

Reconciling Art, Science, and Prediction in Real Estate Valuation: Toward a Hybrid Epistemology for the Ai Era

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ABSTRACT

Real estate valuation has long been characterised by tensions between subjective professional judgement and objective scientific methodology, resulting in a persistent art-science dichotomy within the discipline. Traditional valuation practice has relied heavily on interpretive expertise, contextual reasoning, and experiential judgement, while subsequent efforts to professionalise the field have emphasised standardisation, empirical validation, and methodological consistency. More recently, advances in artificial intelligence (AI), automated valuation models (AVMs), and machine learning have introduced a third paradigm, prediction, shifting valuation practice toward data-driven forecasting and algorithmic intelligence. These developments raise fundamental questions regarding the nature of valuation knowledge and the epistemological foundations that underpin professional valuation practice in the AI era. This conceptual paper examines the epistemological evolution of real estate valuation across art, science, and prediction paradigms and argues for the need to move beyond binary debates that position these approaches as competing or mutually exclusive. Adopting a conceptual analytical approach, the study synthesises peer-reviewed valuation literature, professional valuation standards, and contemporary research on AI-enabled valuation. Through comparative epistemological analysis and the application of a Pragmatist philosophical lens, the study develops the Valuation Epistemological Continuum (VEC), a unifying framework that conceptualises valuation knowledge as progressing from interpretive understanding to methodological validation and predictive optimisation. The findings demonstrate that art, science, and prediction are underpinned by distinct yet complementary epistemic logics, each contributing essential forms of knowledge to valuation practice. Rather than displacing professional judgement, predictive intelligence can be understood as extending the epistemological repertoire of valuation when appropriately integrated. This paper contributes theoretical clarity to emerging debates on AI-enabled valuation and provides a coherent epistemological foundation for future empirical, technical, and interdisciplinary research, particularly studies examining structured human-AI collaboration in real estate valuation. As a conceptual and theoretical study, this paper does not involve empirical model testing or performance evaluation.

Keywords: valuation epistemology, automated valuation model (AVM), artificial intelligence (AI), predictive analytics, hybrid epistemology, real estate valuation.

INTRODUCTION

Real estate valuation has long been characterized by a fundamental epistemological tension: is valuation an art or a science? This debate, which has persisted throughout the profession's modern history, reflects deeper questions about the nature of valuation knowledge, the validity of valuation methods, and the role of professional expertise in determining property worth (French, 2011; Crosby & Henneberry, 1996). Traditionally, valuation

has been understood as an interpretive practice requiring professional judgement, contextual insight, and experiential wisdom qualities that resist standardization and quantification. Simultaneously, the profession has pursued scientific legitimacy through standardized methodologies, quantitative techniques, and regulatory frameworks designed to ensure consistency, transparency, and objectivity (Pagourtzi et al., 2003; RICS, 2020).

The advent of artificial intelligence (AI), big data analytics, and machine learning has introduced a transformative third dimension to this discourse: valuation as prediction. Automated valuation models (AVMs), neural networks, and algorithmic forecasting systems now generate property valuations at unprecedented speed and scale, leveraging vast datasets and computational power to predict market values with increasing accuracy (McCluskey & Borst, 2017; Zurada et al., 2011). These models have become a central application of these techniques, particularly in mass appraisal and mortgage valuation contexts, due to their scalability, efficiency, and ability to process large datasets (McCluskey & Borst, 2017). This technological shift has fundamentally altered the epistemological landscape of valuation, raising critical questions: What constitutes valid valuation knowledge in an AI-driven environment? How do algorithmic predictions relate to professional judgement and scientific method? Can traditional valuation expertise coexist with computational intelligence, or does AI represent a paradigmatic rupture?

Despite the growing body of literature on AI applications in valuation, current research remains fragmented across disciplinary boundaries. Behavioural valuation studies emphasize the subjective, interpretive dimensions of professional judgement (Diaz, 1999; Levy & Schuck, 2005), while methodological research advocates for standardization and scientific rigour (French & Gabrielli, 2004; Mallinson & French, 2000). Concurrently, computational studies demonstrate the predictive superiority of machine learning models over traditional methods (Díaz & Hansz, 2020; Peterson & Flanagan, 2009). However, these streams of inquiry have yet to be integrated within a coherent epistemological framework that acknowledges the complementary contributions of human judgement, scientific method, and predictive analytics.

Recent studies have increasingly demonstrated the growing role of AI and machine learning (ML) in real estate valuation. Advanced models such as random forests, gradient boosting, and neural networks have shown improved predictive accuracy compared to traditional hedonic approaches, particularly in large-scale residential markets (Antipov & Pokryshevskaya, 2012; Baldominos et al., 2018; Ho et al., 2021). Empirical evidence further indicates that machine learning methods are capable of capturing complex non-linear relationships and interaction effects that conventional valuation techniques may overlook (Čeh et al., 2018).

More recent research has also focused on explainable artificial intelligence (XAI) to address transparency challenges associated with automated valuation models, highlighting the importance of interpretability, accountability, and trust in professional valuation contexts (Lundberg & Lee, 2017; Molnar, 2020). Despite these advancements, existing studies remain largely technical and fragmented, with limited integration into valuation theory and professional epistemology. This gap highlights the need for a unified conceptual framework such as the Valuation Epistemological Continuum (VEC).

This conceptual paper addresses this gap by proposing a hybrid epistemology for real estate valuation—one that transcends the art-science dichotomy and accommodates the predictive capabilities of AI. Drawing on Pragmatism as a unifying philosophical stance, the study introduces the VEC, a conceptual model that positions judgement, method, and prediction not as competing paradigms but as interconnected dimensions of valuation knowledge. This continuum recognizes that modern valuation practice requires the integration of professional interpretation (art), standardized methodology (science), and algorithmic forecasting (prediction) to produce credible, contextually grounded, and empirically robust valuations.

The implications of this hybrid epistemology are significant. For practitioners, it redefines the valuer's role from sole expert to augmented decision-maker, where AI serves as an analytical tool that amplifies rather than replaces professional judgement. For educators, it necessitates curriculum redesign to integrate data science, AI literacy, and ethical governance into valuation training. For regulators and professional bodies, it demands the development of standards that address algorithmic transparency, accountability, and bias mitigation. Ultimately, this framework supports the emergence of a Valuation 4.0 human-machine collaborative paradigm that preserves professional accountability while harnessing computational intelligence.

