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Implementation of The Quantum Paradigm For Policy Studies in Indonesia

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Abstract

Abstract: This research aims to analyze the potential implementation of the quantum paradigm as an alternative analytical framework in public policy studies in Indonesia. The research is motivated by the limitations of the classical/conventional policy paradigm, which tends to be deterministic and linear in its understanding of the uncertainty and complexity of policies in Indonesia. Through qualitative methods with literature study techniques, this paper critically examines the development of policy theory—from the rational-comprehensive model, incrementalism, to complexity-based theory—and identifies theoretical gaps that can be filled by a quantum approach. The quantum paradigm, with the concepts of superposition, entanglement, and interference, is offered not merely as an analogy but as a mathematical-conceptual foundation for modeling the contextual nature of preferences, non-linear relationships between issues, and the role of measurement in the policy process. The research results formulate a framework of 3 components that can be operationalized: 1) Quantum Stakeholder Preference Mapping; 2) Linkage Analysis for Policy Integration, and 3) Policy Window Modeling as Resonance. This study concludes that the quantum paradigm offers a more sophisticated and contextual way to understand and navigate Indonesia's plural and interconnected policy realities, while opening up opportunities to enhance the effectiveness, legitimacy, and resilience of policy governance.

Introduction

Public policy studies have long been dominated by paradigms rooted in Newtonian and Cartesian logic, which tend to be deterministic, linear, and based on the assumption of rational actors operating within stable systems. These include classical rational choice models, incrementalism, and various stage-based policy process frameworks (Howlett et al., 2020). While perhaps useful and relatively suitable for certain structured problems, these approaches exhibit significant limitations when faced with complex problems characterized by complexity, deep uncertainty, and contextual embeddedness, such as climate change, digital disruption, socio-political polarization, and multi-stakeholder negotiations (Head & Alford, 2015).

Furthermore, there are two types of issues/problems in policy studies that tend to use classical, deterministic approaches. First, theoretical issues. Deterministic models assume that policy inputs lead predictably to outputs, but ignore the role of feedback loops, emergent

properties, and path dependencies in complex adaptive systems (Capano & Howlett, 2020). Furthermore, classical probability-based frameworks rely on the assumption of well-defined independent variables and stable preference orderings, which often do not hold in complex policy environments, where preferences are dynamic, context-dependent, and subject to cognitive biases (Busemeyer & Bruza, 2012). The digital age, despite offering vast amounts of data and computing power, often exacerbates these problems by promoting a deterministic view of technology that prioritizes efficiency over deliberation, adaptability, and value pluralism (Myeong et al., 2025).

Second, empirical issues. Empirically, the limitations of conventional/classical approaches to public policy studies are manifested in persistent policy failures such as implementation gaps (Pülzl & Treib, 2017), unforeseen consequences (de Vries & Nemec, 2025), stakeholder backlash (Prakash, 2020), and the erosion of public trust (Jesuit & Greitens, 2025). In a diverse archipelagic nation like Indonesia, these challenges are exacerbated by geographic fragmentation, ethnic and religious plurality, decentralized governance, and uneven state capacity. Traditional policy instruments, such as cost-benefit analysis, feasibility studies, and linear project management, tend to struggle to capture the interplay between local norms, institutional history, political incentives, and technological change.

Therefore, the quantum paradigm emerges as an attractive alternative. It originates from quantum mechanics but is increasingly applied in cognitive science, economics, and (now) policy studies. This paradigm offers mathematical and conceptual tools for modeling superposition (the simultaneous coexistence of multiple preferences or policy states), embeddedness (non-local correlations between seemingly separate policy issues or actors), and interference (where the context of measurement or consideration alters expressed preferences) (Busemeyer & Bruza, 2012; Pothos & Busemeyer, 2013). This paradigm not only adds complexity but also provides a structured way to represent and analyze the uncertainty and relationality inherent in policy processes. Another policy quantum study on South Korean nuclear policy demonstrated its usefulness in capturing the volatility of policy preferences and the collapse of opinion states through measurement (e.g., public deliberation) (Myeong et al., 2025). Based on these studies, no one has previously examined the potential application of the quantum paradigm. Furthermore, no policy quantum study has been conducted in Indonesia. These two aspects constitute the novelty of this research.

