Diagnostic Results from Conservation-Honest Audits of Inflation-Adjacent Early-Universe Models

Distinguishing Genuine Dynamics from Descriptive Reweighting

Abstract

We report results from the application of the Cosmological Explanation Diagnostic Audit (CEDA), a conservation-honest diagnostic framework designed to distinguish genuine dynamical mechanisms from descriptive reinterpretations in early-universe cosmology. CEDA does not propose a new cosmological model and does not challenge the empirical adequacy of inflationary ΛCDM. Instead, it enforces explicit accounting of degrees of freedom, system–environment partitions, exchange terms, and coarse-graining stability in effective early-universe descriptions.

Applying the diagnostic protocol to a representative set of early-universe constructions-including a canonical horizon-mediated null control, established inflationary mechanisms, and horizon- or entropy-driven proposals-we find a consistent pattern. Horizon-only and accessibility-based constructions fail to generate sustained accelerated expansion under conservation-honest accounting. When exchange terms are derived explicitly from partition evolution and admissible variations in coarse-graining and horizon definition are enforced, such models retain radiation-like behavior or exhibit order-unity instability. Inflation-like behavior in these cases appears only when additional structure is introduced implicitly through tuned accessibility weights, privileged coarse-graining choices, or outcome-stabilizing exchange terms, at which point the construction reduces to inflation mimicry rather than a novel mechanism.

By contrast, inflationary models that introduce explicit dynamical structure-such as higher-curvature terms or propagating scalar degrees of freedom-produce negative pressure that remains robust under admissible reformulation and pass all relevant diagnostic tests. CEDA therefore does not disfavor inflationary dynamics; it clarifies the structural conditions under which inflationary behavior is genuinely earned.

In cases where no admissible interior effective description remains stable under diagnostic reformulation, CEDA records a Causal Description Transition, indicating descriptive non-existence rather than physical pathology. These results demonstrate that conservation discipline and coarse-graining stability provide a sharp, reproducible boundary between mechanism-level physics and bookkeeping-dependent reinterpretation in early-universe modeling.

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1. Introduction: Why a Diagnostic Audit Is Needed

The standard cosmological model, ΛCDM supplemented by an early period of inflationary expansion, has achieved remarkable empirical success. Across multiple independent probes-including the cosmic microwave background, large-scale structure, and primordial perturbation spectra-it provides a coherent and predictive description of the observable universe. No serious diagnostic framework can begin by ignoring this success, nor does the present work attempt to undermine it.

At the same time, the early-universe literature exhibits a persistent and widely acknowledged ambiguity at the level of explanation. In many proposed constructions, it is not always clear where physical dynamics end and effective description begins. Distinct roles-dynamical degrees of freedom, coarse-graining prescriptions, horizon definitions, entropy bookkeeping, and stress–energy sourcing-are frequently entangled in ways that obscure explanatory provenance even when observational outputs appear inflation-like.

One recurring source of confusion lies in the treatment of horizons and entropy. Horizons are, in principle, causal boundaries that delimit which degrees of freedom are dynamically accessible within a given description. Entropy, likewise, is a state-counting property defined relative to a coarse-graining choice. Yet in a broad class of early-universe proposals, horizon growth, entropy increase, or accessibility reclassification are implicitly assigned causal agency, effectively standing in for dynamical sources of negative pressure or accelerated expansion. When this occurs, it becomes difficult to determine whether inflation-like behavior arises from genuine dynamics or from descriptive reweighting embedded in the chosen bookkeeping scheme.

This ambiguity is not resolved by improved numerical precision or closer observational agreement. A model may fit existing data while still leaving unanswered questions about what physical structures are doing the explanatory work. Conversely, distinct constructions may reproduce similar effective equations of state while relying on fundamentally different mechanisms-or on none at all. Without a disciplined way to separate dynamics from description, such distinctions are easily lost.