Accordingly, this paper contributes at the level of theory by developing a conceptual epistemological framework, rather than proposing a technical valuation model or empirical testing protocol.

This study makes three key contributions to literature. First, it advances valuation theory by reconceptualizing the long-standing art-science debate into a multi-dimensional epistemological continuum that incorporates predictive analytics. Second, it provides a novel theoretical foundation for understanding human–AI collaboration in valuation practice, moving beyond purely technical discussions of automated valuation models. Third, it offers a structured conceptual basis for future empirical research, particularly in developing hybrid valuation frameworks that integrate professional judgement, standardized methods, and machine learning techniques.

The paper is structured as follows. The next section outlines the methodological approach adopted in this study. This is followed by a discussion of the evolution of valuation epistemology across the art, science, and prediction paradigms, and a comparative analysis of their underlying assumptions. The paper then develops a hybrid epistemological framework through the VEC, before discussing its implications for professional practice, education, and research. The paper concludes by outlining directions for future empirical work.

Methodological Approach

This study adopts a conceptual analytical approach aimed at developing a hybrid epistemological framework for real estate valuation. Unlike empirical studies that rely on primary data collection, this conceptual paper synthesises multiple theoretical, methodological, and technological perspectives to explain the epistemic shift from art to science and, subsequently, to prediction. The method follows four systematic steps.

First, the study identifies and reviews the evolution of valuation paradigms by analysing foundational works in behavioural valuation (e.g., Crosby & Henneberry, 1996; Diaz, 1999), scientific valuation methodology (e.g., French, 2011; Pagourtzi et al., 2003), and predictive analytics (e.g., Zurada et al., 2011; Díaz & Hansz, 2020). This step establishes the theoretical basis for understanding how valuation knowledge has developed across interpretive, positivist, and computational traditions.

Second, the study conducts a comparative epistemological analysis, contrasting the ontological and methodological assumptions embedded within the three paradigms. Key criteria include the source of knowledge, validation logic, methodological stance, and implications for professional judgement. This comparison provides a structured foundation for examining convergence and divergence between paradigms.

Third, insights from the three paradigms are integrated through an interpretive synthesis, drawing on Pragmatism as the overarching philosophical position. Pragmatism is used to connect professional judgement (art), empirical standardisation (science), and predictive intelligence (AI/ML) by emphasising the practical usefulness and consequences of knowledge claims. This step enables the consolidation of fragmented valuation theories into a coherent epistemological continuum.

Finally, the study develops a conceptual framework, termed the VEC. This model is constructed by mapping the progression from judgement-based interpretation to methodological validation and predictive optimisation. The model is refined by integrating concepts of hybrid knowledge production, human-AI collaboration, and decision-support logic in contemporary valuation practice.

Overall, the methodological approach is qualitative, integrative, and theory-building, relying exclusively on peer-reviewed literature, industry standards (e.g., IVS, RICS), and conceptual insights rather than empirical data. The purpose is not to test hypotheses, but to construct a theoretical foundation that can guide future empirical research on AI-driven valuation.

The outcome of this methodological process is not empirical data but a set of synthesised theoretical insights that inform the construction of a unified epistemological model. The study therefore proceeds through conceptual synthesis and comparative epistemological analysis to develop a coherent explanation of how valuation knowledge transitions from art to science and, ultimately, to prediction in the AI era. Accordingly, the following

section presents the analytical results of this synthesis by comparing, integrating, and reframing the three valuation paradigms within the proposed VEC.

RESULT AND DISCUSSION

The results of the conceptual analysis follow directly from the methodological steps outlined in the previous section. By reviewing the major theoretical traditions in valuation and comparing their epistemological logics, the analysis reveals clear distinctions in how knowledge is constructed under the art, science and prediction paradigms. These insights form the basis for synthesising a hybrid understanding of valuation, consistent with the Pragmatist stance adopted in the method. This section therefore discusses the conceptual outcomes of the analysis: first, the comparative dimensions of valuation paradigms; second, their integration into a unified epistemological continuum; and third, the implications of this continuum for AI-enabled valuation practice.

The Evolution of Valuation Epistemology

The epistemological foundations of real estate valuation have evolved through three distinct yet overlapping paradigms, each reflecting broader shifts in professional identity, methodological practice, and technological capability. This section traces this evolution, demonstrating how valuation knowledge has progressively expanded from interpretive judgement to scientific standardization to predictive analytics.

Valuation as an Art

The conceptualization of valuation as an art represents the profession's earliest and most enduring epistemological stance. Rooted in constructivist and interpretivist traditions, this paradigm emphasizes the subjective, contextual, and experiential dimensions of valuation practice. Valuation is understood as an interpretive act requiring professional judgement, intuition, and tacit knowledge qualities that resist codification and quantification (Crosby & Henneberry, 1996; Ratcliff, 1961). The valuer, in this view, is a craftsman whose expertise derives not from algorithmic application but from accumulated experience, market familiarity, and the ability to synthesize diverse qualitative and quantitative information into a reasoned opinion of value.

Central to this paradigm is the recognition that value is not an objective property inherent in real estate, but a socially constructed phenomenon shaped by perception, context, and market psychology (Diaz, 1999). As Crosby (2000, p. 211) observes, "value is what someone is prepared to pay, not what a formula calculates." This perspective acknowledges the irreducible complexity of real estate markets, where heterogeneity of assets, information asymmetries, and behavioural factors render purely mechanical valuation methods insufficient. Professional judgement becomes essential for navigating uncertainty, interpreting market signals, and adjusting standardized techniques to account for property-specific and contextual variables.

Empirical research within the behavioural valuation tradition has substantiated this view by documenting systematic biases, heuristics, and cognitive influences in valuation practice. Studies have identified phenomena such as anchoring effects, where valuers unconsciously anchor their estimates to prior valuations or asking prices (Northcraft & Neale, 1987; Diaz & Hansz, 1997); confirmation bias, where valuers selectively interpret evidence to support initial hypotheses (Gallimore, 1996); and client influence, where valuers adjust estimates in response to perceived client expectations (Levy & Schuck, 2005). These findings demonstrate that valuation is not a purely rational, objective process but one mediated by psychological, social, and organizational factors.