Furthermore, based on bibliometric identification results from the VOSviewer application, after entering the keywords “Quantum” and “Public Policy” on the Scopus website, 357 articles were found. Figure 1 below shows a visualization of the study mapping using these two keywords:

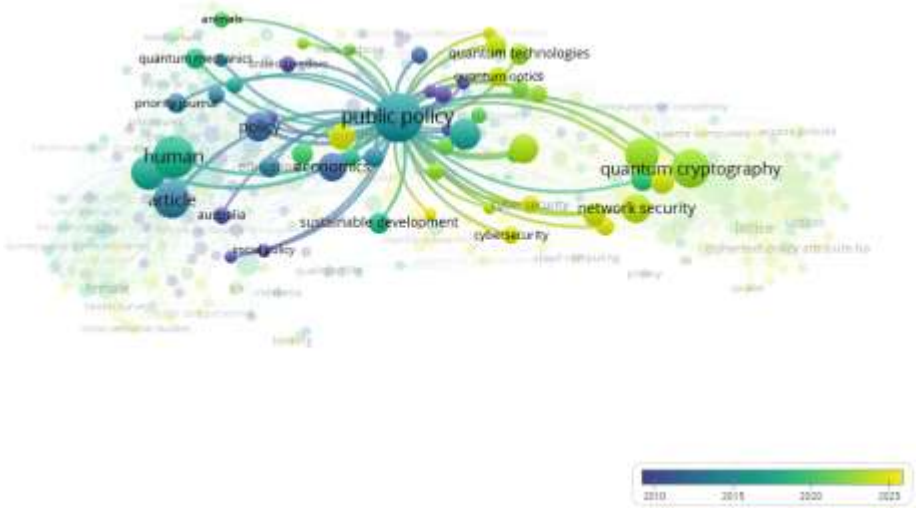

Figure 1: Results of the Identification of the Quantum Paradigm Research Network with Public Policy
Source: VOSviewer from Scopus Database

The network visualization overlay results in Figure 1 above show that from 2010 to 2025, research on the quantum paradigm and public policy remains very limited, especially in the Indonesian context, having never been conducted before. Previous studies on public policy have focused more on economics, human resources, quantum cryptography, and network security; none specifically address the quantum paradigm, especially in the Indonesian context. This further emphasizes the novelty of this research. Therefore, this study was conducted to analyze the potential application of the quantum paradigm as an alternative analytical framework in public policy studies in Indonesia.

Classical Foundations of Public Policy

The Rational-Comprehensive Model dominated the pinnacle of postwar policy science (Leach & Stewart, 2025; Rassanjani & Meesonk, 2025), an intellectual edifice built on two pillars of economics: neoclassical and positivist social science. This model proposed an ideal sequence for public policy, starting with: defining goals, identifying all alternatives, predicting all consequences, and selecting the optimal option (Lindblom, 2018). Its strength lay in its normative clarity and alignment with the modernist belief in technocratic control. This model's approach promised a science of administration, where values were defined by politics and efficiency maximized by public policy experts/technocrats.

However, this model's weakness lies in its heroic, and ultimately fictitious, anthropology. It assumes the policymaker is Homo economicus—omniscient, computationally infinite, and driven by consistent utility maximization. Herbert Simon's trenchant critique was not only an observation of practical failures but also a philosophical correction. Simon argued that the human mind is a “boundedly rational” processing system (Simon, 1955). Decision/policy makers, he argued, operate within cognitive and informational constraints; they “satisfy themselves” by choosing the first option that meets an acceptable threshold, rather than optimizing. This is the first major flaw in the deterministic construct. Simon shifted the focus from how decisions should be made in an ideal world to how decisions are made in a complex world. However, while bounded rationality injects realism, it remains tied to procedural logic. The goal remains to make the best decision within constraints, not to model how constraints

and decisions dynamically interact. Cognitive processes are viewed as sequential, albeit imperfect, computations, rather than as realms of potential.