The motivation for the present work is therefore methodological rather than theoretical. We do not propose a new early-universe mechanism, modify known laws, or advocate for alternatives to inflation. Instead, we introduce and apply a diagnostic audit designed to enforce conservation-honest accounting, explicit identification of dynamical degrees of freedom, and stability under admissible reformulation. The goal is not to rank models by observational success, but to clarify the provenance of the physical effects they claim to explain.

Accordingly, this work reports the outcomes of applying a conservation-honest diagnostic protocol to a representative set of early-universe proposals, focusing on explanatory provenance rather than observational fit. By doing so, it aims to make explicit which inflation-like behaviors are dynamically earned, which are descriptive reinterpretations, and which fail to remain stable once bookkeeping choices are exposed and varied.

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2. Diagnostic Framework and Method

The Cosmological Explanation Diagnostic Audit (CEDA) is employed in this work strictly as a methodological tool. It is not a cosmological mechanism, does not introduce new degrees of freedom, and does not constitute an alternative to inflationary ΛCDM. Its role is diagnostic: to audit how early-universe models generate their claimed physical effects once conservation laws, causal structure, and coarse-graining discipline are enforced explicitly.

CEDA operates by translating a given proposal into a standardized descriptive layer that makes all implicit assumptions explicit. This translation is intentionally model-agnostic and does not privilege any particular theoretical paradigm. The framework is designed to be neutral with respect to observational success and to focus solely on explanatory provenance.

Each audited model is first specified using a standardized ***Model Card****, which requires explicit declaration of: the dynamical degrees of freedom treated as active, any degrees of freedom treated as inactive or integrated out, the definition and evolution of the causal domain and horizon, the coarse-graining prescription, and the construction of the effective stress–energy tensor that sources the geometry. Exchange terms between sectors, if present, must be written explicitly. Proposals that cannot be rendered in this form are classified as underspecified and are not advanced to diagnostic testing.*

Before any diagnostic test is applied, each run must pass a ***Run Validity Gate****. This gate enforces basic accounting requirements: conservation of energy–momentum within the declared system–environment partition, consistency between declared degrees of freedom and the effective stress–energy used in the equations of motion, and the absence of outcome-targeting closures or teleological assumptions. Runs that fail this gate are not interpreted further.*

Models that pass the validity gate are then subjected to a sequence of diagnostic tests. ***Test D1*** *evaluates whether horizon reconfiguration or accessibility repartitioning alone-without added dynamics-can generate sustained accelerated expansion, establishing a null baseline.* ***Test D2*** *probes stability under admissible variations in coarse-graining scale, horizon definition, and near-boundary mode assignment.* ***Test D3*** *examines the provenance of any exchange terms, testing whether they arise from explicit partition evolution or function as implicit control terms tuned to achieve a desired outcome.* ***Test D4*** *assesses whether a proposal that claims novelty possesses a well-defined predictive wedge distinguishing it operationally from standard ΛCDM with inflation.*

A central feature of the diagnostic protocol is the ***no-rescue rule****. Once a model is translated and tested, failed diagnostics may not be repaired by introducing additional structure,* *reinterpretive language, or post hoc constraints within the same run. Any such modification constitutes a new proposal and must be evaluated independently from the beginning.*

All diagnostic steps are deterministic given a specified Model Card, and the audit is designed to be reproducible by independent analysts. By restricting its scope to explicit accounting and stability criteria, CEDA aims to separate genuine dynamical mechanisms from descriptive reinterpretations without introducing theoretical bias or speculative assumptions.

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3. Sample Selection and Audit Scope

The audits reported in this work are not intended as a comprehensive survey of early-universe cosmology. The goal is not to catalog the full literature, nor to adjudicate between competing proposals on observational or phenomenological grounds. Instead, the sample is deliberately structured to test the diagnostic framework against representative classes of explanatory strategies commonly employed in early-universe modeling.

Models were selected according to their structural role in the diagnostic program rather than their prominence or completeness. In particular, the sample was chosen to include four distinct categories that together span the explanatory landscape relevant to the questions addressed by CEDA.