The strengths of the art paradigm lie in its recognition of valuation's contextual complexity and the irreplaceable role of professional expertise in interpreting ambiguous market information. Experienced valuers possess tacit knowledge and intuitive understanding of market dynamics, property characteristics, and locational factors that cannot be fully articulated or algorithmically replicated (Baum et al., 2000). This interpretive capacity is particularly valuable in illiquid markets, unique properties, or situations involving incomplete information, where standardized methods provide insufficient guidance.

However, the art paradigm also faces significant limitations. The reliance on subjective judgement introduces variability and potential bias, undermining consistency and comparability across valuations (Crosby et al., 1998).

The absence of explicit methodological standards makes it difficult to validate valuations, assess accuracy, or hold practitioners accountable. Moreover, the characterization of valuation as an art has historically impeded the profession's efforts to establish scientific legitimacy and regulatory credibility (French, 2011). As valuation has become increasingly integrated into financial markets, regulatory frameworks, and litigation processes, the demand for transparency, standardization, and empirical validation has intensified, creating pressure to move beyond purely interpretive approaches.

Valuation as a Science

The scientific paradigm represents a positive response to the limitations of the art-based approach, emphasizing objectivity, standardization, and methodological rigour. Emerging prominently in the mid-20th century and gaining institutional momentum through the development of international valuation standards, this paradigm seeks to establish valuation as a systematic, replicable, and empirically grounded discipline (French & Gabrielli, 2004; RICS, 2020). The scientific stance asserts that value, while market-determined, can be measured objectively through standardized methodologies, transparent assumptions, and verifiable data (Pagourtzi et al., 2003).

Central to this paradigm is the development and institutionalization of valuation standards, most notably the Royal Institution of Chartered Surveyors (RICS) Valuation Global Standards (the "Red Book") and the International Valuation Standards (IVS). These frameworks establish uniform definitions of value, prescribe acceptable valuation methods, mandate disclosure requirements, and specify professional conduct standards (RICS, 2020; IVSC, 2022). By codifying best practices and establishing procedural consistency, these standards aim to reduce variability, enhance transparency, and increase the reliability of valuation outputs.

Methodologically, the scientific paradigm emphasizes quantitative techniques grounded in economic theory and statistical analysis. The income capitalization approach, particularly discounted cash flow (DCF) analysis, exemplifies this orientation by modelling property value as the present value of future income streams, explicitly incorporating assumptions about rental growth, discount rates, and exit yields (Baum & Crosby, 2008). Similarly, the comparative method has been formalized through hedonic regression models, which decompose property prices into constituent attributes and estimate the marginal contribution of each characteristic to overall value (Rosen, 1974; Malpezzi, 2003). These techniques provide explicit, replicable frameworks for translating market data into value estimates, reducing reliance on subjective judgement.

The scientific paradigm also emphasizes empirical validation and accuracy assessment. Research has developed metrics such as mean absolute percentage error (MAPE), root mean square error (RMSE) and hit rates to evaluate valuation performance and compare methodological approaches (Crosby et al., 1998; French & Gabrielli, 2004). Studies examining valuation accuracy have revealed persistent variance and bias, even within standardized frameworks, prompting ongoing methodological refinement (Baum et al., 2000; Crosby, 2000). This commitment to empirical testing and continuous improvement reflects the scientific ethos of falsifiability and progressive knowledge accumulation.

The strengths of the scientific paradigm are substantial. Standardization enhances consistency, facilitates comparability, and supports regulatory compliance. Quantitative methods provide transparent, auditable frameworks that can be scrutinized and replicated. The emphasis on empirical validation promotes accountability and drives methodological innovation. Moreover, the scientific approach has elevated the profession's credibility within financial markets, regulatory agencies, and legal contexts, where objective, defensible valuations are essential.

However, the scientific paradigm also faces inherent limitations. Standardized methods, while promoting consistency, can be rigid and insufficiently responsive to property-specific complexities and market nuances (French, 2011). The emphasis on quantification may lead to spurious precision, where valuations appear objective but rest on subjective assumptions embedded in model specifications, parameter estimates, and data selection (Mallinson & French, 2000). Furthermore, the positivist stance tends to underestimate the role of professional judgement in interpreting data, selecting comparable properties, and adjusting for qualitative factors elements that remain essential even within ostensibly scientific frameworks (Crosby & Henneberry, 1996).

Valuation as Prediction

The emergence of big data, AI, and machine learning has introduced a third epistemological paradigm: valuation as prediction. This paradigm shifts the focus from static estimation to dynamic forecasting, leveraging computational algorithms to identify patterns in large datasets and generate probabilistic value predictions (McCluskey & Borst, 2017; Díaz & Hansz, 2020). Rather than relying primarily on professional judgement or standardized methodologies, the predictive paradigm treats valuation as a data-driven process where value is derived algorithmically from historical transaction data, property characteristics, and market variables.

AVMs represent the most prominent manifestation of this paradigm. AVMs employ statistical and machine learning techniques including multiple regression, hedonic modelling, neural networks, random forests, and gradient boosting to predict property values based on training data comprising prior sales, property attributes, and locational factors (Zurada et al., 2011; Peterson & Flanagan, 2009). These models can process millions of transactions, incorporate hundreds of variables, and generate valuations instantaneously, offering unattainable scalability and efficiency through traditional methods (McCluskey & Borst, 2017).

The predictive paradigm is grounded in an empirical computational epistemology, where knowledge validity is assessed through predictive accuracy rather than theoretical coherence or professional consensus. Model performance is evaluated using metrics such as R-squared, RMSE, mean absolute error (MAE), and cross-validation accuracy, with algorithmic refinement driven by iterative testing and optimization (Zurada et al., 2011). This approach reflects a pragmatic orientation: a model is considered valid if it consistently predicts market outcomes with acceptable accuracy, regardless of whether its internal logic aligns with conventional valuation theory.

Research comparing AVMs with traditional valuation methods has demonstrated the predictive superiority of machine learning approaches, particularly in homogeneous residential markets with abundant transaction data (Pace et al., 1998; Peterson & Flanagan, 2009). Neural networks and ensemble methods have proven especially effective in capturing non-linear relationships and interaction effects that linear models and human valuers may overlook (Zurada et al., 2011; Čeh et al., 2018). Moreover, AVMs eliminate certain sources of human bias, such as anchoring and client influence, potentially enhancing objectivity (Díaz & Hansz, 2020).

The predictive paradigm also introduces temporal dynamism into valuation practice. Unlike traditional valuations, which provide point-in-time estimates, machine learning models can incorporate time-series data, track market trends, and update predictions in real-time as new information becomes available (McCluskey & Borst, 2017). This capability is particularly valuable in rapidly changing markets, where static valuations quickly become obsolete.

