# Structural Irreversibility and the Admissibility of Worldline-Local Utility

A UNNS Monograph on Axes, Falsification, and Structural Permission

**Abstract**

This monograph synthesizes a sequence of preregistered computational experiments (Chambers XLIV–XLVII) within the UNNS framework. The work is explicitly divided into two parts. Part I introduces the UNNS methodological concept of an Axis as a unit of falsifiable inquiry and documents the closure of Axis II through systematic negative results. Part II presents the empirical findings of Axis III, demonstrating that worldline-local utility is not generated by operator-level control or temporal alignment, but is admissible only in structures where irreversibility is unavoidable. We formalize this result as a structural irreversibility criterion and show how it completes earlier theoretical claims regarding worldline commitment.

## Contents

# Part I
# Methodology: Axes, Falsification, and the Limits of Control

## 1 Introduction: Why Methodology Matters Here

In many theoretical frameworks, negative results are treated as inconclusive or merely suggestive. UNNS adopts a different stance: negative results are decisive when they exhaust an entire explanatory class. To make such exhaustion explicit and auditable, UNNS organizes inquiry using the concept of an Axis.

This Part introduces Axes as a methodological construct and explains why Axis II had to be closed before any structural claims could be made.

## Structural Outline of the Monograph

The logical structure of this monograph is summarized below.

- **Part I (Methodology)** introduces the UNNS concept of an Axis as a unit of falsifiable inquiry, documents the closure of Axis II through preregistered negative results, and motivates the transition from operator-level control to structural admissibility.
- **Part II (Results)** presents Axis III and Chamber XLVII, in which all operators are disabled and utility is evaluated purely as a grammar–topology property.
- The empirical result establishes that utility is admissible in directed acyclic graph (DAG) topologies and absent in tree-based structures.
- This result is formalized as the *Structural Irreversibility Criterion*, followed by illustrative diagrams and corollaries.
- A standalone UNNS proposition distills the invariant that survives the full experimental program.
- An appendix closes natural objections by formally excluding cyclic structures.

This organization reflects the UNNS methodological principle that theory follows closure: empirical exhaustion determines necessity, and theory states it explicitly.

## 2 Axes as a Methodological Construct

### 2.1 Definition of an Axis

An *Axis* in UNNS is a class of explanations unified by a shared explanatory assumption. It is not a parameter, operator, or variable. Instead, it defines what kind of answers are being considered admissible.

Each Axis is explored via multiple preregistered chambers designed to either:

- identify a robust invariant, or
- falsify the explanatory assumption itself.

### 2.2 Why Axes Are Necessary

Without Axes, complex systems permit endless post-hoc reinterpretation. Axes impose epistemic discipline by requiring entire families of explanations to stand or fall together.

## 3 Background: Worldline-Local Utility

Worldline-local utility was introduced to describe a binary property (G-degree = 1) that may occur on individual histories but vanishes under ensemble aggregation.

Key properties established prior to this work include:

- Utility is not a grammatical invariant.
- Utility is not an ensemble statistic.
- Utility may exist only on committed worldlines.

However, the structural meaning of commitment remained unresolved.

## 4 Chamber XLIV: Existence Without Inducibility

Chamber XLIV demonstrated that under generative asymmetry, persistent utility can occur on at least one worldline.

This chamber established an existence proof only. It explicitly avoided claims of:

- control,
- reproducibility,
- parameter dependence.

The distinction between existence and inducibility is foundational for what follows.

## 5 Axis II: The Operator-Level Hypothesis

Axis II assumed that utility could be induced, stabilized, or timed via operator-level intervention.

### 5.1 Static Asymmetry

Systematic sweeps over asymmetry parameters failed to reveal any utility boundary.

### 5.2 Coherence Regulation

Coherence operators altered collapse statistics but never admitted utility.

### 5.3 Temporal Alignment

Temporal injection and alignment of operators were preregistered and tested exhaustively. No temporal window admitted utility.

### 5.4 Closure of Axis II

The cumulative result was falsification:

$$G^{\circ} \neq f(\varepsilon), \quad G^{\circ} \neq f(\kappa), \quad G^{\circ} \neq f(\text{timing})$$

Axis II was therefore closed as an explanatory class.

