

Building High-Performance Distribution Ecosystems A Secondary-Data Study of Distributed Adaptive Capacity

Kamran Pitafi

Independent Researcher and Industry Practitioner, Dubai, United Arab Emirates

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Abstract

Distribution partners can receive timely information yet fail to agree on a response or implement it before service deteriorates. This paper develops Distributed Adaptive Capacity (DAC) to explain that conversion problem. An integrative conceptual synthesis connects organizational information processing, ecosystem coordination, supply-chain resilience and configurational theory. DAC comprises digital permeability, orchestration intensity and reconfiguration velocity. These capabilities are proposed to influence detection, alignment and execution delays, respectively, within an independently specified adaptation window. Five diagnostic archetypes and seven proposition families distinguish the framework's definitions from relationships requiring empirical testing. A documentary illustration of Pak Elektron Limited examines the evidential limits of applying DAC to public disclosures. Dealer-share dissimilarity is approximately 0.216 against four-province population exposure and 0.234 against an urban-population proxy. Commercial and service networks also have different provincial distributions. These calculations describe network structure; they neither measure DAC nor establish its effects. The paper supplies a twelve-indicator protocol, separates missing evidence from low capability, and identifies requirements for event-based validation against established supply-chain constructs. Its contribution is a bounded account of how information becomes coordinated operational change across organizational boundaries. Whether the proposed capability profile improves prediction beyond existing measures remains an open empirical question.

Keywords: distribution ecosystems; adaptive capacity; supply-chain resilience; information processing; orchestration; reconfiguration

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1. Introduction

A stock-out alert does not replenish a retailer. Someone must establish which inventory is available, obtain agreement to redirect it and arrange a feasible delivery. Each step may involve a different organization. Even when a manufacturer has an accurate dashboard, a distributor may resist reallocating stock because its incentives favor local sales, or a carrier may lack the capacity to execute the agreed response. Distribution performance therefore depends partly on what happens between recognizing a problem and putting a shared

decision into operation.

This paper examines that interval. High performance is defined here as maintaining or restoring a specified distribution service under change. It does not imply the lowest operating cost or the highest sales growth in every setting. The unit of theoretical interest is an adaptation episode involving interdependent actors in a physical-goods distribution ecosystem. A focal firm's assets, technology expenditure or national dealer count cannot, by themselves, describe that episode.

Several established theories explain parts of this problem. Resilience research addresses preparation, response and recovery from disruption (Christopher and Peck, 2004; Ponomarov and Holcomb, 2009; Pettit et al., 2010). Agility research examines responsiveness and flexibility (Swafford et al.,

2006), while dynamic-capabilities theory addresses sensing, seizing and reconfiguration (Teece, 2007). Ecosystem research makes interdependencies among autonomous actors central to explanation (Adner, 2017; Jacobides et al., 2018). Lee's (2004) Triple-A framework already combines agility, adaptability and alignment. Its AAA+ extension explicitly addresses digital capability and ecosystem governance (Patrucco et al., 2026). Any additional construct must acknowledge this substantial overlap.

Distributed Adaptive Capacity (DAC) is proposed as a more narrowly specified configuration of digital permeability (DP), orchestration intensity (OI) and reconfiguration velocity (RV). It links capabilities measured before an episode to the delays experienced during that episode. The argument concerns the conversion of distributed information into authorized, executable action before a task-specific deadline. It does not claim that the three ingredients, adaptive capacity or bottleneck reasoning are new. Earlier organizational and social-ecological research provides a broader lineage for adaptive capacity (Staber and Sydow, 2002; Folke, 2006; Smit and Wandel, 2006). The exact phrase also appears in a flood-resilience preprint (Hasan and Ahmad, 2026); lexical novelty is not claimed.

Three questions guide the paper. RQ1 asks how DP, OI and RV could influence the conversion of information into operational change across organizations. RQ2 asks which temporal and contextual predictions would distinguish DAC from adjacent constructs. RQ3 asks what public documentary evidence can establish, and how the proposed configuration could subsequently be measured and falsified. The paper answers these questions through conceptual development, a bounded PEL illustration and an explicit validation design. It makes no claim of empirical construct validation.

Theoretical development

Three conversion functions

Organizational information-processing theory relates uncertainty to the information requirements of coordinated work (Galbraith, 1974; Tushman and Nadler,

1978). In a distribution ecosystem, uncertainty concerns both operating conditions and the actions of other organizations. A manufacturer may know that an order is late without knowing whether a dealer has substitute inventory. A carrier may have spare capacity but require an authorization that neither the distributor nor the manufacturer can issue alone.

DP concerns whether decision-relevant operating information is available across the required actors. Its proposed indicators are visibility, update timeliness, cross-actor integration and practical accessibility. Information abundance is insufficient: a system that records thousands of events but omits the affected retailers may offer little help with the focal task. DP concerns a capability for information availability; the actual time taken to recognize a particular event is measured separately.

OI concerns the reach and effectiveness of arrangements that make a shared response possible. Incentives, information-governance rules, compatible standards and relational governance can reduce disputes about priorities or authority. Intensity refers to the extent to which those arrangements govern real operating decisions. It should not be measured by meeting frequency, approval counts or centralization. Additional approvals can lengthen the very delay that orchestration is intended to reduce.

RV concerns the readiness of alternative routes, capacity, partners and activation routines. An unused carrier on a vendor list offers little usable flexibility if qualification takes longer than the delivery window. Conversely, a modest network may adapt quickly when a suitable alternative is already contracted and tested. RV is an antecedent capability; execution time is an episode outcome. Keeping the two separate prevents fast observed execution from serving simultaneously as the measure of capability and the evidence for its effect.

The mapping is deliberately imperfect. Data standards may affect both DP and OI, and governance may determine whether a carrier can be activated. Indicators are assigned according to their primary function, with cross-effects recorded rather than suppressed. The validity of those assignments requires expert review and field evidence.