However, the predictive paradigm also presents significant epistemological and practical challenges. Machine learning models, particularly deep neural networks, often function as "black boxes," generating predictions without transparent, interpretable reasoning (Molnar, 2020). This opacity creates accountability problems: when an AVM produces an erroneous valuation, it is often unclear whether the error stems from data quality, model specification, or algorithmic bias (Díaz & Hansz, 2020). The lack of interpretability also limits professional learning and undermines trust among stakeholders who require explainable valuations.

Furthermore, AVMs are highly dependent on data availability and quality. They perform well in liquid markets with standardized properties and abundant transactions but struggle in illiquid markets, unique properties, or situations involving incomplete data (McCluskey & Borst, 2017). The models also risk perpetuating historical biases embedded in training data, such as discriminatory pricing patterns, raising ethical and legal concerns (Agarwal et al., 2020). Finally, the predictive paradigm tends to prioritize statistical accuracy over contextual understanding, potentially overlooking qualitative factors such as planning constraints, environmental risks, or market sentiment that experienced valuers would consider (French, 2011).

Synthesis: From Dichotomy to Continuum

The evolution of valuation epistemology reveals not a linear progression from inferior to superior paradigms but rather a cumulative expansion of valuation knowledge. Each paradigm contributes distinct strengths: the art paradigm provides contextual insight and interpretive flexibility; the science paradigm ensures methodological consistency and transparency; the prediction paradigm offers scalability and empirical precision. Conversely, each paradigm also exhibits limitations: the art paradigm risks subjectivity and bias; the science paradigm can be rigid and oversimplified; the prediction paradigm may lack interpretability and contextual sensitivity.

Rather than viewing these paradigms as mutually exclusive alternatives, contemporary valuation practice increasingly recognizes them as complementary dimensions of a broader epistemological continuum. Professional valuers routinely integrate judgement, standardized methods, and data analytics within individual valuation assignments, adjusting the balance based on property type, market conditions, and client requirements (French, 2011). The challenge, therefore, is not to choose between art, science, and prediction but to develop a coherent epistemological framework that integrates these dimensions while addressing their respective limitations.

Comparing Epistemological Paradigms In Valuation

To clarify the relationships and distinctions among the three valuation paradigms, this section provides a systematic comparison of their ontological assumptions, knowledge sources, validation criteria, and practical strengths and limitations. Table 1 synthesizes these dimensions, highlighting both the divergences and potential complementarities among paradigms.

Table 1: Comparative Analysis of Valuation Epistemological Paradigms

Aspect	Art	Science	Prediction
Epistemic Stance	Constructivist/ Interpretive	Positivist / Rationalist	Empirical– Computational
Ontology of Value	Subjective, context-dependent, socially constructed	Objective, measurable, market-determined	Data-derived, probabilistic, algorithmically generated
Knowledge Source	Professional judgement, tacit knowledge, experience	Market evidence, standardized methods, economic theory	Large datasets, algorithmic pattern recognition, statistical learning
Primary Method	Intuitive synthesis, qualitative interpretation, heuristic reasoning	Comparative analysis, DCF, hedonic regression, standardized frameworks	Machine learning, neural networks, AVMs, predictive modelling
Validation Criterion	Reasonableness, professional consensus, client acceptance	Compliance with standards (RICS, IVS), methodological transparency, replicability	Predictive accuracy (RMSE, R ² , MAE), cross-validation, out-of-sample testing
Role of Valuer	Expert interpreter, craftsman, professional authority	Methodological practitioner, standards-compliant analyst	Data scientist, model auditor, augmented decision-maker
Strength	Contextual sensitivity, handling of unique properties, interpretive flexibility, tacit market knowledge	Consistency, transparency, regulatory compliance, methodological rigour, replicability	Scalability, speed, real-time updates, elimination of certain biases, handling of complex non-linear relationships
Limitation	Subjectivity, potential bias (anchoring, client influence), lack of	Rigidity, oversimplification of complex realities, spurious precision, insufficient	Opacity ("black box" problem), data dependency, difficulty

	transparency, variability across valuers, limited accountability	responsiveness to qualitative factors, embedded subjective assumptions	with unique properties, risk of perpetuating historical biases, limited contextual understanding, ethical concerns
Epistemological Risk	Inconsistency and unverifiable claims	Over-reliance on standardization at expense of judgement	Algorithmic determinism and loss of professional agency

Ontological Divergence and Convergence

The three paradigms rest on fundamentally different ontological assumptions about the nature of value. The art paradigm adopts a constructivist ontology, viewing value as a subjective, context-dependent phenomenon shaped by perception, negotiation, and social processes (Diaz, 1999). The science paradigm, in contrast, assumes a realist ontology, treating value as an objective property that can be measured through systematic observation and analysis of market behaviour (French & Gabrielli, 2004). The prediction paradigm adopts a pragmatic, empirical stance, treating value as whatever a well-calibrated algorithm predicts, based on patterns in historical data (McCluskey & Borst, 2017).

Despite these differences, convergence is possible. All three paradigms ultimately ground value in market transactions whether interpreted through professional judgement, analyzed through standardized methods, or predicted through algorithmic learning. The key distinction lies not in the ontological status of value itself but in the epistemological approach to knowing and determining value.

Knowledge Sources and Validation

The paradigms differ significantly in their sources of valuation knowledge and criteria for validation. The art paradigm privileges experiential knowledge, professional intuition, and tacit understanding, validated through reasonableness and peer consensus (Crosby & Henneberry, 1996). The science paradigm emphasizes explicit, codified knowledge derived from market data and economic theory, validated through compliance with professional standards and methodological transparency (RICS, 2020). The prediction paradigm relies on algorithmic knowledge extracted from large datasets through statistical learning, validated through predictive accuracy metrics (Zurada et al., 2011).

These differing validation criteria create potential conflicts. A valuation may be considered valid under the art paradigm (professionally reasonable) yet fail scientific validation (methodologically inconsistent) or predictive validation (statistically inaccurate). Conversely, a highly accurate AVM prediction may lack the contextual nuance and qualitative judgement that professional standards require. Reconciling these validation criteria is a central challenge for hybrid epistemology.