First, a **canonical null control** was included. This construction implements horizon-mediated accessibility reconfiguration under strict conservation-honest accounting and without introducing new dynamical degrees of freedom. Its purpose is not to succeed as a cosmological model, but to establish a calibrated baseline against which claims of inflation-like behavior without added dynamics can be evaluated.

Second, at least one **genuine inflationary mechanism** was examined as a calibration case. These models introduce explicit dynamical structure-such as additional fields or higher-curvature terms-known to produce accelerated expansion. Including such cases ensures that the diagnostic framework does not penalize inflationary dynamics and provides a reference for stable, mechanism-level behavior.

Third, the sample includes **horizon- or entropy-driven constructions** that attribute inflation-like behavior to causal boundaries, entropy growth, entanglement structure, or accessibility reclassification, often without introducing new dynamical sources. These proposals occupy the conceptual boundary where descriptive language and physical mechanism are most likely to be conflated and therefore represent a critical stress test for the audit.

Finally, the sample incorporates **inflation-mimicking effective models** that reproduce aspects of inflationary phenomenology through effective fluids, exchange terms, or reweighted stress–energy constructions. These cases are particularly useful for diagnosing stability under reformulation and for identifying when inflation-like behavior depends on privileged bookkeeping choices rather than intrinsic dynamics.

The scope of the present work is intentionally limited. The models audited are **representative rather than exhaustive**, and no claim is made that the sample spans all viable early-universe proposals. However, the selected cases are sufficient to establish robust diagnostic patterns across classes. The consistency of outcomes within and across these categories suggests that the reported results reflect structural features of the explanatory strategies employed, rather than idiosyncrasies of individual models.

Expanding the audit to additional proposals would refine and extend the classification, but it is not required to establish the central conclusions reported here.

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4. Results I - Canonical Null Control (WF1.2)

The first diagnostic run applies CEDA to a canonical null construction, designated WF1.2, which implements horizon-mediated accessibility reconfiguration without introducing additional dynamical degrees of freedom or modified gravitational dynamics. WF1.2 is not proposed as a viable early-universe model; it serves as a control designed to establish the baseline behavior of conservation-honest repartitioning alone.

In this construction, all dynamically active degrees of freedom obey radiation-like dilution, and the causal domain is defined solely through horizon-based accessibility criteria. The effective stress–energy tensor sourcing the geometry is constructed from a weighted sum of these constituents, with weights determined by horizon-mediated accessibility. Exchange terms between accessible and inaccessible sectors are derived explicitly from the evolution of the partition and are not tuned to produce any particular equation of state.

Under Diagnostic Test D1, WF1.2 exhibits no sustained accelerated expansion. The effective equation of state remains radiation-like throughout the evolution, and no interval with vacuum-like behavior ($w \simeq -1$) is generated. This outcome holds independent of the specific functional form used to implement smooth horizon gating, provided conservation and non-teleological exchange are enforced.

Diagnostic Test D2 further shows that this null result is stable under admissible reformulations. Variations in horizon definition, coarse-graining scale, and near-boundary mode assignment do not induce qualitative changes in the effective dynamics. No privileged slicing or descriptive choice produces inflation-like behavior without violating the validity gate.

These results confirm the null hypothesis: **horizon-mediated accessibility reconfiguration alone does not generate negative pressure or accelerated expansion**. Importantly, this outcome is not a failure of WF1.2 but its defining result. The construction behaves exactly as required for a trustworthy control, establishing a baseline constraint that any proposal claiming inflation-like behavior without new dynamics must explicitly evade.

WF1.2 therefore anchors the diagnostic program. It demonstrates that, under conservation-honest accounting, repartitioning radiation-like degrees of freedom produces radiation-like effective behavior. All subsequent diagnostic classifications are made relative to this calibrated null baseline.

Results II - Genuine Inflationary Mechanisms

As a calibration check, CEDA was applied to established inflationary constructions that introduce explicit dynamical structure known to produce accelerated expansion, such as additional scalar degrees of freedom or higher-curvature terms in the gravitational action. These models are not evaluated here for observational viability or microphysical completeness, but solely for the provenance and stability of their inflationary behavior under diagnostic scrutiny.

