that in sustainability research practice, researchers often implicitly blend elements from different positions. This suggests that the rigid polarization between ontological objectivism and subjectivism does not reflect the complexity of actual research. This synthesis thus points to the need for a framework that can accommodate both the objective dimensions of social structures and the constitutive role of human meaning and action.

Bridging Without Imperialism: Critical Offerings and Methodological Pluralism

The ontological tension between the natural and social sciences is not philosophical speculation, but rather an empirical reality in interdisciplinary projects. . Persson et al., (2018) meticulously document how eight attempts at integration from environmental economics to sociobiology failed to produce a comprehensive understanding of sustainability due to incompatible ontological assumptions. Their solution is a sophisticatedly managed pluralism, not a unification that risks scientific imperialism, nor a structureless pluralism that creates communication barriers. This position is reinforced by Longo et al., (2025), who position critical realism as a "middle way." Through a layered ontology (empirical, actual, and real realms) inherited from Bhaskar, critical realism recognizes that both ecological and social structures have causal powers independent of human perception, while rejecting the prioritization of one ontological level over the other. In doing so, it enables more equitable and productive collaboration.

Despite its promise, critical realism's offerings still face operational challenges. Kaidesoja (2013) cautions that naturalizing the ontology of critical realism requires significant modifications, including abandoning transcendental arguments and limiting the application of the concept of causal power to concrete systems. This means that critical realism cannot simply be adopted as a ready-made doctrine; it must be reconstructed to align with contemporary social science practices and empirical evidence.

Integrasi Naturalistic Mentaphysics as an Integration Umbrella

In a more abstract realm, efforts to bridge natural and social ontologies are embodied in the project of an integrated naturalistic metaphysics. Saunders (2020), questions the skepticism that considers social science insufficiently reliable as a basis for the naturalization of metaphysics. Using a case study of contextual effects in social epidemiology, he demonstrates that social science can provide relevant and robust evidence for metaphysical claims. Bryant (2025), goes even further by demonstrating that archaeology, often viewed as inferior, is now increasingly methodologically converging with the exact sciences, making long-held prejudices against social science untenable. These two studies pave the way for the naturalization of social metaphysics without requiring social science to emulate the predictive standards of physics.

Meanwhile, the debate between model-based approaches (Sarkia, 2022) and inference to the best explanation (Shevchenko, 2023) suggests that no single method is superior for naturalization. Sarkia emphasizes that modeling is truly central to the practice of social ontology, while Shevchenko, while critical of IBE, acknowledges that only IBE is capable of producing a consistent realist ontology because it avoids both

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empirically grounded concepts and normative prescriptions. Both approaches, along with the criticisms they receive, emphasize the need for methodological pluralism: various paths to naturalization can be pursued according to the context of the ontological question being posed. This stance aligns with Ross (2023), radical naturalistic metaphysical program, which prohibits the use of transcendental categories and bases metaphysics entirely on first-order scientific theories and models.

Implications for IPAS Development

This synthesis provides a solid foundation for the development of Natural and Social Sciences (IPAS) as a reflective interdisciplinary field. First, findings regarding ontological diversity across both domains require IPAS researchers to possess metaphysical literacy—the ability to recognize, articulate, and negotiate their held ontological assumptions. Without this ability, interdisciplinary collaborations are vulnerable to failure due to unconscious clashes of assumptions.

Second, the resulting conceptual model (Table 2) can serve as a roadmap for designing interdisciplinary dialogue. Providing a "liminal" space where researchers explicitly discuss their metaphysical assumptions is a prerequisite for successful integration. Third, the Indonesian science and science curriculum, which serves as the starting point for this study, must include modules on the ontology and metaphysics of science to avoid falling into shallow methodological syncretism. Students need to be encouraged to understand that integrating the natural and social sciences is not simply about combining methods, but rather about harmonizing perspectives on reality. Fourth, future interdisciplinary research needs to empirically test the effectiveness of the critical realism and methodological pluralism frameworks advocated in this synthesis. So far, support for both frameworks has been conceptual; case studies that trace shifting ontological assumptions in long-term collaborative projects would be invaluable.

CONCLUSION

This study concludes that the natural sciences are based on metaphysical naturalism that is now shifting to pluralism with critical realism as the main bridge, while the social sciences show high ontological diversity from critical realism to constructivism—so that ontological tensions in interdisciplinary research often thwart integration. The solution lies in consciously articulated pluralism and the adoption of critical realism as a mediating framework. Practical implications for science education include developing metaphysical literacy in the curriculum, designing interdisciplinary dialogue spaces that explicitly negotiate ontological differences, and strengthening the metaphysical foundations of social science based on its own best practices to create an equal partnership with the natural sciences.

While providing a coherent conceptual map, this study is limited to English-language international databases, spanning 2015–2026, and predominantly Western perspectives, thus failing to capture the richness of local ontologies. Future research agendas should expand the search to non-Western literature and Indonesian local wisdom, develop metaphysical literacy assessment instruments, and test the effectiveness of critical realism and methodological pluralism frameworks through longitudinal case studies in real interdisciplinary projects. In this way, IPAS can develop into a collaborative model that is not only tolerant of ontological differences but also makes them a productive resource for integration.

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