Pragmatic Shift in Policy towards Incrementalism

As a counterpoint to comprehensive rationalism in public policy, the incrementalist approach emerged. This concept holds that comprehensive rationality is not only impractical but also undesirable in a pluralist democracy (Schumaker, 2021; Thoma, 2024). Public policy, according to the incrementalist view, is made through successive limited comparisons, focusing on marginal changes from the status quo. This model brilliantly captures the political realities of negotiation, compromise, and path dependency. It is a stability theory, where radical change is avoided in favor of manageable adjustments, and political expediency trumps theoretical optimality.

Incrementalism's great strength is its political realism (Adam et al., 2022), but this presents a profound theoretical limitation. It excels at explaining policy continuity but struggles to explain change. By focusing on marginal adjustments, the theory is plagued by the phenomenon of punctuated equilibrium, periods of stagnation punctuated by bursts of radical policy change (Baumgartner & Jones, 2024). Furthermore, its conservative bias has been criticized for reinforcing the power of established interests and being inadequate for addressing “complex problems” that require transformative, non-marginal solutions. Incrementalism describes the process of political bargaining but lacks a robust theory of preference formation. It considers actors' preferences as relatively fixed inputs into the policy agenda, rather than as endogenous and fluid constructs shaped by the process itself. However, the core model of decision-making remains linear: (static) preferences → political bargaining in shaping the policy agenda, which tends to be sequential → marginal outputs.

Dynamic Policy: Process Theory and the Shift to Complexity

The late 20th century saw the emergence of intermediate-level frameworks that attempt to explain dynamics and non-linearity. Kingdon's Multiple Streams Approach (MSA) visualizes policy change as a temporary confluence of three independent streams: issues, policy, and politics (Kingdon, 1984). The Advocacy Coalition Framework (ACF) (Sabatier & Jenkins-Smith, 1993) focuses on the role of deep-seated core beliefs and learning within competing policy subsystems. Punctuated Equilibrium Theory (PET) further applies concepts from evolutionary biology to explain why policy monopolies maintain stability until external pressures cause progressive shifts (Fernández-i-Marín et al., 2022; Yildirim, 2022).

These frameworks introduce the concepts of randomness (MSA's "policy window"), path dependence, belief systems, and feedback loops. Furthermore, this concept is capable of modeling the macro-dynamics of policy change over time. However, critical gaps remain at the micro-fundamental level. As Cairney & Zahariadis note, while MSA explains when windows open, it falls short in explaining the cognitive mechanisms of how policymakers “connect” flows—a process that can be highly nonlinear and context-sensitive (Cairney & Zahariadis, 2025). ACF, on the other hand, centers on stable belief systems, potentially underestimating the fluidity and inconsistency of individual policy preferences in real-time deliberation (Busemeyer & Bruza, 2012). PET, on the other hand, explains systemic shifts but lacks formal tools to model the “attractor states” of policy subsystems or the precise conditions for “collapse” from one equilibrium to another. Essentially, these theories brilliantly map the topography of the policy landscape, but rely on classical, often qualitative, tools to explain the

movements of individual actors ("particles") across the landscape. They depict complexity but lack the mathematical language to formalize it.

Quantum Concept of Public Policy

Quantum theory initially emerged to explain phenomena unexplained by classical physics, phenomena governed not by certainty but by probability (Bongaarts, 2015; Pitowsky, 2006). In quantum mechanics, particles can exist in superposition, occupying multiple potential states until observed (Saluja, 2025). Systems are interconnected, meaning the state of one element cannot be separated from another, regardless of distance. Crucially, quantum theory recognizes uncertainty not as an error, but as an inherent feature of reality.

When debate arose about whether public policy might resemble such a system, the analogy proved intellectually provocative and analytically fruitful. Policy processes often involve states of "simultaneous possibility," where multiple trajectories coexist before a decision "collapses" into an outcome. Policy actors are not static entities but are embedded in dynamic relationships where actions reciprocally influence—and are influenced by—others. In this sense, policymaking resembles a quantum field rather than a classical machine.