Complementary Strengths and Limitations

Table 1 reveals that the strengths of one paradigm often compensate for the limitations of others. The art paradigm excels in handling unique properties and complex contexts where standardized methods and data-driven models struggle, but it suffers from subjectivity and inconsistency. The science paradigm provides consistency and transparency but can be rigid and insufficiently responsive to qualitative factors. The prediction paradigm offers scalability and empirical precision but lacks interpretability and contextual sensitivity.

This complementarity suggests that optimal valuation practice may require integrating elements from all three paradigms. For example, an AVM might generate an initial value estimate (prediction), which is then adjusted using standardized methodologies (science) and refined through professional judgement to account for property-specific factors (art). This integrated approach leverages the efficiency of algorithms, the consistency of standards, and the contextual insight of human expertise.

The Need for a Hybrid Framework

The comparative analysis demonstrates that no single paradigm is epistemologically sufficient for contemporary valuation practice. The art paradigm alone cannot meet demands for consistency, transparency, and scalability. The science paradigm alone cannot accommodate the complexity, heterogeneity, and qualitative dimensions of real estate markets. The prediction paradigm alone cannot provide interpretability, contextual sensitivity, or ethical accountability.

A hybrid epistemology is therefore necessary—one that integrates the interpretive flexibility of art, the methodological rigour of science, and the predictive power of AI within a coherent conceptual framework. The next section develops this hybrid epistemology, proposing the VEC as a unifying model.

These conceptual results illustrate the value of the analytical approach used in this study. By combining comparative epistemology with Pragmatist integration, the discussion demonstrates how the VEC emerges not as a speculative model, but as the logical outcome of a structured interpretive synthesis. This alignment between methodology and conceptual results reinforces the coherence and theoretical contribution of the paper.

Toward A Hybrid Epistemology Of Valuation

The hybrid epistemology proposed in this paper rests on three foundational premises.

First, valuation knowledge is inherently multidimensional, encompassing interpretive judgement, methodological standardization, and predictive analytics. No single dimension is sufficient; all are necessary for producing credible, contextually grounded, and empirically robust valuations.

Second, these dimensions operate in a mutually reinforcing manner, operating along a continuum rather than as discrete alternatives.

Third, the integration of human and algorithmic intelligence represents not a threat to professional expertise but an opportunity for augmentation, where AI enhances human capabilities while remaining subject to professional oversight.

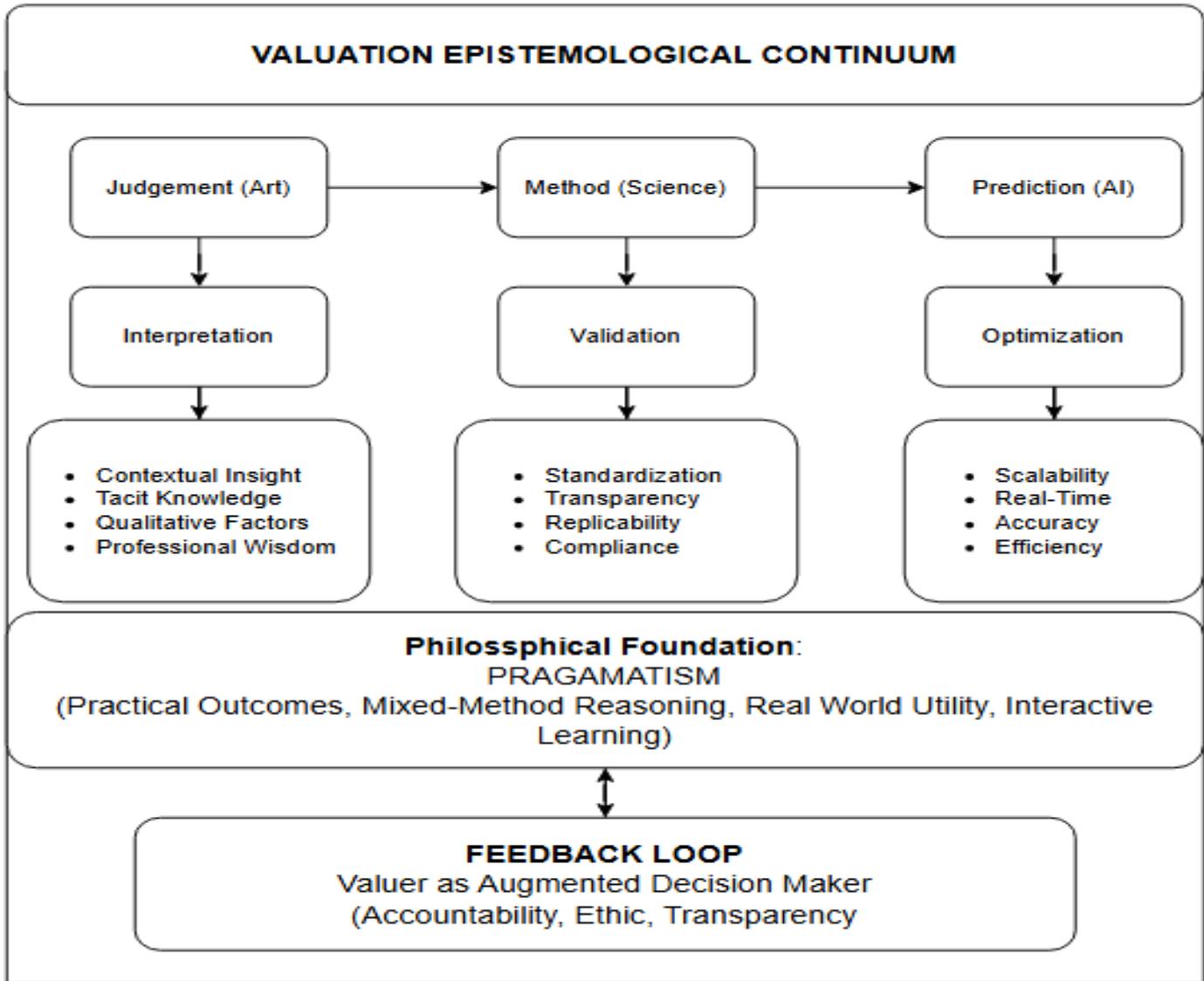
This hybrid epistemology draws on Pragmatism as its overarching philosophical stance. Pragmatism, as articulated by philosophers such as William James, John Dewey, and Charles Sanders Peirce, rejects binary epistemological dichotomies and instead evaluates knowledge claims based on their practical consequences and real-world utility (James, 1907; Dewey, 1938). From a pragmatist perspective, the validity of valuation knowledge is determined not by adherence to a single methodological orthodoxy but by its effectiveness in producing reliable, useful, and contextually appropriate value estimates that serve stakeholders' needs.