Time, dependencies and the adaptation window

Let t_0 denote the earliest externally identifiable signal relevant to an episode. Let t_d denote decision-usable

recognition, to the authorization needed for execution, and to the time at which the operating change takes effect. In a strictly sequential episode, the intervals are defined by Equation 1.

$$T_{detect} = t_d - t_0; T_{align} = t_a - t_d; T_{execute} = t_e - t_a; T_{adapt} = t_e - t_0. (1)$$

These are accounting definitions. Their truth cannot validate DAC. Empirical claims concern whether independently measured capabilities predict the intervals and whether the intervals predict independently measured service outcomes.

For overlapping work, adding broad stage intervals would double-count time. The investigator must record task dependencies and calculate elapsed completion time on the necessary critical path. Authorization can be provisional, a carrier can prepare before allocation is final, and several routes may be evaluated concurrently. The main clock remains $t_e - t_0$, but attribution requires the task graph. Where two paths are equally critical, the analyst should record joint constraints rather than force one dominant stage.

Define W_0 as the maximum acceptable elapsed time established from information available at or before t_0 . A contractual cutoff, an engineering limit or a preregistered stock-cover rule can supply this threshold. The reference

must not be the eventual observed breach time: a successful intervention may prevent that breach altogether. If W_0 is forecast, record the forecast assumptions and its uncertainty. Deadline revisions during an episode belong in a separate sensitivity analysis and must not be selected retrospectively to favor the theory.

$$\text{Deadline margin } M = W_0 - T_{adapt}. (2)$$

A nonnegative M indicates timely implementation relative to the specified window. It does not establish that the chosen action was correct, sufficient or economical. Adaptive performance must therefore be measured independently, for example by order fill, service continuity or duration below a contractual standard. A fast but unsuitable reallocation can meet the deadline and still harm customers.

Time-to-survive and time-to-recover are the closest temporal comparators. They concern how long a disrupted supply chain can sustain service and how long restoration requires (Simchi-Levi et al., 2014). W_0 can coincide with a survival limit in a particular application; a distinction should not be manufactured where none exists. DAC instead proposes a decomposition of cross-actor response delays and antecedent capabilities. Adaptation may involve rerouting or substitution before the original operation fully recovers.

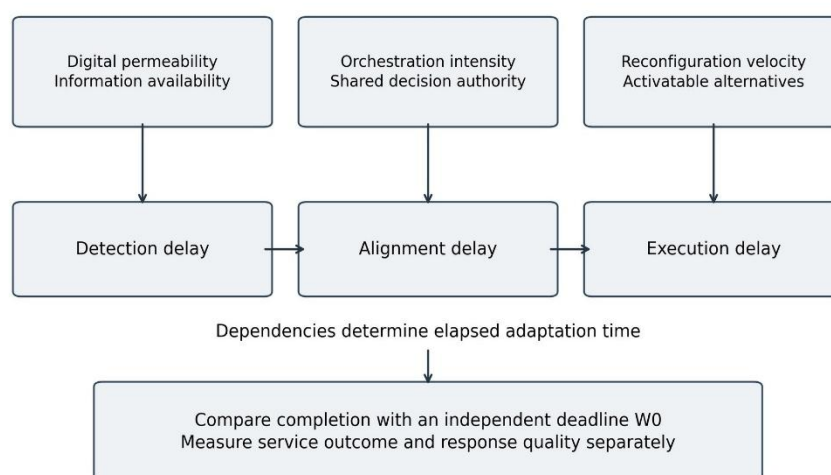


Figure 1. Proposed DAC conversion mechanism. The horizontal path depicts a sequential episode; concurrent work requires a dependency graph. Capability-to-delay relationships are hypotheses. Timing definitions alone do not validate the framework. Source: original schematic prepared with code and AI assistance.

Construct boundaries and incremental contribution

Table 1 identifies the comparisons that matter most. DAC cannot establish originality by renaming alignment, digitalization or flexibility. Its defensible contribution is a proposed relationship between a pre-episode capability profile, observable conversion delays and a separately

defined tolerance window. This relationship must ultimately outperform simpler explanations.

Table 1. Adjacent constructs and the proposed DAC distinction

Comparator	Established focus	Test required for DAC
Resilience	Preparation, response and recovery (Christopher and Peck, 2004).	Explain service outcomes beyond established resilience measures.
Agility and flexibility	Speed and feasible response options (Swafford et al., 2006).	Distinguish prior readiness from realized episode delay.
Dynamic capabilities	Sensing, seizing and reconfiguration (Teece, 2007).	Show value from a narrower cross-actor conversion specification.
Triple-A AAA+	and Agility, adaptability, alignment and digital ecosystem capability (Lee, 2004; Patrucco et al., 2026).	Demonstrate incremental stage-level and predictive information.
Ecosystems	Interdependent actor activities (Adner, 2017; Jacobides et al., 2018).	Observe how dependencies produce recognition and authorization delays.
Viability	Long-term network survivability (Ivanov and Dolgui, 2020).	Distinguish episode adaptation from sustained survival.
TTS and TTR	Service survival and restoration times (Simchi-Levi et al., 2014).	Avoid relabeling the survival window; test the delay decomposition.
Bottleneck analysis	Critical constraints and their movement (Lawrence and Buss, 1994).	Identify cross-actor constraints using feasible interventions and dependencies.

A further boundary concerns digital dependence. Face-to-face coordination, telephone calls and paper records can sometimes deliver adequate information quickly. The present framework is intended for ecosystems in which digital exchange materially supports coordination. Successful adaptation through predominantly nondigital arrangements would challenge any claim that DP is universally necessary. A field study should record these substitutes explicitly and test whether they supplement or replace the proposed digital function.

Configurations and partial non-compensation

DAC is represented as a profile, not a validated scalar index. Formative and composite measurement research explains why indicator selection and weighting change the meaning of such a construct (Diamantopoulos and Winklhofer, 2001; Jarvis et al., 2003; Edwards, 2011;

Bollen, 2011). The present study does not estimate a causal-formative measurement model. It proposes dimensions whose coverage, overlap and predictive usefulness remain to be assessed.

The non-compensation argument is conditional. When every feasible response requires a function that cannot be completed in time, strength elsewhere cannot fully recover timely implementation. This is a constraint statement, not evidence that each of the twelve proposed indicators is individually necessary. Some indicators may substitute within a dimension, and some episodes may bypass an otherwise typical stage. A validated codebook must distinguish required functions from particular technologies or organizational arrangements.