Recent research reflects this shift. Studies such as Myeong, Lee, Bae, and Cho's quantum probability model demonstrate how policy decisions—such as nuclear energy governance—cannot always be captured by classical probability (Myeong et al., 2025). Their model demonstrates that public preferences and policy outcomes do not behave linearly; they exhibit interference effects, contextual dependencies, and trajectory shifts. Similarly, emerging work in quantum governance and decision-making theory emphasizes that policy realities are layered, contextual, and contingent (Moloney & Al-Kuwari, 2025).

The quantum paradigm reframes policy reality. Rather than attempting to eliminate uncertainty, the quantum paradigm seeks to understand and navigate policy dynamics, from agenda setting to policy evaluation. Rather than assuming actors in the policy ecosystem operate in isolation, the quantum paradigm highlights the relationality and co-evolution of public policy. Rather than predicting linear outcomes, the quantum paradigm anticipates the probabilistic future of a public policy.

Method

This research uses a qualitative research method, with a literature study technique. The data obtained in this study are sourced from secondary data obtained from international journals such as Scopus and Web of Science found on the Google Scholar page. Data from these sources are then collected and systematically categorized based on the projected trajectory of the implementation of the quantum paradigm in policy studies in Indonesia, consisting of: 1) Bridging Quantum Formalism and the Reality of Policy Governance in Indonesia; 2) Framework for Quantum-Based Policy Analysis in Indonesia; and 3) Critical Evaluation and Synthesis. The data according to the categorization of the projected trajectory of the implementation of the quantum paradigm in policy studies in Indonesia are then discussed/analyzed in more depth, and then concluded.

Results and Discussion

The transition from conceptual discussion to practical implementation of the quantum paradigm in Indonesian policy analysis requires a shift from metaphor to methodological specifics. This section presents a concrete framework for implementation, grounded in empirical political science and supported by the growing quantum social science literature. We

examine how quantum principles can address Indonesia's persistent governance challenges, with particular attention to their measurable implications for policy effectiveness, stakeholder legitimacy, and institutional resilience.

1. Bridging Quantum Formalism and the Reality of Policy Governance in Indonesia

The application of quantum models to Indonesian policy must be theoretically robust. Recent studies provide this bridge. Busemeyer and Bruza's Quantum Model of Cognition and Decision Making mathematically demonstrates how human decision-making violates classical probability axioms through order effects (Busemeyer & Bruza, 2012), conjunction fallacies, and context-dependent preferences—well-documented phenomena in Indonesian policy processes, from abrupt regulatory shifts (Warburton, 2020) to polarized public acceptance of economic reforms (Aspinall & Mietzner, 2019). Pothos and Busemeyer further establish that quantum probability provides a superior geometric framework for modeling these irrational yet systematic deviations (Pothos & Busemeyer, 2013).

For governance, the work of Myeong et al. is crucial (Myeong et al., 2025). The application of superposition and its entanglement to South Korea's nuclear policy demonstrates how stakeholder positions are not fixed but exist in a probabilistic state that collapses through measurement (e.g., public deliberation). This directly informs the analysis of similarly controversial policies in Indonesia (e.g., the 2020 Omnibus Law on Job Creation), where public opinion exhibits remarkable volatility across different measurement contexts (surveys vs. street protests). Khrennikov's development of quantum models for social systems (Khrennikov, 2010) provides a formal mathematical foundation, showing that policy subsystems can be modeled as information spaces where non-commutativity (order dependence) is the rule, not the exception.

2. A Framework for Quantum-Based Policy Analysis in Indonesia

This paper proposes a three-component analytical framework, each addressing documented limitations in Indonesia's current policy system. The first component: Quantum Stakeholder Preference Mapping. The problem with this first component is that traditional stakeholder conditions in Indonesia often categorize groups as pro/anti, ignoring meaningful, ambivalent, or conditional support. This leads to resistance to policy implementation.

Quantum Solution: Quantum Stakeholder Preference Mapping treats stakeholder positions as state vectors in a Hilbert space defined by core policy dimensions (e.g., for mining policy: economic benefits, environmental impacts, indigenous peoples' rights). A group's "position" is a superposition of various possible attitudes. Using a method adapted from Trueblood et al.'s thesis on the effects of quantum question order (Trueblood et al., 2017), policy analysts would need to conduct sequential surveys or focus groups in which the context (framing) of the questions is systematically varied.