Pragmatism is particularly well-suited to valuation for several reasons. First, it accommodates methodological pluralism, recognizing that different contexts and purposes may require different combinations of judgement, method, and prediction (Rorty, 1982). Second, it emphasizes the practical consequences of valuation decisions, aligning with the profession's ultimate goal of informing real-world transactions, investments, and policy decisions. Third, it supports iterative learning and adaptive refinement, consistent with the evolving nature of valuation practice in response to technological change and market dynamics (Dewey, 1938).

Conceptual Foundation

The VEC conceptualizes valuation knowledge as flowing through three interconnected stages: Judgement (Art), Method (Science), and Prediction (AI). Rather than replacing one another, these stages represent cumulative layers of epistemic processing, each contributing distinct forms of knowledge and validation.

Figure 1: The Valuation Epistemological Continuum (VEC)



In simpler terms, the VEC can be understood as a layered decision process rather than a replacement of traditional valuation approaches. The “art” component ensures that valuation remains context-sensitive and professionally grounded. The “science” component provides structure, consistency, and defensibility. The “prediction” component enhances analytical capability through data-driven insights. Together, these layers form a complementary system in which each component addresses the limitations of the others, enabling more robust and reliable valuation outcomes.

The Valuation Epistemological Continuum (VEC) (Figure 1)

Stage 1: Judgement (Interpretation)

The first stage involves professional interpretation of valuation context, including property characteristics, market conditions, client requirements, and qualitative factors that resist quantification. This stage draws on the valuer's tacit knowledge, experiential learning, and contextual understanding. It encompasses problem framing, identification of relevant comparables, assessment of qualitative factors (e.g., location desirability, building condition, planning constraints), and preliminary value estimation.

Professional judgement remains essential even in AI-enhanced valuation because algorithms cannot fully capture the contextual nuances, qualitative factors, and emerging market dynamics that experienced valuers intuitively recognize. Judgement provides the interpretive lens through which data is selected, methods are chosen, and algorithmic outputs are assessed for reasonableness.

Stage 2: Method (Validation)

The second stage applies standardized methodologies to structure, formalize, and validate the valuation process. This includes selection of appropriate valuation approaches (comparative, income, cost), application of recognized techniques (hedonic regression, DCF, comparable analysis), and compliance with professional standards (RICS, IVS). Methodological standardization ensures consistency, transparency, and regulatory compliance, providing a systematic framework that grounds professional judgement in market evidence and economic theory.

The scientific dimension serves as a quality control mechanism, ensuring that valuations are methodologically defensible, replicable, and auditable. It translates interpretive insights into explicit, verifiable procedures, reducing arbitrariness and enhancing credibility.

Stage 3: Prediction (Optimization)

The third stage leverages AI and machine learning to optimize value estimates through algorithmic analysis of large datasets. AVMs and predictive models identify patterns, quantify relationships, and generate probabilistic value predictions that complement and refine human judgement and standardized methods. This stage offers scalability, speed, and the ability to process complex, high-dimensional data that exceeds human cognitive capacity.

Crucially, prediction is not positioned as a replacement for judgement and method but as an augmentation of a computational tool that enhances accuracy, efficiency, and consistency while remaining subject to professional oversight. The valuer retains responsibility for model selection, parameter specification, output interpretation, and final value determination.

Taken together, these three stages form a sequential yet iterative valuation process rather than independent analytical steps. In practice, valuation begins with judgement to frame the problem and define relevant variables, proceeds through methodological structuring to ensure consistency and compliance, and is subsequently enhanced through predictive modelling to refine and optimise value estimates. Importantly, this process is not strictly linear; outputs from predictive models may prompt re-evaluation of assumptions at the judgement stage, while methodological constraints guide both data selection and model design. This dynamic interaction reinforces the role of the valuer as an integrative decision-maker within an AI-enabled valuation environment.

To further clarify the operational application of the VEC, the three stages can be translated into a practical valuation workflow. Table 2 summarises how each epistemological stage corresponds to specific tools, outputs, and professional roles within real-world valuation practice.

Table 2: Operationalization of the Valuation Epistemological Continuum (VEC) in Real Estate Valuation Practice

Stage	Typical Tools / Techniques	Output	Role of Valuer
Judgement	Site inspection, market analysis, professional experience	Contextual understanding	Interpret and frame valuation context
Method	Comparative method, DCF, hedonic analysis	Structured value estimate	Validate and standardise valuation
Prediction	AVM, machine learning models	Predicted value	Audit, interpret, and reconcile outputs

This structured mapping illustrates that the VEC extends beyond a conceptual model and can be operationalised within real valuation workflows. Each stage contributes a distinct form of knowledge, while the valuer maintains an integrative role in interpreting, validating, and reconciling outputs across the continuum. This reinforces the argument that AI does not replace professional expertise but reconfigures it within a hybrid decision-making structure.

Integration and Feedback

The VEC is not a unidirectional pipeline but an iterative, feedback-driven process. Predictive outputs inform professional judgement by revealing data-driven insights and challenging assumptions. Methodological frameworks guide algorithm design and validation. Professional judgement assesses the reasonableness of algorithmic predictions and identifies when models fail to capture relevant contextual factors. This iterative interaction creates a synergistic relationship where human and machine intelligences mutually reinforce and correct one another.

Theoretical Underpinnings

The VEC integrates insights from multiple epistemological traditions, each contributing to a different stage of the continuum:

Constructivism (Judgement Stage): Recognizes that valuation knowledge is socially constructed, context-dependent, and mediated by professional communities and interpretive practices (Berger & Luckmann, 1966). This perspective grounds the art paradigm, acknowledging that value is not simply discovered but interpreted through professional frameworks and experiential lenses.

Positivism (Method Stage): Asserts that valuation knowledge can be systematically generated through empirical observation, standardized procedures, and logical reasoning (Comte, 1853). This perspective underpins the science paradigm, emphasizing objectivity, replicability, and empirical validation.

Empirical Computational Epistemology (Prediction Stage): Treats knowledge as emergent from data-driven algorithmic learning, validated through predictive accuracy and iterative refinement (Kitchin, 2014). This perspective supports prediction paradigm, emphasizing pattern recognition, probabilistic reasoning, and computational scalability.

