Conservation, Coarse-Graining, and Mechanism

A Comparative CEDA Analysis of Three Inflation-Adjacent Frameworks

Abstract

I report the results of three Cosmological Explanation Diagnostic Audits (CEDA) applied to representative inflation-adjacent proposals spanning classical averaging, action-level scalar–tensor dynamics, and quantum backreaction. The selected cases—Buchert (2000) scalar averaging in General Relativity, Generalized G-inflation (Kobayashi–Yamaguchi–Yokoyama 2011), and graviton one-loop backreaction (Janssen–Prokopec 2008)—were deliberately chosen to probe distinct explanatory pathways that are frequently conflated in the early-universe literature.

Across these cases, CEDA distinguishes descriptive reorganization from earned dynamics, regime-limited mechanisms from globally predictive ones, and physically derived effects from scheme-fragile artifacts. I further document the impact of protocol evolution between CEDA v0.1 and v1.2, showing how stricter pre-declaration and branching rules eliminate ambiguity without biasing outcomes toward or against inflationary frameworks.

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1. Motivation and Case Selection

The three papers audited here form a minimal explanatory basis for claims of accelerated expansion beyond canonical slow-roll inflation.

First, Buchert (2000) addresses whether acceleration can arise from classical General Relativity alone through scalar averaging of inhomogeneous spacetimes, without introducing new degrees of freedom. Second, Generalized G-inflation (2011) represents the opposite extreme: explicit action-level scalar–tensor dynamics engineered to generate inflation while maintaining second-order field equations and conservation. Third, Janssen & Prokopec (2008) explores a quantum route, asking whether graviton one-loop effects can screen a cosmological constant or generate inflation-like behavior without classical inflaton dynamics.

Together, these cases isolate three commonly proposed explanatory strategies, averaging, generalized couplings, and quantum backreaction, and subject them to the same diagnostic question: where does the acceleration actually come from, and is it stable under the authors' own declared assumptions?

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2. CEDA Methodology (Brief)

CEDA is a diagnostic audit framework, not a cosmological theory. Each paper is processed through a Model Card (declared ontology, degrees of freedom, and regime of validity), a Translation Card (mapping author language to CEDA primitives), and a pre-declared Diagnostic Card specifying which tests will be applied. Verdicts are constrained by Conditional Verdict Symmetry: no model is credited beyond what it explicitly claims, and no penalty is assigned for the absence of claims not made.

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3. Test 009: Buchert Averaging in General Relativity (2000)

3.1 What the Paper Does

Buchert derives exact, non-perturbative scalar-averaged Einstein equations for irrotational dust on compact comoving domains. The construction introduces no new fundamental degrees of freedom and enforces local conservation exactly. Effective modification of the expansion arises through a backreaction scalar constructed from variance in expansion and shear.

Crucially, the paper explicitly states that the averaged system is not closed without additional assumptions, that all effective quantities are domain-dependent, and that no preferred coarse-graining scale is identified.

3.2 Diagnostic Outcome (CEDA v1.2)

Two diagnostics determine the outcome. The Coarse-Graining Stability test (D2) conditionally fails by design: effective expansion depends on domain size, shape, and location, and no convergence or universality is claimed. The Coupling Provenance and Redundancy test (C1) fails because the backreaction term has no independent evolution equation; closure requires externally chosen functional relations, allowing it to mimic multiple expansion histories without new physical structure.

3.3 Verdict

CEDA classifies the framework as a Reinterpretation, Scale-Dependent Bookkeeping Framework. This verdict is precise rather than dismissive: the formalism reorganizes existing

General Relativity degrees of freedom but does not supply a dynamical mechanism for acceleration.

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4. Test 008: Generalized G-Inflation (2011)

4.1 Role as a Control Case

Generalized G-inflation serves as a control against which many alternative proposals implicitly compare themselves. The framework introduces explicit scalar–tensor interactions at the action level, preserving second-order equations and conservation, and therefore represents a genuine attempt to earn inflationary dynamics.

4.2 Diagnostic Outcome (CEDA v1.2, Admissible Run)

Under a framework-level audit, the model trivially satisfies the Horizon Reconfiguration Null (D1). Coarse-Graining Stability (D2) conditionally passes within the declared effective-field-theory and stability regime: inflationary behavior persists under admissible variations until known instabilities or EFT breakdown are encountered. Exchange-Term Provenance (D3) passes cleanly, as all effective stress–energy is action-derived.

The Coupling Provenance and Redundancy test (C1), however, fails at the framework level. The four arbitrary Horndeski functions provide substantial freedom, and predictive compression is not paid until specific submodels are fixed. Predictive Wedge (D4) is therefore not evaluable without subfamily declaration.

4.3 Verdict

CEDA assigns the classification Conditional Mechanism Framework (Regime-Limited). Inflationary dynamics are earned rather than bookkeeping artifacts, but universality is neither claimed nor granted.

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5. Test 007: Quantum Backreaction and Graviton One-Loop Effects (2008)

5.1 Motivation for Inclusion

Quantum backreaction is frequently invoked as a route to inflation or cosmological-constant screening without classical inflaton dynamics. This paper explicitly advances such claims, making it an ideal stress test for scheme and state stability.

5.2 Diagnostic Outcome (CEDA v0.1)

The Coarse-Graining Stability test (D2) fails. The authors themselves acknowledge that the regimes where secular effects dominate are precisely those where counterterm ambiguity, vacuum/state dependence, and the absence of resummation undermine control. Exchange-Term Provenance (D3) conditionally passes at the formal level—loop contributions are derived, but physical robustness is not established. Coupling Redundancy (C1) fails, and the framework is classified as scheme-fragile under S1.

5.3 Verdict

CEDA assigns an Ambiguous classification: scheme- and state-fragile, regime-limited. The verdict does not deny the existence of quantum effects but denies that the claimed cosmological outcomes are robustly earned under the paper's own caveats.

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6. Cross-Case Comparison

Across the three cases, a consistent pattern emerges. Averaging without new degrees of freedom reorganizes dynamics but does not generate mechanisms. Action-level scalar–tensor structure earns conditional mechanism status, bounded by regime control and functional freedom. Quantum backreaction demands extraordinary control; without it, explanatory status collapses under scheme and state sensitivity.

These distinctions are often blurred in the literature but become sharp under diagnostic enforcement.

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7. Version Notes: CEDA v0.1 to v1.2

Two of the audits occurred under CEDA v0.1, prior to the introduction of strict audit-mode locking, admissible-variation pre-declaration, and explicit branching rules. CEDA v1.2 resolves ambiguities not by reinterpretation but by forcing them to be declared. Divergent outcomes in exploratory runs are retained as calibration artifacts rather than averaged away, strengthening auditability rather than weakening conclusions.

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8. Conclusion

Taken together, these three audits demonstrate that CEDA is mechanism-literal rather than model-partisan. Dynamical structure earns credit where it exists, descriptive reorganization is identified as such, and regime limitations bound all verdicts. The framework does not ask which model is correct, but what is doing the explanatory work, and whether that work survives its own assumptions.

This distinction is not rhetorical. It is diagnostic, and it is the point.

References

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Kobayashi, T., Yamaguchi, M., & Yokoyama, J. (2011). *Generalized G-inflation: Inflation with the most general second-order field equations*. Progress of Theoretical Physics, 126, 511–529. arXiv:1105.5723.

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