Empirical Application: Before revising a policy (e.g., the 2009 Mineral and Coal Mining Law), Quantum Stakeholder Preference Mapping can be applied. A survey might first ask about support for, for example, “increasing state royalties” (Context A), then about “protecting community land rights” (Context B), and finally repeat the question about royalties. The classical model would expect consistent answers. The quantum model predicts interference: the amplitude of support for royalties can increase or decrease depending on its relevance to the land rights question in the survey subjects’ cognition. This interference term, which can be measured as a deviation from the law of total probability, quantifies the context-sensitivity of the issue—a crucial insight for sequencing policy communication and building coalitions. This

approach goes beyond the static stakeholder maps generated by conventional power-interest networks in policy paradigms/studies.

Second Component: Linkage Analysis for Policy Integration. The problem with this second component is that Indonesian government institutions (such as ministries) tend to be compartmentalized, resulting in fragmented policies. For example, peatland restoration goals (Ministry of Environment and Forestry) often conflict with agricultural expansion targets (Ministry of Agriculture), resulting in policy implementation paralysis. Quantum Solution: Drawing on the formal concept of quantum linkage applied to interconnected decision-making systems (Yukalov & Sornette, 2017), this analysis maps the correlation structure between policy domains. The question is: does the measurement (implementation of policy in) Domain X instantaneously change the likelihood of outcomes in Domain Y, beyond simple causal pathways?

Empirical Application: Using time-series data on policy directives, budget allocations, and outcome indicators across ministries, analysts can calculate quantum correlation coefficients (a measure of inseparability). A high degree of interconnection between, for example, energy subsidy policy and transportation infrastructure investment would indicate that they cannot be treated independently. The finding of strong linkages will require a new policy governance structure: a cross-ministerial "linked policy unit" with shared decision-making authority, formalizing the coherent management of these interconnected domains rather than relying on often-failed ad-hoc coordination.

Third Component: Modeling Policy Windows as Resonance. A key problem with this component is that Kingdon's Multiple Streams Framework identifies policy windows but lacks predictive power regarding their opening. In Indonesia, the windows for major reforms (e.g., the 1998 democratization, the 2004 direct elections) appear unpredictable. Quantum Solution: Modeling the policy space as a quantum field is necessary. Kingdon's three streams (problem, policy, politics) are represented as oscillators with different frequencies. Policy windows open not through simple conjunction, but when a driving event (crisis, election) provides the energy that brings these streams into resonance—a state in which their wave functions constructively interfere, dramatically amplifying the probability amplitude for a particular policy solution (applying quantum resonance to organizational change).

Empirical Application: Longitudinal analysis of media sentiment (issue streams), legislative proposals (policy streams), and political coalition stability (political streams) can be conducted using quantum wave function analysis. Periods where the phase and frequency of these streams align—as measured through spectral coherence analysis—will be identified as high-probability resonance zones. Monitoring these indicators can provide an early warning system for periods of high reform potential, allowing policymakers to prepare legislative drafts and coalition-building strategies before crises occur, resulting in more planned and less chaotic reforms.

3. Critical Evaluation and Synthesis

The proposed framework shifts the quantum paradigm from a philosophical analogy to a set of actionable and testable methodologies. Its value lies in formalizing phenomena already understood by policymakers in Indonesia. Its thesis is that context is a key determinant in the application of the quantum paradigm to public policy. Furthermore, the issues are closely interconnected, and the act of amplifying policy is fundamentally socio-political.

However, significant challenges remain. Operationalizing the quantum paradigm in public policy requires an interdisciplinary team that combines resources across disciplines (e.g., public policy analysts/scholars, data scientists, political analysts, and social theorists). The data requirements for quantum models (e.g., repeated-measures surveys, high-frequency time-series data) are intensive. There are also legitimacy challenges: introducing the seemingly esoteric language of quantum mechanics into the pragmatic world of policy can be perceived as irrelevant academicism.