Nor does a sequential process automatically imply that reducing its longest stage has a greater marginal timing

benefit. If stages are strictly additive, removing one hour from any necessary stage removes one hour from total elapsed time. Priority depends on feasible reductions, intervention cost, uncertainty and effects on response quality. Under concurrency, shortening a noncritical activity may produce no completion-time gain until its path becomes critical. Bottleneck studies already recognize shifting constraints (Lawrence and Buss, 1994; Skoogh et al., 2023). DAC applies that reasoning to information exchange, authorization and activation across organizations.

Configurational theory allows combinations and asymmetric relationships to be examined without presuming a single linear recipe (Fiss, 2007, 2011;

Furnari et al., 2021). It does not establish DAC's empirical equifinality. Alternative governance or technology arrangements may satisfy the same function, but the existence of several sufficient high-level DP-OI-RV profiles must be demonstrated rather than asserted.

Diagnostic archetypes

Five archetypes describe possible failure patterns (Table 2). They are provisional diagnostic categories, not observed clusters, maturity levels or an exhaustive partition of all combinations. High and low refer to functional adequacy for a defined task. Mixed, contradictory or missing evidence remains indeterminate. No archetype is assigned to PEL.

Table 2. Provisional archetypes

Archetype	DP / OI / RV	Diagnostic signature
Adaptive coherence	Adequate / adequate / adequate	Information, authorization and activation support a suitable timely response.
Connected fragmentation	Adequate / weak / variable	Relevant information exists, but actors cannot authorize coherent action.
Coordinated opacity	Weak / adequate / variable	Coordination arrangements exist, but necessary operating states arrive late or remain inaccessible.
Connected rigidity	Adequate / adequate / weak	Actors recognize the issue and agree, but usable operating alternatives cannot be activated.

Reactive churn Weak or unstable / weak / Repeated operational changes follow unreliable signals high or apparent or disputed priorities.

Consider three hypothetical examples. A refrigerator distributor receives an accurate stock alert but waits for two partners to agree on who absorbs the transfer cost. This is a possible alignment problem. A wholesaler has agreed allocation rules but receives rural dealer updates only after the dispatch cutoff; the likely constraint is information availability. A service network identifies and authorizes an urgent replacement but cannot obtain a vehicle with suitable handling equipment; execution readiness becomes the concern. These examples explain the distinctions and are not observations from PEL or other firms.

Context and response quality

Infrastructure reliability, address quality, partner

fragmentation, digital access and settlement arrangements can affect both latency and the set of feasible responses. The theory therefore treats context as a set of measurable constraints. It does not use an emerging-market label as a substitute for those measurements. Loading and unloading research in Mexico illustrates why apparently small operating frictions can matter for urban deliveries (Mora-Quinones et al., 2024).

Disruption severity also needs careful treatment. A more severe disruption may shorten the tolerable window, remove alternatives or damage the effectiveness of a response. These mechanisms should be measured separately. Severity does not necessarily change a fixed contractual deadline. The relevant prediction is conditional: where severity reduces usable stock cover or service tolerance, an unchanged delay may have a larger consequence.

Maintaining spare capacity or alternative providers carries cost. DAC should therefore be evaluated against both service benefits and the resources needed to achieve them. A capability profile useful under disruption need not maximize steady-state efficiency, and rapid action should never be treated as sufficient evidence of a good decision.

Research design and documentary methods

Conceptual synthesis

The study uses integrative conceptual synthesis and a descriptive documentary illustration. Its conceptual approach follows the distinction between theoretical integration, model development and empirical testing discussed by Jaakkola (2020) and MacInnis (2011). Documentary analysis supplies a way to examine traceable operational claims while accounting for selective reporting and missing detail (Bowen, 2009; Rabinovich and Cheon, 2011).

The literature was assembled around information processing, ecosystem coordination, resilience, Triple-A capabilities, configuration and measurement. Foundational sources establish construct boundaries; empirical studies provide limited mechanism evidence; recent conceptual work tests whether the proposed contribution is already covered by adjacent frameworks. This is a purposive synthesis. No exhaustive database search, screening denominator, independent double coding or inter-rater statistic is claimed.

The documentary calculations were checked against the PEL investor briefing dated 19 May 2026, PEL Annual Report 2025 and the PBS National Census Report for Census 2023. The source manifest in Appendix A identifies the relevant pages and the variables extracted. Bibliographic metadata checks are distinct from reading and evaluating a source's full methods. Neither a valid DOI nor an official domain guarantees that a particular causal interpretation is supported.

Source roles and inferential limits

The synthesis separates provenance from inferential fitness. The PEL briefing can establish what the company disclosed about its network. It cannot establish why that geography arose or whether the network adapts effectively. Audited financial statements support accounting amounts, while management discussion within the same annual report retains the status of management commentary. Official census data supply a

demographic benchmark, not a demand estimate for appliances.

Studies using different firms, countries and units of observation are not pooled. Evidence is classified as theoretical grounding, empirical association, documentary description or contextual qualification. Mechanism-compatible findings motivate a proposition; they do not test a newly introduced construct. The selected evidence matrix in Appendix B makes these distinctions explicit.

PEL as a bounded illustration

PEL is suitable for examining the limits of public evidence because its disclosures identify several distribution layers and product categories. The briefing reports 1,513 dealers, 23 sales offices and 524 authorized service centres. Provincial dealer shares are given as whole percentages, while office and service-centre counts are integers (Pak Elektron Limited, 2026b, slide 5). The appliance distribution layer is the spatial focus. Power products have different institutional and project-sales characteristics, so their outcomes are used only to illustrate within-firm reporting heterogeneity.

The geographic universe comprises Punjab, Sindh, Khyber Pakhtunkhwa and Balochistan. Census counts are normalized across these four provinces; Islamabad Capital Territory is excluded to match the briefing's four-row classification. The population total for this comparison is 239,135,568. The classification does not establish where ICT dealers or service activity are assigned in PEL's reporting. That unresolved boundary limits national interpretation.