Pragmatism (Integrative Foundation): Unifies these perspectives by evaluating knowledge claims based on their practical consequences and real-world effectiveness (James, 1907; Dewey, 1938). Pragmatism rejects epistemological purism, instead advocating for methodological pluralism and adaptive reasoning. It supports VEC by legitimizing the integration of interpretive, scientific, and computational approaches based on their collective contribution to reliable, useful valuation outcomes.

The Valuer's Role in the AI Era

The VEC fundamentally redefines the valuer's professional identity and role. Historically, valuers have been characterized as craftsmen (art paradigm) or methodological practitioners (science paradigm). In the AI era, the valuer emerges as an augmented decisionmaker, a professional who integrates human expertise with computational intelligence to produce superior valuation outcomes.

This role entails several key competencies:

- i. **AI Literacy:** Understanding how machine learning models function, their strengths and limitations, and appropriate contexts for their application.
- ii. **Data Governance:** Ensuring data quality, addressing biases in training data, and maintaining ethical standards in algorithmic valuation.
- iii. **Model Auditing:** Critically evaluating algorithmic outputs, identifying anomalies, and assessing whether predictions align with market realities and professional judgement.
- iv. **Interpretive Integration:** Synthesizing algorithmic predictions with contextual knowledge, qualitative factors, and professional insight to produce holistic value assessments.

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- v. Ethical Accountability: Maintaining responsibility for final valuations, ensuring transparency, and addressing potential harms from algorithmic errors or biases.

The augmented decision-maker model preserves professional agency and accountability while leveraging AI's computational advantages. The valuer does not simply accept algorithmic outputs but actively interrogates, contextualizes, and refines them, ensuring that valuations remain credible, explainable, and ethically defensible.

Epistemological Validity in Hybrid Valuation

A critical question for hybrid epistemology is: what constitutes valid valuation knowledge when judgement, method, and prediction potentially conflict? The VEC proposes a multi-criteria validation framework:

- i. Professional Reasonableness (Art Criterion): Does the valuation align with professional judgement and contextual understanding?
- ii. Methodological Compliance (Science Criterion): Does the valuation follow standardized procedures and professional standards?
- iii. Predictive Accuracy (AI Criterion): Does the valuation align with data-driven predictions and empirical patterns?
- iv. Pragmatic Utility (Integrative Criterion): Does the valuation effectively serve its intended purpose and stakeholder needs?

Valid valuation knowledge, in this framework, is not determined by any single criterion but by the coherent integration of all four. Tensions among criteria are resolved through professional judgement, with transparency about trade-offs and limitations. For example, a valuation might prioritize methodological compliance over predictive accuracy when valuing a unique property with limited comparable data or prioritize predictive accuracy over professional intuition when valuing standardized residential properties in liquid markets.

To demonstrate the practical applicability of the VEC, consider a residential property valuation scenario in a suburban housing market. At the first stage (Judgement), the valuer interprets the property's contextual characteristics, including neighbourhood quality, physical condition, and locational advantages, forming an initial qualitative assessment. At the second stage (Method), the valuer applies the comparative method and cross-checks using hedonic regression or discounted cash flow analysis in accordance with RICS or IVS standards. At the third stage (Prediction), an AVM or machine learning algorithm is used to generate a data-driven value estimate based on large-scale transaction data.

Rather than treating these outputs independently, the valuer integrates them through professional reconciliation. For example, discrepancies between AVM predictions and comparable evidence may signal data limitations or unique property features requiring adjustment. In this way, the VEC operates as a structured decision-support process, where AI enhances analytical depth while professional judgement ensures contextual validity and accountability.

This positions the VEC as not merely a descriptive model, but as a unifying theoretical construct that reconciles previously fragmented paradigms within valuation knowledge.

Implications For Valuation Practice and Education

Professional Practice

The hybrid epistemology has profound implications for valuation practice, necessitating changes in professional standards, technological adoption, and ethical governance.

Redefining Professional Standards

Professional bodies such as RICS and IVSC must evolve their standards to accommodate AI-enhanced valuation while maintaining accountability and transparency. This includes:

- i. **Algorithmic Transparency Standards:** Requiring disclosure of model types, training data sources, key assumptions, and performance metrics when AVMs are used.
- ii. **Hybrid Valuation Protocols:** Establishing guidelines for integrating algorithmic predictions with professional judgement, specifying when human oversight is mandatory.
- iii. **Bias Mitigation Requirements:** Mandating audits for discriminatory patterns in algorithmic valuations and requiring corrective measures.
- iv. **Competency Standards:** Defining AI literacy requirements for practicing valuers, including understanding of machine learning principles, data quality assessment, and model interpretation.

Human-AI Collaboration Models

The VEC supports several practical models for human–AI collaboration:

- i. **AVM-Assisted Valuation:** Algorithms generate initial value estimates, which valuers then adjust based on property-specific factors, market conditions, and professional judgement.
- ii. **Tiered Valuation Systems:** Standardized properties in liquid markets receive fully automated valuations, while complex or unique properties require full professional valuation with AI as a supporting tool.
- iii. **Ensemble Approaches:** Multiple valuation methods (professional judgement, standardized techniques, machine learning models) are applied independently, with final values determined through weighted integration or professional reconciliation.
- iv. **Continuous Learning Systems:** Algorithmic models are continuously updated with new transaction data and valuer feedback, improving accuracy over time while maintaining human oversight.

Ethical and Legal Considerations

The integration of AI into valuation raises significant ethical and legal issues:

- i. **Accountability:** When an algorithmic valuation is erroneous, who is responsible for the valuer, the algorithm developer, or the data provider? The hybrid epistemology maintains that professional valuers retain ultimate accountability, even when using AI tools.
- ii. **Transparency:** Stakeholders have a right to understand how valuations are produced. "Black box" algorithms undermine trust and impede dispute resolution. Explainable AI (XAI) techniques should be employed to make algorithmic reasoning interpretable.
- iii. **Fairness:** Algorithms trained on historical data may perpetuate discriminatory pricing patterns. Valuers must actively audit for bias and implement fairness-aware machine learning techniques.
- iv. **Data Privacy:** The use of granular property and personal data in AVMs raises privacy concerns. Compliance with data protection regulations (e.g., GDPR) is essential.

Valuation Education and Research

The hybrid epistemology necessitates fundamental changes in valuation education and research agendas.