In these cases, accelerated expansion arises from identifiable intrinsic dynamics. Negative pressure is localized to explicit terms in the action-such as scalar potentials, modified kinetic structure, or higher-curvature contributions-and does not depend on horizon bookkeeping, entropy reassignment, or accessibility reweighting. The effective stress–energy sourcing the geometry remains well defined under translation to the CEDA descriptive layer.

Under Diagnostic Test D2, inflationary behavior in these models is stable with respect to admissible variations in coarse-graining scale, horizon definition, and near-boundary treatment. Reformulations that alter descriptive choices without modifying the underlying dynamics do not eliminate or qualitatively alter the period of accelerated expansion. No privileged slicing or tuning of exchange terms is required to sustain the effect.

Diagnostic Test D3 further confirms that exchange terms, when present, are not outcome-targeting controls. Accelerated expansion persists even when such terms are removed or varied within conservation-consistent bounds, demonstrating that the inflationary behavior does not rely on descriptive closure.

Accordingly, these constructions are classified by CEDA as **Stable Mechanisms**. This classification reflects the fact that inflation-like behavior is dynamically earned rather than descriptively imposed.

The inclusion of these cases serves a critical role in the audit. It demonstrates that CEDA does not penalize inflationary dynamics or favor alternatives. Instead, it clarifies why successful inflationary models work: they introduce genuine dynamical structure capable of sourcing negative pressure in a manner that is robust under reformulation. The diagnostic framework therefore sharpens, rather than undermines, the conceptual foundations of inflation.

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6. Results III - Horizon- and Entropy-Driven Proposals

A substantial class of early-universe proposals attributes inflation-like behavior to horizon growth, entropy increase, entanglement structure, or reclassification of dynamically accessible degrees of freedom, often without introducing new dynamical sources. These constructions constitute a primary target of the CEDA audit, as they sit at the boundary between physical mechanism and descriptive reinterpretation.

Across all audited cases in this category, **Diagnostic Test D1 confirms the null baseline** established by WF1.2. When horizon reconfiguration or accessibility repartitioning is implemented under conservation-honest accounting and without added dynamics, no sustained accelerated expansion is produced. The effective equation of state remains radiation-like, and negative pressure does not emerge from the bookkeeping alone.

Under **Diagnostic Test D2**, these proposals consistently exhibit instability under admissible reformulation. Small variations in horizon definition, coarse-graining scale, or near-boundary mode assignment either eliminate the inflation-like behavior entirely or induce order-unity changes in the effective equation of state. Inflationary behavior, when reported, depends on privileged descriptive choices rather than on invariant dynamical structure.

Where inflation-like behavior is maintained, **Diagnostic Test D3 identifies exchange terms as the critical failure point**. In these cases, exchange or effective pressure terms are not derived uniquely from partition evolution but are either left underspecified or implicitly tuned to counteract dilution and stabilize the desired outcome. Such terms lack neutral provenance and function as outcome-targeting controls rather than consequences of the declared dynamics.

Accordingly, CEDA classifies these constructions as **Reinterpretations or Inflation-Mimicking Models**, depending on the degree to which inflation-like behavior is claimed. This classification does not depend on numerical implementation details or observational comparisons. The failures are **structural rather than numerical**: once conservation discipline and descriptive stability are enforced, the claimed mechanisms do not survive.

The central diagnostic conclusion is that inflation-like behavior in horizon- and entropy-driven proposals depends on bookkeeping choices rather than intrinsic dynamics. When those choices are made explicit and varied within admissible bounds, the apparent acceleration either disappears or becomes diagnostically unstable.

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7. Results IV - CDT-Triggered Descriptive Failure

In a subset of audited constructions, the diagnostic process reveals a more severe failure mode than simple instability under reformulation. In these cases, no admissible interior effective description remains stable once conservation-honest accounting and descriptive neutrality are enforced. CEDA identifies this outcome as a **Causal Description Transition (CDT)**.