The network disclosure and census describe different dates. The analysis compares a 2026 disclosed network with a 2023 population benchmark, without treating them as a synchronized panel. Provincial totals also conceal within-province travel distances, cross-border servicing, dealer size and urban concentration. Consequently, the results describe shares under a stated classification rather than customer access or service quality.

Reproducible spatial measures

Let d_i be province i 's dealer share, p_i its normalized population share and s_i a selected network-layer share. The dissimilarity statistic and location quotient are defined in Equations 3 and 4 (Hoover, 1936; Duncan and Duncan, 1955; Isard, 1960).

$D(d,p) = 0.5 \times \sum_i |d_i - p_i|$, with shares expressed as fractions. (3)

$$LQ_i = d_i / p_i; D(d,p) = 0.5 \times \sum_i p_i |LQ_i - 1|. \quad (4)$$

D ranges from zero to one and measures distributional divergence. The LQ identity shows that local quotients and aggregate dissimilarity summarize the same underlying share differences. They should not be counted as independent confirmation. Concentration within a distribution is summarized by $HHI = \sum_i s_i^2$, using the conventional Herfindahl-Hirschman lineage (Hirschman, 1945; Herfindahl, 1950). All compared distributions use four categories.

The urban sensitivity benchmark multiplies each exact provincial population count by the published urban percentage and then normalizes the resulting values. These products are approximate because the urban rates are rounded. Applying published urban rates to the full headcounts also assumes compatible coverage; the census distinguishes full headcounts from detailed demographic coverage. The calculation is therefore an urban-exposure proxy, not a reconstruction of exact urban counts.

Dealer-share rounding is examined under an explicit nearest-percentage-point assumption. Each share is allowed to vary by 0.005, subject to the four shares summing to one. Bounds on D are computed over that feasible set. These are deterministic sensitivity bounds, not confidence intervals. They do not describe uncertainty from reporting dates, dealer activity or the adequacy of population as a market benchmark.

Layer comparisons use office counts divided by 23 and service-centre counts divided by 524. Approximate service intensity is 100 times provincial service centres divided by 1,513di. The implied dealer denominator is fractional because the company publishes rounded shares. It must not be reported as an observed provincial dealer count.

Evidence and descriptive results

What the literature supports

The literature supports treating information availability and adaptive response as distinct concepts. Brusset (2016) examines visibility and agility, while Gomes and Silva (2025) study digitalization and Triple-A capabilities using 408 Portuguese manufacturing firms. In the latter study, alignment and adaptability mediate the digitalization-resilience relationship in the structural

model, whereas agility does not; the configurational analysis identifies alternative combinations. These are findings about that study's measures and sample, not direct evidence for DAC's latency mechanism.

Governance research provides another relevant link. Lu et al. (2024) examine supply-chain governance and resilience through information-processing theory. Reconfiguration research addresses the availability of alternative operating structures (Dolgui et al., 2020). Together these streams motivate measuring information, authority and executable options separately. Their differences in design and level of analysis prevent a pooled inference about the magnitude of DAC's effect.

Recent work also raises the novelty threshold. Patrucco et al. (2026) describe digital super-agility, sustainable adaptability and ecosystem alignment in an invited editorial. It supplies conceptual comparison, not an independent empirical test. DAC's proposed stage-level predictions must add value beyond that account and beyond established response-time measures. The present evidence cannot establish that incremental value.

Geographic exposure and denominator sensitivity

Table 3 reports the inputs and normalized shares. PEL's dealer distribution places 75% of the reported share in Punjab, compared with 53.40% of the four-province population benchmark. The corresponding dealer-to-population dissimilarity is 0.2160. This means that approximately 21.60 percentage points of distributional share would need to move between provinces to reproduce the benchmark. It is not a recommendation to relocate dealers.

Table 3. Population inputs and dealer exposure

Province	Census count	Total share %	Urban proxy %	Dealer share %
Punjab	127,688,922	53.40	56.02	75
Sindh	55,696,147	23.29	32.40	12
Khyber Pakhtunkhwa	40,856,097	17.08	6.61	11
Balochistan	14,894,402	6.23	4.97	2
Total	239,135,568	100.00	100.00	100

The urban proxy changes the benchmark, especially in Sindh and Khyber Pakhtunkhwa. Dealer-tourban dissimilarity is 0.2337. Khyber Pakhtunkhwa's location quotient changes from approximately 0.644 against total population to 1.664 against the urban proxy. A province can therefore appear relatively underrepresented under one denominator and relatively overrepresented under another. Neither comparison establishes unmet demand.

Dealer HHI is 0.5894, compared with approximately 0.3724 for total-population exposure and 0.4257 for the urban proxy. These are concentration summaries at the

provincial scale. They do not measure competition among dealers, market power or the financial concentration of sales.

Under the stated rounding assumption, dealer-to-total dissimilarity lies approximately between 0.2110 and 0.2210, and dealer-to-urban dissimilarity between 0.2237 and 0.2437. Thus the existence of aggregate divergence is insensitive to plausible share rounding. The economic interpretation remains sensitive to the denominator, the geographic classification and missing demand variables.

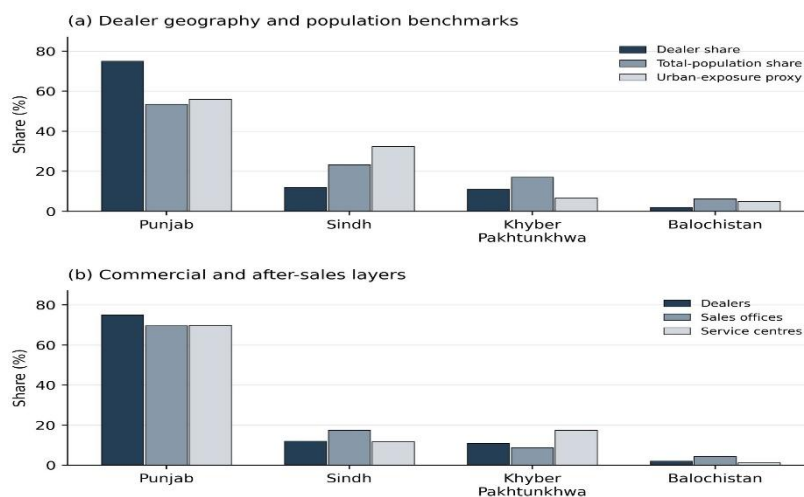


Figure 2. PEL provincial distributions. Total population is normalized over four provinces; the urban series is an approximate exposure proxy. Dealer shares are rounded company disclosures. Sources: PEL (2026b), slide 5; PBS (2025), Table 4.2 and Figure 4.1. Calculations and plotting use code with AI assistance.