Curriculum Redesign

Traditional valuation education has focused on legal frameworks, valuation methods and market analysis, but the AI era demands a more comprehensive and multidisciplinary curriculum. First, data science fundamentals need to be made a core component, encompassing statistics, regression analysis, machine learning principles and data visualization techniques. Second, programming skills and the use of computational tools such as Python, R and specialized analytical software need to be applied to enable students to develop and test data-driven valuation models. Third, the ethical and governance aspects of AI should be strengthened, including an understanding of algorithmic bias, fairness, transparency and ethical implications in the automated decision-making process. Fourth, students need to be trained to critically evaluate algorithmic performance, identify model limitations and interpret algorithmic output ethically and professionally. Fifth, interdisciplinary perspectives from computer science, behavioral economics and data ethics should be integrated to broaden understanding of the role of AI in valuation. In line with this change, educational programs are recommended to adopt a project-based learning approach, where students are allowed to develop, test and critique hybrid valuation models that combine professional judgment with modern algorithmic tools. This approach not only improves technical competence but also produces valuers who are prepared to face future challenges in the digital valuation landscape. Valuation education has emphasized legal frameworks, valuation methods, and market analysis.

Interdisciplinary Research

The hybrid epistemology proposed in this study also opens up a number of significant interdisciplinary research opportunities, in line with the rapid development of assessment technology. First, there is significant room for empirical research that tests the effectiveness of hybrid models by comparing the accuracy, consistency and reliability of traditional approaches, hybrid models and full AVMs. Second, research on explainable AI is a critical agenda, particularly in the development of machine learning models that can provide transparent justification for value predictions, thereby increasing trust and accountability in their use. Third, behavioral studies of human–AI interactions are needed to understand how raters use, trust and potentially over-rely on algorithmic outputs, as well as how systems can be designed to optimize human–AI collaboration. Fourth, there is an urgent need to explore issues of algorithmic bias and fairness, including identifying patterns of discrimination in automated assessment systems and developing algorithms that are sensitive to fairness principles. Fifth, epistemological research can deepen understanding of the nature of assessment knowledge, validity criteria and professional identity in the digital age. Finally, research in the areas of regulation and law needs to be designed to assess the implications of liability, professional standards and regulatory frameworks in the context of AI-supported valuation. Overall, this research agenda demonstrates the broad potential of hybrid epistemologies as a theoretical and practical foundation for the future development of the field of real estate valuation.

Professional Development

Professional valuation practitioners are now faced with the need to improve their competencies through continuous professional development to adapt to rapid technological changes, especially in the era of data-driven valuation and AI. In this regard, professional bodies play an important role in providing relevant and structured learning platforms. First, AI literacy programs should be offered in the form of short courses and specific certifications that cover the basics of data science, machine learning and understanding of property valuation algorithms. Second, ethics training should be strengthened through workshops that emphasize aspects of algorithm transparency, model bias, accountability issues, and ethical governance in the use of AI-based systems. Third, peer learning communities should be established as a space for exchange of experiences, professional dialogue and sharing of best practices in integrating AI technology into valuation practices. This combination of initiatives not only increases the technical capacity of valuers but also ensures that practitioners are always prepared to evaluate, monitor and justify the use of new technologies in a responsible and ethical manner.

CONCLUSION

This paper examined the epistemological evolution of real estate valuation through three paradigms art, science, and prediction, and proposed a hybrid epistemology to reconcile these perspectives in the AI era. The analysis

demonstrates that valuation knowledge is inherently multidimensional, encompassing interpretive judgement, methodological standardization, and predictive analytics. Rather than viewing these dimensions as competing alternatives, the proposed VEC positions them as complementary stages in an integrated knowledge production process, grounded in Pragmatism as a unifying philosophical foundation.

The hybrid epistemology offers several key contributions to valuation theory and practice. First, it transcends the limiting art–science dichotomy that has long characterized valuation discourse, providing a more nuanced and comprehensive framework for understanding valuation knowledge. Second, it accommodates the transformative role of AI and machine learning while preserving the essential contributions of professional judgement and standardized methodology. Third, it redefines the valuer's professional identity from sole expert to augmented decision-maker, where human expertise and algorithmic intelligence co-produce credible valuation knowledge. Fourth, it establishes a multi-criteria validation framework that integrates professional reasonableness, methodological compliance, predictive accuracy, and pragmatic utility.

The implications of this framework are far-reaching. For practitioners, it provides conceptual guidance for integrating AI into valuation practice while maintaining professional accountability, ethical standards, and contextual sensitivity. For professional bodies, it highlights the need to evolve standards, competence requirements, and ethical guidelines to address algorithmic transparency, bias mitigation, and human-AI collaboration. For educators, it necessitates curriculum redesign to integrate data science, AI literacy, and interdisciplinary perspectives into valuation training. For researchers, it opens rich avenues for empirical testing, methodological innovation, and philosophical inquiry.

Ultimately, the hybrid epistemology supports the emergence of Valuation 4.0, a paradigm where human and machine intelligence collaborate to produce valuations that are simultaneously contextually grounded, methodologically rigorous, and empirically precise. This vision recognizes that neither human expertise nor algorithmic computation is sufficient alone; both are necessary and mutually reinforcing. The valuer of the future will be a professional who understands when to rely on judgement, when to apply standardized methods, and when to leverage AI and, most importantly, how to integrate these dimensions into coherent, credible, and ethically defensible valuations.

Several avenues for future research emerge from this framework. Empirical studies should test the performance of hybrid valuation models against traditional approaches and pure AVMs across different property types, market conditions, and geographical contexts. Research is needed on explainable AI techniques that make algorithmic reasoning transparent and interpretable to valuers and stakeholders. Behavioural studies should investigate how valuers interact with AI tools, including issues of trust, over-reliance, and cognitive biases in human-AI collaboration. Ethical research must address algorithmic bias, fairness, and discrimination in automated valuations, developing technical and governance solutions. Finally, longitudinal studies should examine how the integration of AI reshapes professional identity, skill requirements, and the social organization of the valuation profession.

The epistemological journey of valuation from art to science to prediction is not complete but ongoing. The hybrid epistemology proposed here offers a conceptual roadmap for navigating this evolution, ensuring that valuation practice remains credible, relevant, and responsive to technological change while preserving professional judgement, ethical accountability, and contextual insight that define the valuation profession's enduring value.

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