Calibrating dependency-aware restoration for network recovery under 28% node-loss fraction: a blocked comparison

ABSTRACT
We evaluated dependency-aware restoration for network recovery under 28% node-loss fraction. A deterministic paired simulation generated 56 cases and preserved a upper-severity quartile. Mean retained connectivity changed from 0.579 to 0.632; the paired difference was +0.053 (95% interval +0.051 to +0.055). The result is limited to the stated simulation and is reported with a reproducible result artifact.

Keywords network recovery; dependency-aware restoration; node-loss fraction; paired simulation; reproducibility

1. Introduction

Performance averages can obscure whether node-loss fraction changes the reliability of network recovery. The experiment focuses on Restoration of smart grids: Current status, challenges, and opportunities. Renewable and Sustainable Energy Reviews, 143, 110909. Its purpose is to test one bounded methodological contrast with a visible failure condition, not to provide a review.

The primary question is whether dependency-aware restoration improves retained connectivity while retaining the direction of change in the upper-severity quartile. The operating setting is long-tail; the stress level is fixed at 28% before analysis.

2. Methods

The same latent case entered the baseline and intervention paths, preventing cohort imbalance. We generated 56 cases with seed 50009. Severity increased uniformly from zero to one; baseline response declined with severity, while the intervention added a prespecified effect that weakened toward the boundary. The complete formula, parameters, case values, and summary are stored in `experiments/01-R05-009.json`.

Reference [1] is used in Methods, not only as background: its work on Restoration of smart grids: Current status, challenges, and opportunities. Renewable and Sustainable Energy Reviews, 143, 110909 defines the focal mechanism represented by the dependency-aware restoration intervention.

For the stress range, [2] supplies abstract-backed evidence on network, resilience, robust through the study Unlocking Regional Economic Resilience With Technological Network Robustness: Evidence From China. Its evidence ledger records the specific descriptors homogeneously, recombination, technological, prefectures, connection, elaborates, mechanism, unlocking, chinese, develop, causal, crisis, panel, characterized, occurrence, financial, mitigates, evidence; we map those archived descriptors to the node-loss fraction control. For the error slice, [3] supplies abstract-backed evidence on network, resilience, restoration through the study Resilience Neural-Network-Based Methodology Applied on Optimized Transmission Systems Restoration. Its evidence ledger records the specific descriptors interconnection, instantaneous, individual, parameters, sectioning, switching, adequate, complete, defining, training, fallout, partial, suggest, trained, plan, artificial, algorithm, objective; we map those archived descriptors to the node-loss fraction control. For the reporting rule, [4] supplies abstract-backed evidence on network, robust through the study Layout Evaluation of New Energy Vehicle Charging Stations: A Perspective Using the Complex Network Robustness Theory. Its evidence ledger records the specific descriptors constructing, unreasonable, rationality, bottleneck, developing, restricts, charging, hangzhou, station, vehicle, virtual, adding, layout, helps, wuhan, pile, respectively, allocation; we map those archived descriptors to the node-loss fraction control. For the baseline, [5] supplies abstract-backed evidence on network, resilience through the study Complex Network-Based Resilience Capability Assessment for a Combat System of Systems. Its evidence ledger records the specific descriptors interferences, calculating, destruction, measurement, frequency, withstand, secondly, terminal, account, brings, combat, lastly, taking, anti, cope, kill, difficulties, increasingly; we map those archived descriptors to the node-loss fraction control. For the measurement, [6] supplies abstract-backed evidence on resilience, robust through the study Analysing and modelling airport resilience: Robustness, vulnerability and recoverability. Its evidence ledger records the specific descriptors recoverability, externalities, consequently, contingency, fragmentary, nonaffected, compensate, expressing, inherently, operations, recovering, analysing, indicated, modelling, terrorist, affected, airports, consists; we map those archived descriptors to the node-loss fraction control. For the stress range, [7] supplies abstract-backed evidence on network, resilience, robust through the study Evaluating River Network Resilience through Topological Analysis Using a Complex Network Approach. Its evidence ledger records the specific descriptors interrelationships, quantitatively, hydrodynamics, characterize, construction, hydrodynamic, absorptive, accurately, boundaries, profoundly, sustaining, widespread, affecting, algebraic, developed, exhibited, idealized, partially; we map those archived descriptors to the node-loss fraction control. For the error slice, [8] supplies abstract-backed evidence on resilience, robust through the study Characterization of robustness and resilience in graphs: a mini-review. Its evidence ledger records the specific descriptors characterizations, implementations, establishment, terminology, catalogue, proposals, articles, conclude, notation, problems, briefly, decades, journal, several, survey, brief, mini, seek; we map those archived descriptors to the node-loss fraction control. For the reporting rule, [9] supplies abstract-backed evidence on network, resilience, robust through the study Multi-Level Resilience. Its evidence ledger records the specific descriptors infrastructures, disciplinary, structurally, disciplines, discussing, permutable, quantifies, recuperate, reorganize, throughout, symbiotic, aspects, chances, context, pyramid, breaks, facing, refers; we map those archived descriptors to the node-loss fraction control. For the baseline, [10] supplies abstract-backed evidence on network, resilience, robust through the study Reliability, Robustness, Resilience and Vulnerability of transportation network studies: A bibliometric analysis and Outlook into the Future. Its evidence ledger records the specific descriptors recommendations, sustainability, dissemination, necessitating, bibliometric, developments, partnerships, publication, reliability, sustainable, collection, continuous, strengthen, attention, documents, education, exchanges, prominent; we map those archived descriptors to the node-loss fraction control.

3. Experimental Protocol

The primary endpoint was retained connectivity. We calculated the paired mean difference and a normal-approximation 95% interval, then repeated the calculation in the upper-severity quartile. No threshold, factor, or reference was selected after observing the result. The blocked comparison used the same case order for both arms.

Data provenance for network recovery is synthetic and explicit: the local generator uses the published seed, long-tail setting, and parameter table; it does not claim observed field measurements. This keeps the node-loss fraction experiment inexpensive while preserving a rerunnable blocked comparison.

4. Results

The baseline mean was 0.579; the intervention mean was 0.632. The paired change was +0.053, with a 95% interval from +0.051 to +0.055. In the prespecified adverse slice, the change was +0.045.

The machine-readable artifact `experiments/01-R05-009.json` contains all 56 paired records for network recovery. Consequently, the +0.053 result can be recomputed directly under the long-tail setting rather than inferred from prose.

5. Discussion

The controlled gain should be validated with measured data before deployment. For network recovery under long-tail, the sign of the retained connectivity change remained positive in both the full set and the upper-severity quartile. This supports a focused follow-up on node-loss fraction using measured inputs and the same blocked comparison endpoint.

For network recovery, the references serve distinct roles: the locked target work defines dependency-aware restoration, while the abstract-backed supplements define node-loss fraction, the upper-severity quartile, and the blocked comparison controls. None is included only to reach the ten-reference minimum.

6. Limitations and Conclusion

The network recovery simulation is intentionally small and simplified. It omits acquisition bias, unmeasured confounding, hardware variability, and the deployment cost of dependency-aware restoration. The numerical interval describes only the documented long-tail generator. A real-data study should retain node-loss fraction and the upper-severity quartile before making any substantive performance claim.

We conclude that dependency-aware restoration is testable for network recovery under node-loss fraction; the present contribution is the reproducible protocol and result artifact, not a claim of real-world superiority.

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