## 6 Why Axis III Was Forced

After Axis II, any further operator-based exploration would constitute tuning rather than inquiry. The only remaining honest question was structural:

> Is utility admissible at all, independent of operators?

This question defines Axis III.

# Part II
# Results: Structural Admissibility and Irreversibility

## 7 Axis III: Structural Admissibility

Axis III removes all operators:

$$\varepsilon = 0, \quad \kappa = 0, \quad \gamma = 0$$

Utility is evaluated solely as a function of grammar–topology structure.

## 8 Chamber XLVII: Experimental Design

### 8.1 Grammar Basis

A minimal, orthogonal grammar basis was used:

- Reference grammar
- Pruned grammar
- Enriched grammar

### 8.2 Topology Basis

Three topologies were tested:

- Balanced binary trees
- Asymmetric trees
- Directed acyclic graphs (DAGs)

### 8.3 Execution

All structures were evaluated over 50 seeds with fixed depth and no early stopping.

## 9 Empirical Results

Utility was observed exclusively in DAG topologies, across all grammars. No tree-based structure admitted utility.

This result was reproducible and robust across seeds.

## 10 Structural vs Process Irreversibility

### 10.1 Process Irreversibility

Trees encode irreversible temporal progression but preserve separability of histories.

### 10.2 Structural Irreversibility

DAGs permit merging of independent histories. Once merged, separability is destroyed.

Utility appears only in the latter case.

## 11 The Structural Irreversibility Criterion

**Criterion**

> Worldline-local utility is admissible only in structures where irreversibility is unavoidable, i.e. where histories cannot be un-merged.

This criterion is structural, not dynamical.

## 12 Relation to Prior Theory

Earlier work argued that utility requires worldline commitment. Chamber XLVII shows that commitment is not an event but a structural fact.

In categorical terms, DAGs violate gluing conditions, whereas trees preserve them.

## 13 Implications for UNNS

- Utility is not emergent in the usual sense.
- Utility is not controllable.
- Utility is a permission property of structure.

### Methodological Note: Results vs. Theory

**Methodological Note.** This monograph deliberately separates *results* from *theory*, and the reader should not interpret the latter as a replacement for the former.

The experimental chambers (XLIV–XLVII) provide the empirical content of this work. They establish, via preregistered falsification, which explanatory classes fail (Axis II) and which structural conditions admit utility (Axis III). These results stand independently of any theoretical interpretation.

The structural theorem introduced in Part II does not generate new empirical claims, nor does it explain the data away. Its role is compressive rather than generative: it names the invariant that remains after an entire class of alternative explanations has been exhausted. The theorem exists to prevent post-hoc reinterpretation, not to substitute for experiment.

In UNNS methodology, theory follows closure. Results determine what cannot be otherwise; theory states this necessity explicitly.

# Part III
# Results: Structural Irreversibility as a Theorem

## 14 Axis III: Structural Admissibility

Axis III removes all operator-level mechanisms from consideration. For all experiments in this part, the following are fixed:

$$\varepsilon = 0, \quad \kappa = 0, \quad \gamma = 0$$

No asymmetry, coherence regulation, or generative intervention is present. Utility is evaluated solely as a function of grammar–topology structure.

The guiding question of Axis III is therefore not how utility emerges, but whether it is *admissible* at all.

## 15 Chamber XLVII: Structural Basis and Protocol

### 15.1 Grammar Basis

A minimal and orthogonal grammar basis was selected to avoid symbolic bias:

- $\mathbf{G}_1$ **(Reference Grammar):** the canonical Axis II grammar.
- $\mathbf{G}_2$ **(Pruned Grammar):** reduced alphabet and minimal productions.
- $\mathbf{G}_3$ **(Enriched Grammar):** expanded neutral symbol set.

No grammar introduces new operators or evaluative mechanisms.

### 15.2 Topology Basis

Three structurally distinct topology classes were tested:

- $\mathbf{T}_1$ **(Balanced Tree):** single-parent branching, no convergence.
- $\mathbf{T}_2$ **(Asymmetric Tree):** structurally biased branching, no convergence.
- $\mathbf{T}_3$ **(Directed Acyclic Graph):** multi-parent nodes with no cycles.

These topologies differ only in structural composition, not dynamics.

