

A Bohmian Framework for Quantum Potentials in AI Governance: Mills-Validated Empirics for Value Measurement

Milan B. Vemić

 <http://orcid.org/0000-0002-6814-8031>

Faculty of Business Studies and Law, University Union - Nikola Tesla, Belgrade, Serbia

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ABSTRACT

Quantum-substantiated AI provider value measurement model grounded in regulatory uncertainty and Bohmian mechanics institutes AI Growth-Stability Evolution Equation, $\Delta G \cdot \Delta S \geq k^*(1 + \beta * IF)$, quantifies innovation potential and regulatory compliance trade-offs through quantum potential $Q(r,t)$, classical regulatory forces $V(r,t)$, and internal governance $U(x)$. While not regulatorily tested, Mills' four inductive methods validated Lennard-Jones-Sheldrake-Aharonov-Bohm findings, correlating with Hierarchical Reasoning Model (HRM), proving nonlocal influence as a universal organizing principle across interdisciplinary potentials. Correspondence and complementarity methods: (1) mathematically enact time-dependent AI regulatory Hamiltonian $\hat{H} = [-(\hbar^2/2m)\nabla^2 + V(r,t) + Q(r,t) + U(x)]\psi(r,t)$; (2) capture quantum-to-classical shifts in Boolean algebra $(a \wedge b \wedge c) \vee (a \wedge b \wedge c') \vee (a \wedge b' \wedge c) \vee (a' \wedge b \wedge c)$; (3) enable proof with AI solenoids proving field-free regulatory interference. Quantized harmonic oscillator models, spectral coherence ($E = h\nu$), capture invisible value indicators of "AI curvature", enable nuanced evaluation.

KEYWORDS

AI Capacity Index, AI Governance, Bohmian Mechanics, Boolean Mathematization, HRM, Hamiltonian Evolution, Mills' Inductive Methods, Nonlocal Influence, Quantum Potential, Regulatory Friction

INTRODUCTION

Artificial Intelligence (AI)'s rapid evolution creates new opportunities for measurement while exposing limitations in traditional metrics, which fail to capture uncertainty, regulatory pressure, and systemic complexity. Research highlights the need for integrated frameworks that reflect societal, ethical, and financial dimensions: Brynjolfsson and McAfee (2014) emphasize broad societal impacts, Davenport and Ronanki (2018) stress sustainable development, Kaplan and Haenlein (2019) note evaluation complexity, and Schrage et al. (2023) focus on performance measurement.

As global regulations such as GDPR and the AI Act reshape the landscape, measuring AI provider value must extend beyond the accuracy of financial indicators to account for the interplay between innovation, compliance, and uncertainty. Quantum mechanics offers a new conceptual lens for modeling these dynamics. By extending Bohmian interpretations of uncertainty, complementarity, and non-locality, this study developed optimization instruments that quantify AI value under regulatory and market constraints. Building on de Broglie's pilot-wave foundations and Bohm's wholeness

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dynamics, the proposed AI Growth–Stability Evolution equation captures the trade-off between innovation drive and regulatory constraints, requiring a Hamiltonian extension analogous to particle physics (Nielsen & Chuang, 2010, p. 284).

It becomes increasingly necessary to prepare for inevitable regulation (Candelon et al., 2021) by integrating visible and invisible value indicators (Abraham & Mallatt, 2022; Lev, 1984).

Grounded in Bohmian uncertainty (Bohm, 1951; M. Vemić, 2025) and specifically the Aharonov–Bohm insight that potentials influence behavior even in field-free regions (Aharonov & Bohm, 1959), proposed frameworks show how AI providers respond to both explicate (Bohm, 1980, pp. 188–190, 200–202) regulatory interventions and hidden variables such as market pressures and anticipatory compliance incentives (Kahneman & Tversky, 1979; Zaidan & Ibrahim, 2024). As with particles reacting to potentials before fields appear, AI providers can adjust behavior in anticipation of regulation (Kasirzadeh, 2024; Kop, 2021), responding to both direct and indirect governance effects (Agrawal, Gans, & Goldfarb, 2018).

GLOSSARY OF KEY TERMS

Several exact definitions are necessary for key AI implications:

Aharonov-Bohm Effect. Charged particle’s wave function phase is shifted by electromagnetic potentials (A, ϕ) even when moving through a region with zero magnetic (B) and electric (E) fields.

AI Measurement. Regulations create a dynamic environment in which AI providers must balance performance optimization with compliance obligations (Kasirzadeh, 2024). The introduced quantum-mechanics-driven framework offers a systematic approach to measurement under real-world constraints, aligning governance principles with sustainable innovation.

EU AI Act & Risk-Based Regulation. The EU AI Act classifies systems by risk level and imposes proportionate oversight (Kop, 2021). High-risk domains such as healthcare (Huebner & Flessa, 2022), and finance (Acharya et al., 2018) face extensive validation and monitoring, often slowing innovation cycles.

GDPR & Data Governance. AI models must comply with data-privacy rules governing collection, storage, and processing. These constraints introduce regulatory friction that limits adaptability, particularly in machine-learning systems (Biamonte et al., 2017).

Hamiltonian. A function H describing the time-evolution of a dynamic physical system, traditionally applied to particle motion and here extended to the management and monitoring of AI system behavior.

Lennard–Jones Potential. Lennard-Jones (1924) showed that molecular interactions combine short-range repulsion with long-range attraction (p. 463). Empirical analysis of argon confirmed this dual structure, providing a natural precedent for field-like influences.

Polarity of Auxin Transport. Shelldrake (1974) demonstrated that basipetal auxin polarity persists even when plant tissues are inverted, with newly formed cells inheriting existing directional patterns (p. 637).

Quantum Potential. ∇q , represents invisible regulatory forces, policy uncertainty, self-regulation, and anticipated compliance, shaping AI decisions, aligning with hidden-variables interpretation (Bohm, 1952b).

Regulatory Friction. Bohm (1951, p. 289) noted that reduced friction sharpens resonance by increasing wave amplitudes. AIs face costs and slowed innovation when steering quantum-like potentials of regulatory compliance, balancing growth with GDPR and AI Act obligations and sectoral rules (Acharya et al., 2018).

Reverse Annealing. A specialized attribute of quantum computing that improves classical solutions to complex optimization problems by annealing backward from a specified state, then forward to a new state.

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