On the other hand, the potential rewards are enormous. By providing a formal language for complexity, these models can: 1) Reduce Negative Externalities of Policy: By measuring interference and entanglement, these models can more reliably predict unintended consequences and stakeholder reactivity; 2) Enhance Democratic Legitimacy: By making the process of measurement (transparency) and superposition of public opinion explicit, these models can base policies on a more authentic representation of society's complex aspirations; 3) Enhance Institutional Learning: By modeling policy evolution as state-vector dynamics, these models shift conventional evaluation models from binary success/failure to understanding the system's trajectory through a quantum-typical multidimensional value space.

In short, the application of the quantum paradigm in Indonesia is not about importing physics into empirical social phenomena. Rather, it is about adopting more powerful mathematical and conceptual tools to navigate the non-commutative, interconnected, and overlapping realities of Indonesian society within the public policy ecosystem. Indonesia's distinctive character as an archipelagic nation, framed by diversity (Bhinneka Tunggal Ika), will find its most sophisticated analytical expression not in classical policy reductionist models, but in the holistic, relational, and probabilistic mathematics and/or physics of quantum theory. The next step is a pilot application: testing Quantum Stakeholder Preference Mapping on concrete policy drafts, for example, draft regional autonomy regulations, or conducting an entanglement analysis of the food-energy-water relationship in Java. Through these empirical trials, the abstract power of the quantum paradigm can be translated into concrete gains in the effectiveness and legitimacy of policy governance in Indonesia.

Conclusion

This paper has outlined arguments supporting the implementation of the quantum paradigm as an appropriate and transformative theoretical lens for policy studies in Indonesia. This research stems from a recognition of the fundamental limitations of the classical policy paradigm, which is deterministic, linear, and assumes stable rationality when faced with the uncertainty, complexity, and dynamic plurality that characterizes the Indonesian policy landscape. Geographic fragmentation, government decentralization, socio-cultural diversity, and the interplay of local norms, institutional history, and political incentives create a policy reality that more closely resembles a probabilistic and relational field than a predictable machine. The quantum paradigm, originally developed in physics, offers a set of concepts and mathematical tools such as entanglement, superposition, and interference that can sophisticatedly model policy phenomena that have previously been difficult to adequately explain. These concepts are not mere metaphors but provide a formal foundation for understanding how policy issues are interconnected in non-local ways, how stakeholder preferences can exist in a state of superposition (conditional and contextual), and how measurement contexts (such as communication framing or public deliberation) actively shape policy outcomes.

The proposed three-component framework: Quantum Stakeholder Preference Mapping, Linkage Analysis for Quantum Policy Integration, and Quantum Policy Window Modeling as Resonance, has the potential to demonstrate how these theoretical abstractions can be operationalized into actionable policy methodologies. Its implementation has the potential to address specific challenges of Indonesian governance, such as inter-ministerial policy fragmentation, implementation resistance due to overly simplistic stakeholder mapping, and uncertainty in capitalizing on reform opportunities. While policy implementation challenges such as the need for interdisciplinary teams, intensive data collection, and academic legitimacy cannot be dismissed, the potential benefits are significant. The quantum paradigm in policy studies can enhance policy resilience by better predicting unintended consequences and stakeholder reactions, strengthening democratic legitimacy through a more authentic representation of complex public preferences, and fostering more dynamic institutional learning.

Essentially, implementing the quantum paradigm in Indonesian policy studies is not an attempt to reduce social reality to the laws of physics, but rather an attempt to adopt a more relational, probabilistic, and holistic mathematical and conceptual language to navigate the complexity of policy dynamics in Indonesia. Indonesia's pluralistic nature finds its deepest resonance precisely in a logic that recognizes the coexistence of multiple possibilities, the close interconnectedness of elements, and the dependence on context. Therefore, an important step forward is to test this framework through pilot studies on concrete policy issues, such as regional autonomy or the energy-food-water policy nexus. In this way, the power of the quantum paradigm can be translated from academic discourse into concrete utility in the effectiveness and legitimacy of public policy governance in Indonesia.

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