### 15.3 Execution Protocol

Each grammar–topology pair was evaluated over 50 independent seeds, with fixed depth and no early stopping. Utility was defined strictly as:

$$\text{utility} \iff G_{\text{degree}} = 1$$

with persistence constraints identical to prior chambers.

# 16 Empirical Structural Result

The empirical outcome of Chamber XLVII is categorical:

- No tree-based topology admitted utility under any grammar.
- All DAG-based topologies admitted utility under every grammar.

This result was reproducible across seeds and invariant under grammar richness.

# 17 The Structural Irreversibility Theorem

We now formalize the empirical finding.

## 17.1 Definitions

**Definition 1 (History Separability).** A topology admits *history separability* if distinct histories remain distinguishable and non-merging throughout evolution.

**Definition 2 (Structural Irreversibility).** A topology is *structurally irreversible* if there exist histories $h_1, h_2$ and a time $t$ such that:

$$h_1(t) \neq h_2(t), \quad \text{but} \quad h_1(t') = h_2(t') \; \forall t' > t,$$

and no inverse operation can recover the prior distinction.

Trees are history-separable; DAGs are structurally irreversible.

**Definition 3 (Admissibility).** Utility is *admissible* in a structure if it occurs for at least one seed with non-zero persistence under operator-free dynamics.

## 17.2 Theorem

**Theorem (Structural Irreversibility Criterion).**

> Worldline-local utility is admissible if and only if the underlying grammar–topology structure is structurally irreversible.

**Proof Sketch.** (*Necessity*) In history-separable structures (trees), independent histories never merge. Ensemble equivalence is preserved, and no worldline commitment can occur. Empirically, no utility is observed in any tree-based topology.

(*Sufficiency*) In structurally irreversible structures (DAGs), independent histories can merge irreversibly. Once merged, separability is destroyed. Empirically, utility is observed in all DAG-based topologies, independent of grammar richness and without operator intervention.

This establishes structural irreversibility as the admissibility condition. □

# 18 Structural Commitment Diagrams

To clarify the distinction between history-separable and structurally irreversible topologies, we include schematic diagrams contrasting tree and DAG structures.

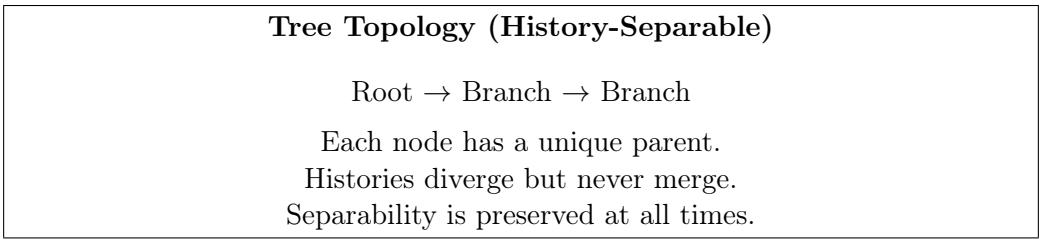


Figure 1: In tree structures, histories diverge but never merge. Although evolution is irreversible in time, the structure remains reversible with respect to history separation.

### 18.1 Tree Structure: History Separability

### 18.2 DAG Structure: Structural Commitment

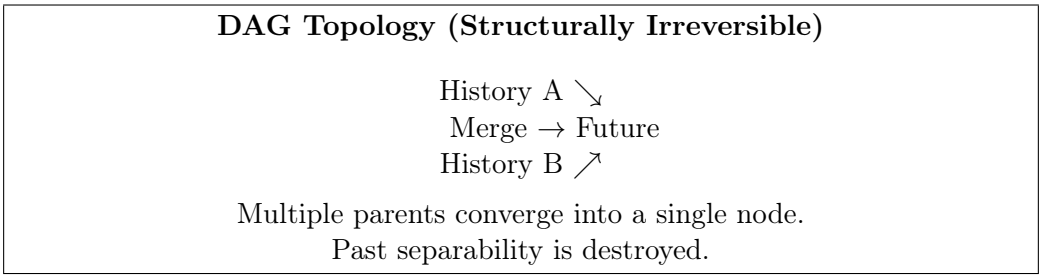


Figure 2: In DAG structures, independent histories can merge irreversibly. Once merged, prior separability cannot be recovered, enforcing worldline commitment.