Commercial and service layers

The sales-office counts are 16, 4, 2 and 1 across the four provinces; the service-centre counts are 366, 61, 91 and 6. Dealer-to-service dissimilarity is approximately

0.0637, dealer-to-office dissimilarity 0.0774, and office-to-service dissimilarity 0.0895. These differences demonstrate that one national footprint cannot adequately describe all network layers.

Khyber Pakhtunkhwa accounts for 11% of reported dealer share and 17.37% of service centres. Its service-

share/dealer-share ratio is 1.58, and its approximate intensity is 54.68 centres per 100 implied dealers. Balochistan's corresponding values are 0.57 and 19.83. Table 4 gives all provinces. These ratios do not measure

service capacity: centre size, workload, installed appliance base, technician coverage and cross-province servicing are unobserved.

Table 4. Service and commercial layer diagnostics

Province	Offices	Service centres	Service / dealer share	Centres per 100 implied dealers
Punjab	16	366	0.93	32.25
Sindh	4	61	0.97	33.60
Khyber Pakhtunkhwa	2	91	1.58	54.68
Balochistan	1	6	0.57	19.83

The appropriate inference is that commercial presence and after-sales support have different reported geographies. An inference about shortages, excess investment or adaptive capability would require operational and market data that the documents do not contain.

Product outcomes and financial reconciliation

Management commentary in Annual Report 2025 reports nominal growth of 30.82% for refrigerators, 36.28% for air conditioners and 72.71% for deep freezers. It reports 67.47% for distribution transformers, -50.24% for power transformers, 23.50% for energy meters and 44.92% for switchgear (Pak Elektron Limited, 2026a, Directors' Report, pp. D-11 to D-14). The spread illustrates

heterogeneous product outcomes within a single firm. Price changes, mix, exports, contracting and market demand remain plausible explanations; no DAC attribution is made.

The annual-report commentary and investor briefing differ in several Power product amounts. Distribution-transformer FY2025 amounts are PKR 11,994 million and PKR 11,854 million, respectively. Power-transformer amounts are PKR 7,310 million and PKR 7,451 million. The switchgear FY2024 comparison base is PKR 4,157 million in the commentary and PKR 4,325 million in the briefing. Table A3 preserves those differences. The disclosures do not explain them, so a reclassification explanation remains a possibility rather than a finding.

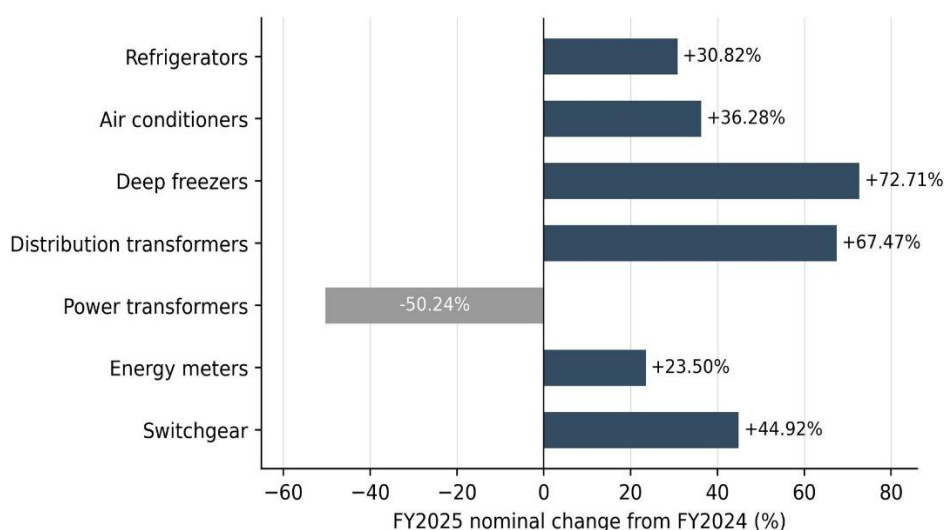


Figure 3. Product outcome heterogeneity. Values are management-reported nominal growth from PEL Annual Report 2025, Directors' Report, pp. D-11 to D-14. These are not physical-volume changes or individually audited product estimates. Plot prepared with code and AI assistance.

The audited statement and Note 35 permit a more precise financial reconciliation. Revenue before sales tax, excise duty and discounts is PKR 83.530003 billion in FY2025 and PKR 69.608716 billion in FY2024. After deductions, net revenue is PKR 63.523506 billion and PKR 53.112906 billion. Their growth rates are approximately 20.00% and 19.60%, respectively. Thus gross and net amounts differ in accounting scope, but both can be traced to the audited statements. The distinction is between measures, not simply between an unaudited gross figure and an audited net figure.

The briefing rounds or truncates several values to millions and uses gross-sales terminology. For financial precision, Appendix A retains the statement's original thousand-rupee amounts. For product comparisons, management's stated growth rates and the briefing's rounded series remain separately labeled. Financial-statement audit status is not extended automatically to every claim in the Directors' Report.

What remains unobserved

PEL's public documents do not record the twelve DAC indicators with sufficient breadth to classify its capabilities. They also lack the episode timestamps, task dependencies and pre-episode window needed to test the timing argument. Dealer geography therefore provides a demonstration of source and denominator discipline. It does not validate the framework, establish the cause of product growth or identify a binding operational constraint at PEL.

Propositions and measurement

Seven proposition families

The propositions below are intended for future empirical work. They preserve the distinction between arithmetic definitions, task-specific feasibility conditions and probabilistic capability claims. Each requires capabilities and outcomes to be measured independently.