These cases typically arise in models that attempt to maintain inflation-like behavior through tightly coupled horizon definitions, coarse-graining prescriptions, and effective stress–energy constructions. When any one of these elements is varied within admissible bounds-such as a small shift in horizon placement, reassignment of near-boundary modes, or adjustment of the coarse-graining scale-the interior description either loses accelerated expansion entirely or becomes internally inconsistent. No alternative descriptive choice within the same framework restores stability without violating the validity gate.

It is crucial to emphasize that a CDT does **not** represent a physical transition or dynamical event in spacetime. Rather, it marks the point at which a proposed effective description ceases to exist as a self-consistent explanatory framework. The breakdown is descriptive, not physical: the model no longer admits an interior effective theory capable of supporting the claimed behavior under the framework’s accounting rules.

CEDA classifies such cases as **Inflation-Mimicking Reinterpretations (CDT-Triggered)**. This designation reflects that inflation-like behavior is present only within a vanishingly narrow set of descriptive choices and cannot be maintained across admissible reformulations. Once the descriptive instability is exposed, continued modeling within the same construction is no longer meaningful without introducing new dynamical structure, at which point the proposal must be treated as a distinct model and re-audited from the beginning.

The identification of CDT-triggered failure highlights a diagnostic boundary that is often obscured in early-universe modeling. While many constructions fail by depending on privileged bookkeeping, CDT cases fail more fundamentally: they lack any stable interior description capable of sustaining the claimed explanatory role.

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8. Cross-Model Patterns and Synthesis

When viewed collectively, the diagnostic outcomes reported in Sections 4–7 exhibit a set of recurring patterns that are consistent across model classes. These patterns do not depend on the specific mathematical realization of individual proposals, nor on their observational status.

They emerge directly from the application of conservation-honest accounting and stability criteria and therefore represent empirical diagnostic results rather than interpretive judgments.

First, **negative pressure consistently localizes to genuine dynamical structure**. In every audited case where sustained accelerated expansion is present and stable, the source of negative pressure can be traced to explicit dynamical terms-such as additional fields, modified kinetic structure, or higher-curvature contributions-in the underlying equations of motion. No construction relying solely on horizon growth, entropy reassignment, or accessibility repartitioning produces negative pressure under conservation-honest accounting.

Second, **horizon language frequently masks descriptive control rather than supplying dynamics**. While horizons play an essential role in defining causal domains, models that attribute causal agency to horizon growth or accessibility changes invariably encode inflation-like behavior through the choice of weighting schemes, partition rules, or effective closures. Once these descriptive choices are made explicit and varied within admissible bounds, the apparent acceleration either disappears or becomes unstable.

Third, **stability under reformulation is the decisive diagnostic separator**. Models that introduce genuine dynamics remain qualitatively unchanged under admissible variations in coarse-graining scale, horizon definition, and near-boundary treatment. By contrast, inflation-mimicking constructions exhibit order-unity sensitivity to such variations. The presence or absence of reformulation stability provides a sharp criterion for distinguishing mechanism-level physics from bookkeeping-dependent reinterpretation.

Fourth, **exchange terms represent the most common site of structural failure**. In many proposals, effective exchange or pressure terms are introduced without unique derivation from partition evolution. These terms often function implicitly as outcome-stabilizing controls, counteracting dilution or enforcing a desired equation of state. Diagnostic Test D3 reliably identifies such terms as lacking neutral provenance.

Finally, **many proposed “alternatives to inflation” inherit inflationary structure implicitly**. When translated into the CEDA descriptive layer, a significant fraction of these constructions reproduce inflation-like behavior only by embedding features functionally equivalent to slow-roll dynamics, vacuum energy, or scalar degrees of freedom, albeit in alternative language. Once this inheritance is exposed, the proposals no longer constitute distinct mechanisms.

Taken together, these findings establish that the diagnostic distinctions drawn by CEDA are not matters of interpretation or preference. They follow reproducibly from enforcing conservation discipline and descriptive stability across model classes. The framework therefore provides a systematic way to separate genuine early-universe mechanisms from reinterpretive narratives that depend on privileged bookkeeping.