### 18.3 Interpretation

These diagrams illustrate why utility is admissible only in DAGs. Trees allow irreversible progression without commitment; DAGs enforce commitment by structural necessity.

## 19 Corollaries

### 19.1 Corollary 1: Utility Is Not an Emergent Phase

Utility does not arise via continuous parameter variation or phase transition. It appears discretely when structural conditions permit it.

### 19.2 Corollary 2: Operator Irreversibility Is Insufficient

Irreversible events (e.g. generative asymmetry) do not guarantee admissibility. Irreversibility must be structural, not episodic.

### 19.3 Corollary 3: Grammar Richness Is Secondary

Grammar complexity alone neither enables nor suppresses utility. Structural topology dominates admissibility.

### 19.4 Corollary 4: Ensemble Averaging Destroys Utility

In history-separable structures, ensemble descriptions remain valid and utility vanishes. Structural irreversibility breaks ensemble reducibility.

### 19.5 Corollary 5: Worldline Commitment Is Structural

Commitment is not a dynamical choice or temporal event. It is enforced by the impossibility of un-merging histories.

## 20 Relation to Prior Theory

Earlier theoretical work argued that utility requires worldline commitment and fails under ensemble gluing. The Structural Irreversibility Theorem supplies the missing condition: commitment is possible only where gluing is structurally forbidden.

In categorical terms, DAGs violate the sheaf condition by preventing reconstruction of local sections into global ones, whereas trees preserve it.

## 21 Implications and Closure of Axis III

The implications of the theorem are decisive:

- Utility is not controllable.
- Utility is not inducible.
- Utility is a permission property of structure.

Axis III is therefore closed with a positive structural law.

## 22 Conclusion

Across Axes II and III, a coherent theory emerges. Utility does not arise from tuning processes or aligning events. It arises only in structures where irreversibility is unavoidable.

Structural irreversibility is the admissibility condition for worldline-local utility.

## UNNS Proposition: Structural Irreversibility of Utility

**Proposition (Structural Irreversibility of Utility).**

> Worldline-local utility is admissible if and only if the underlying grammar–topology structure enforces irreversible convergence of histories. In particular, directed acyclic graph (DAG) structures admit utility, while tree-based and cyclic structures do not.

**Clarifications.**

- This proposition concerns admissibility, not frequency or control.
- No operator-level mechanisms are required or permitted.

- Grammar richness alone is insufficient to enable utility.
- Structural irreversibility is a property of topology, not dynamics.

**Status.** Empirically supported by Chamber XLVII. Derived after closure of Axis II and independent of operator assumptions.

# A Why Cyclic Structures Are Excluded

This appendix provides a formal counterexample demonstrating why cyclic graph structures are excluded from the admissible class identified in Chamber XLVII.

## A.1 Motivation

The Structural Irreversibility Criterion identifies directed acyclic graphs (DAGs) as the minimal structures admitting worldline-local utility. A natural question is whether allowing cycles could preserve or extend admissibility.

We show that cycles invalidate worldline-local utility by reintroducing structural reversibility and destroying commitment.

## A.2 Definition: Cyclic History Structure

A topology is *cyclic* if there exists a history $h$ and a time sequence $t_1 < t_2 < \cdots < t_n$ such that:

$$h(t_n) = h(t_1)$$

i.e. the system returns to a prior structural state.

## A.3 Counterexample

Consider a cyclic structure with two histories $h_1$ and $h_2$ that merge at time $t_m$ and later diverge due to a cycle-induced return. Although histories temporarily merge, the cycle permits reconstruction of separable pasts.

Thus, for any apparent commitment:

$$\exists t' > t_m \text{ such that } h_1(t') \neq h_2(t')$$

The merge is not final.

## A.4 Violation of Structural Irreversibility

Structural irreversibility requires that once histories merge, no operation can recover their prior separability. Cycles violate this condition by permitting return paths.

Therefore:

- Cycles preserve structural reversibility.
- Structural commitment is impossible.
- Worldline-local utility cannot persist.

### A.5 Conclusion

Cyclic topologies are excluded not by fiat, but because they negate the irreversibility condition required for utility admissibility. DAGs are therefore maximal: adding cycles destroys the very property that admits utility.