P1, partial non-compensation. Among comparable episodes requiring all three conversion functions, independently observed weakness in one function will be associated with poorer adaptive service outcomes, even when the other functions are strong. Evidence of stable high performance despite the proposed weakness, without an unmeasured substitute, would challenge the

claim. The test should compare constrained and additive models rather than infer necessity from a positive average association.

P2, information and alignment. Improvements in pre-episode DP will yield greater adaptive benefit where OI enables shared authorization, with reduced alignment delay explaining part of the difference. A similar DP effect across OI levels, coupled with no relationship between authorization delay and outcomes, would weaken this interaction account. Excessive centralization and alternative informal arrangements should be measured as rival explanations.

P3, execution conversion. Pre-episode RV will predict shorter execution delay, conditional on task difficulty and available options; that delay will help explain service outcomes beyond DP and OI. The capability must be measured from prior arrangements and demonstrations rather than the episode's realized execution time. Failure of the proposed temporal ordering or predictive relationship would count against P3.

P4, disruption and tolerance. Where independently measured disruption severity reduces usable service tolerance, comparable delays will be associated with larger service losses. A fixed contractual deadline need not change with severity. A test should distinguish a shorter W0 from a smaller feasible option set and a less effective response. Invariance across adequately measured tolerance conditions would weaken the proposed moderation.

P5, conditional constraint migration. After an intervention reduces a previously dominant constraint sufficiently to change the critical path or the ranking of feasible improvement opportunities, subsequent constraints will be more likely to occur in another conversion function. Merely improving a stage is insufficient: it may remain dominant. Repeated episodes, intervention cost and attainable reductions must be observed. Unchanged constraint patterns despite interventions large enough to satisfy the stated switching condition would challenge the prediction. A single before-and-after anecdote would not establish it.

P6, contextual friction. Measured infrastructure, access, addressing, settlement or partner fragmentation constraints will help explain latency and the availability

of operating alternatives beyond generic country labels. If those variables add no explanatory value across suitably varied contexts, the proposed contextual specification requires revision. Country-level development status alone cannot test this claim.

P7, incremental prediction and criterion specificity. P7a predicts that a pre-specified DAC profile will improve out-of-sample prediction of adaptive service outcomes beyond scale, digital maturity, Triple-A capabilities and established resilience or timing measures. P7b predicts a larger incremental gain for those adaptive outcomes than for stable-period cost efficiency, using comparable models and observation windows. Either claim can fail. Criterion-specific prediction is a conjecture, not a necessary consequence of the DAC definition.

Twelve-indicator protocol

Appendix C defines twelve candidate indicators, four for each dimension. The protocol records capability evidence, confidence and missingness separately. No arithmetic average across dimensions is authorized. Within dimensions, the indicators are candidates for content validation rather than a pre-established list of individually necessary conditions. An analyst should record which functions the focal task requires and whether alternative arrangements fulfill them.

The provisional ordinal anchors are 0 for affirmative evidence of absence, 1 for isolated capability, 2 for partial operational coverage, 3 for broad routine use and 4 for demonstrated coverage across the defined relevant actors. Those labels are coding aids. They have not been calibrated as equal intervals or validated cutoffs. Missing disclosure is coded as missing, not zero; contradictory evidence is retained as contested until resolved.

Confidence depends on directness, temporal relevance, actor coverage and independent corroboration. A first-party document may strongly establish that a formal policy exists yet offer weak evidence that partners follow it. Neither an elaborate annual report nor a high confidence rating should increase the capability score automatically. Documentation richness can otherwise become a hidden proxy for firm size.

Validation sequence

Content validation should begin with practitioners and researchers sorting indicator descriptions across DAC and adjacent constructs. This can identify ambiguous assignments, omissions and redundant indicators. The study should then test whether respondents from different actors describe the same ecosystem consistently. A single manufacturer respondent cannot establish partner-wide capability.

Measurement reliability follows. Archival applications need an explicit codebook, independent coding and reported agreement; field studies need multiple respondents and checks on withinecosystem agreement. No reliability coefficient is supplied here because no such exercise was performed. Capability evidence should precede the disruption episodes used for outcome tests.

Necessary condition analysis and qualitative comparative analysis can examine different aspects of necessity, sufficiency and asymmetric configurations (Dul, 2016; Fiss, 2011). Calibration choices, case diversity, limited configurations and robustness checks must be reported. These methods cannot resolve endogeneity by themselves. Regression or multilevel event models remain useful for interactions and comparisons with simpler explanations.

Temporal validation requires synchronized event logs, a preregistered t0 rule, independent W0 and recorded task dependencies. Repeated episodes nested within ecosystems allow the analysis to distinguish enduring capability from episode difficulty. Where practical, phased interventions or credible comparison groups can help separate capability effects from contemporaneous demand, staffing and infrastructure changes. Power analysis should reflect ecosystem clustering, event frequency and the expected incremental effect; an arbitrary universal sample size is inappropriate.

Finally, predictive evaluation must withhold entire ecosystems or later periods, rather than randomly split nearly identical episodes from the same network across training and testing. Benchmark models should receive equivalent information and tuning opportunities. Figure 4 summarizes the sequence. A failure of discriminant or predictive validity should prompt revision of DAC, not post-hoc reweighting to manufacture a favorable result.

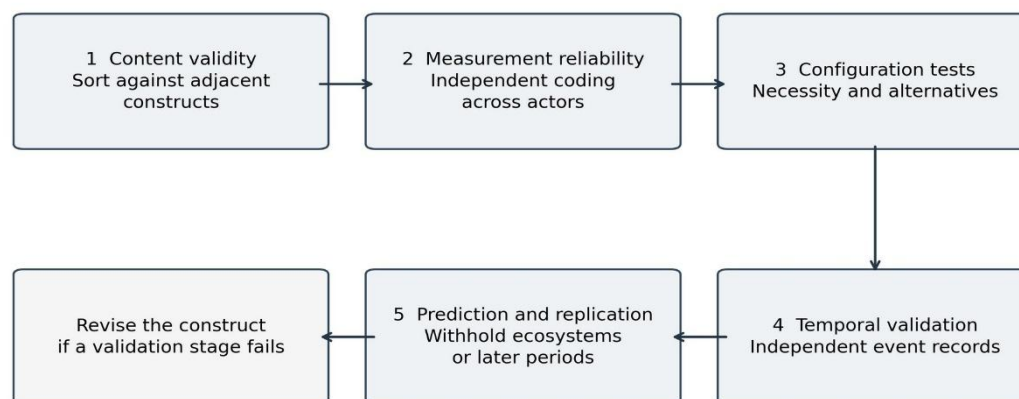


Figure 4. Proposed validation sequence. All five stages concern future research; none represents a completed DAC validation exercise. Failure should prompt measurement or theory revision. Source: original schematic prepared with code and AI assistance.