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9. Discussion: What the Results Do-and Do Not-Imply

The results reported in this work support several clear methodological conclusions, but they do not warrant broad theoretical claims about the early universe. This distinction is essential. CEDA is designed to diagnose explanatory provenance, not to adjudicate the ultimate correctness of any cosmological paradigm.

First, the results imply that **inflationary behavior requires genuine dynamical structure**. Across all audited cases, sustained accelerated expansion and negative pressure arise only when explicit dynamics-such as additional degrees of freedom or modified gravitational terms-are introduced. This finding does not privilege any specific inflationary model, but it does clarify that inflation-like behavior is not generically produced by horizon reconfiguration, entropy growth, or accessibility repartitioning alone.

Second, the results demonstrate that **reinterpretations are diagnostically distinguishable from mechanisms**. Inflation-mimicking constructions can reproduce effective equations of state similar to those of inflation, but they fail to remain stable under admissible reformulation unless they embed additional structure. Stability under reformulation therefore provides a practical criterion for separating mechanism-level physics from descriptive bookkeeping, independent of observational considerations.

Equally important are the limits of what these results imply. The audit does **not** suggest that inflation is incorrect, incomplete, or unnecessary. Established inflationary mechanisms pass the diagnostic tests precisely because they introduce the required structure. Nor do the results rule out alternative early-universe scenarios on observational or phenomenological grounds. Many such proposals may remain viable or even preferable when judged by data or by considerations beyond the scope of this work.

Finally, the identification of **Causal Description Transitions** must not be misinterpreted as evidence for physical transitions or novel spacetime phenomena. A CDT marks the breakdown of a particular effective description under enforced accounting rules; it does not correspond to a dynamical event in the universe. Treating CDTs as physical would reintroduce the very category errors that the diagnostic framework is designed to expose.

In sum, the results support a narrow but important conclusion: conservation discipline and descriptive stability are sufficient to clarify where explanatory power resides in early-universe models. Beyond this, the framework makes no claims. Its value lies in restraint as much as in discrimination.

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10. Conclusion

When conservation discipline and descriptive stability are enforced, early-universe models separate cleanly into genuine dynamical mechanisms and bookkeeping-dependent reinterpretations. Applying the Cosmological Explanation Diagnostic Audit (CEDA) to representative constructions shows that inflation-like behavior is robust only when it is sourced by explicit dynamical structure and remains stable under admissible reformulation. Horizon- or entropy-driven explanations that lack such structure fail not by numerical accident, but by structural dependence on privileged descriptive choices. CEDA does not propose new cosmology or challenge the empirical success of inflation; it provides a reproducible, neutral method for making explicit where explanatory power genuinely resides in early-universe models.

High-Level Summary

Summary of Diagnostic Results to Date

Applying the Cosmological Explanation Diagnostic Audit (CEDA) to representative early-universe constructions yields a consistent and nontrivial set of results. Models that rely solely on horizon growth, entropy arguments, or accessibility reclassification fail to generate sustained accelerated expansion under conservation-honest accounting. When exchange terms are derived explicitly and descriptive choices are varied within admissible bounds, such models retain radiation-like behavior or exhibit order-unity instability. Inflation-like behavior appears only when additional structure is introduced-often implicitly-at which point the construction collapses into inflation mimicry rather than a novel mechanism.

By contrast, established inflationary mechanisms that introduce genuine dynamical degrees of freedom produce negative pressure that remains robust under coarse-graining variation and reformulation. These models pass CEDA diagnostics cleanly, demonstrating that the framework does not challenge inflation's empirical success but clarifies the structural reasons for that success.

Across all audited cases, negative pressure never arises without identifiable dynamics, and stability under reformulation cleanly separates mechanisms from reinterpretations. Causal Description Transitions (CDTs) appear only in models where no admissible interior effective description remains stable, signaling descriptive non-existence rather than physical pathology.

These results establish CEDA as a functioning diagnostic instrument rather than a speculative framework. The framework does not propose new cosmology; it enforces clarity about where explanatory power actually enters early-universe models-and where it does not.