Discussion

The proposed contribution

DAC focuses attention on the organizational work between signal recognition and implemented change. Its three dimensions describe antecedent capabilities, while its event representation records how long conversion takes and whether the action protects service. This separation makes the theory more specific than a list of desirable attributes and creates opportunities for disconfirmation.

The novelty remains incremental. Information-processing theory already explains coordination requirements, Triple-A and AAA+ connect related capabilities, and operations research has long addressed response times and changing constraints. DAC earns a separate label only if its measurements and stage-level predictions reveal something that those alternatives miss. The present paper provides that testable specification; it does not supply the required evidence of superiority.

A useful field result might show that comparable investments in visibility produce different benefits because authorization is fast in one ecosystem and slow in another. Another might show that a readiness intervention changes execution time without improving service because the selected response was unsuitable. Such outcomes would clarify both the reach and the limits of the framework. Treating every unfavorable

outcome as an unspecified bottleneck would make the theory unfalsifiable.

Managerial use

Managers can begin with a specific failed or threatened service commitment. Establish the relevant actors, the earliest usable signal, the authorizations required and the alternatives available. Record how long each necessary activity takes, then assess what can realistically be shortened without reducing decision quality. Technology investment is one possible response, but the evidence may instead point to incentive rules, delegated authority or a qualified backup carrier.

The decision should consider cost and attainable improvement. In a sequential episode, a cheap one-hour reduction in approval delay may be preferable to an expensive one-hour reduction in detection. Under concurrency, the same approval improvement may have no completion-time benefit if another path governs execution. A useful diagnosis therefore combines capability evidence with the episode's actual dependencies.

For geographic planning, the PEL illustration offers a separate lesson. Dealer shares, office shares and service shares answer different questions. Population-based comparisons can flag a pattern worth investigating, but investment requires information on demand, installed base, productivity and travel time. A province's low

population-relative dealer share is not, by itself, a business case for expansion.

Limitations

The purposive synthesis can omit relevant competing accounts and cannot estimate a literature-wide effect. Several foundational sources establish conceptual definitions rather than empirical support. The documentary illustration is restricted to one firm, four provincial categories and nonsynchronous reporting dates. Company disclosures may omit inactive dealers, cross-boundary servicing and differences in node capacity.

Population and the constructed urban proxy are exposure benchmarks with limited relevance to purchasing power or appliance demand. Rounding bounds address only a narrow numerical uncertainty. Product growth is nominal and cannot distinguish volume, price, mix or exchange-rate effects. Differences between management sources remain unexplained.

The theoretical limitations are substantial. The indicator set, archetypes, task thresholds and proposed interactions have not been validated. Digital exchange may be replaceable in some settings. Response quality and unavailable alternatives can dominate speed. Missing capability evidence, endogenous investment and variation in episode severity can bias future tests. These limitations preclude a PEL DAC score and any assertion that the paper establishes a validated ecosystem-performance model.

Conclusion

Distributed Adaptive Capacity proposes a way to study how distribution partners convert operating information into coordinated change within a defined time window. Digital permeability, orchestration intensity and reconfiguration velocity are treated as distinct antecedents whose effects should be tested against event delays and independent service outcomes. Five diagnostic archetypes and seven proposition families provide a research agenda without imposing an unsupported composite score.

The PEL calculations establish narrower descriptive results: dealer geography differs from two population benchmarks, commercial and service layers differ, and financial measures require careful source reconciliation. They demonstrate the limits of documentary inference rather than the effectiveness of DAC. The next

substantive step is a multi-actor, repeated-event study that can determine whether the proposed profile explains adaptation better than existing capability and timing measures.

Declarations

Funding. This research received no external funding.

Competing interests. The author previously held commercial roles with LG Electronics and Panasonic. The author reports no current relationship with PEL. The analysis uses public documents and cited secondary sources.

Ethics. This study analyzes public documents and secondary data. It includes no recruitment of human participants or participant-level personal data.

Data availability. Appendix A provides the numerical inputs, source locations and equations needed to reproduce the descriptive calculations. No proprietary dataset, interviews or disruption-event data are claimed.

Generative AI assistance. OpenAI ChatGPT was used in the development and revision of this manuscript, including conceptual discussion, substantive drafting, language revision, calculation checking and preparation of code-based figures. The human author is responsible for the accuracy, interpretation and originality of the work.

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Appendix A Data and calculation record

A1 Source manifest

Table A1. Primary-source locations

Source	Location	Extracted variables
PEL (2026b), investor briefing, 19 May 2026	Slide 5; PDF page 5	1,513 dealers; shares 75/12/11/2%; offices 16/4/2/1; service centres 366/61/91/6.
PEL (2026b)	Slides 12-13; PDF pages 12-13	Rounded gross and net sales; product and divisional gross-sales series.
PBS (2025), National Census Report	Table 4.2, printed p. 124; PDF p. 151	Exact four-province population counts and geographic coverage.
PBS (2025)	Figure 4.1, printed p. 126; PDF p. 153	Urban rates: Punjab 40.71%; Sindh 53.97%; KP 15.01%; Balochistan 30.96%.
PEL (2026a), Annual Report 2025	Directors' Report, pp. D-11 to D-14; PDF pp. 140-143	Management-reported product growth and selected product amounts.
PEL (2026a)	Note 35, printed p. H-43; PDF p. 296	Revenue before deductions, tax/excise, discounts and net revenue; PKR thousands.

All page references distinguish printed labels from PDF positions. The four-province census denominator is the sum of exact counts. The urban proxy uses published two-decimal urban rates and is approximate. Original company totals are retained even where rounded product components sum differently.

A2 Calculation outputs and sensitivity

Table A2. Recalculated geographic diagnostics

Measure	Value	Interpretation
D dealers vs total population	0.216040	Four-province share divergence.
D dealers vs urban proxy	0.233664	Sensitivity to an alternative exposure denominator.
Total-population D bounds	0.211040 to 0.221040	Conditional share-rounding bounds; not confidence limits.
Urban-proxy D bounds	0.223664 to 0.243664	Conditional share-rounding bounds; not confidence limits.
HHI dealers / total / urban	0.589400 / 0.372428 / 0.425663	Concentration over four categories.
D dealers vs service / offices	0.063664 / 0.077391	Rounded dealer share compared with exact node shares.
D offices vs service	0.089529	Exact reported node-count shares.
LQ total: Punjab / Sindh / KP / Balochistan	1.405 / 0.515 / 0.644 / 0.321	Dealer share divided by total-population share.
LQ urban: Punjab / Sindh / KP / Balochistan	1.339 / 0.370 / 1.664 / 0.402	Dealer share divided by urban-proxy share.

For the rounding analysis, d_i lies within the reported share plus or minus 0.005, with $\sum d_i = 1$. The signs of dealer-minus-benchmark differences remain unchanged in this neighborhood. For total population only Punjab has a positive difference, so D equals d_{Punjab} minus p_{Punjab} and varies by 0.005. For the urban proxy Punjab and Khyber

Pakhtunkhwa have positive differences, so D equals their combined excess share and varies by 0.010. These bounds are conditional on nearestpercentage-point reporting. If the reporting convention differs, the stated bounds need revision.

A3 Product reconciliation

Table A3. Product-source reconciliation in PKR millions

Product	Briefing FY2024	Briefing FY2025	Calculated change %	Annual-report commentary
Refrigerator	20,178	26,389	+30.78	Growth 30.82%.
Split AC	11,362	15,484	+36.28	Growth 36.28%.
Deep freezer	3,582	6,187	+72.72	Growth 72.71%.
Other appliances	4,959	5,789	+16.74	Briefing groups other appliances.
Distribution transformer	6,995	11,854	+69.46	FY2025 11,994; growth 67.47%.
Power transformer	14,690	7,451	-49.28	FY2025 7,310; growth -50.24%.
Energy meter	3,523	4,352	+23.53	Growth 23.50%.
Switchgear	4,325	6,025	+39.31	FY2024 4,157; growth 44.92%.

Annual-report percentages above are management-reported nominal changes. They are not represented as growth in physical units or as separately audited product statistics. Figures recalculated from briefing amounts can differ because those amounts are rounded and some classifications differ.

A4 Accounting reconciliation

Table A4. Audited financial-statement amounts in PKR thousands

Measure	FY2024	FY2025
Revenue before deductions	69,608,716	83,530,003
Sales tax and excise duty	10,495,675	11,546,130
Trade discounts	6,000,135	8,460,367
Total deductions	16,495,810	20,006,497
Net revenue	53,112,906	63,523,506

The original statement is denominated in PKR thousands. Division by one million converts these values to PKR billions. Gross growth is $(83,530,003 / 69,608,716 - 1) \times 100$; net growth is $(63,523,506 / 53,112,906 - 1) \times 100$. Revenue before deductions less sales tax, excise duty and discounts equals net revenue in both years.

Appendix B Evidence roles

Table B1. Evidence roles for central sources

Source	Role in this paper	Limit of inference
Galbraith (1974); Tushman and Nadler (1978)	Information-processing foundation.	General organizational theory; does not validate DAC.

Adner (2017); Jacobides et al. (2018)	Actor interdependencies and ecosystem boundaries.	Conceptual framing rather than episode measurement.
Lee (2004); Patrucco et al. (2026)	Closest capability comparators; the latter is an invited editorial.	Conceptual overlap must be addressed before claiming novelty.
Brusset (2016)	Visibility-agility relationship.	Existing constructs and sample, not a DAC test.
Gomes and Silva (2025)	408-firm study; differing mediation and configurational findings.	Portuguese manufacturing survey; causal and generalization limits remain.
Lu et al. (2024)	Governance and information processing mechanisms.	Study-specific measures; cannot establish DAC dimensions.
Dolgui et al. (2020)	Reconfigurable network logic.	Theory/design contribution; no direct measurement of the proposed profile.
Mora-Quñones et al. (2024)	Loading/unloading context in Mexico.	Specific operational setting, not an emerging-market universal.
PEL (2026a, 2026b); PBS (2025)	Network counts, financial amounts and demographic benchmarks.	Descriptive, nonsynchronous and bounded; no causal test.
Hasan and Ahmad (2026)	Prior use of the phrase distributed adaptive capacity.	Preprint used only for lexical acknowledgment.

This selected matrix documents the role of central sources. It is not a retrospective claim that a systematic search or independent coding exercise was completed. Reference metadata verification establishes bibliographic identity only; it cannot certify a study's validity or remove the need to inspect its methods before relying on detailed findings.

Appendix C Diagnostic protocol

C1 Candidate indicators

Table C1. Twelve candidate indicators

Dimension and indicator	Operational focus	Evidence example	Exclude
DP Visibility	Relevant operating states reach decision makers.	Order/inventory or exception records.	Data volume without relevant visibility.
DP Timeliness	Updates arrive at taskrelevant cadence.	Dated updates and synchronization records.	Realized episode detection time.
DP Integration	Information crosses actor boundaries.	Working interfaces or exchange workflows.	Standalone internal automation.
DP Accessibility	Required partners can practically use information.	Access, use and assisted channel evidence.	Nominal platform availability.
OI Incentive alignment	Rewards support the shared service objective.	Contracts and gain/risk arrangements.	Spending without shared incentives.
OI Information governance	Rules specify sharing and action authority.	Rights, obligations and escalation protocols.	Exchange without authority.

OI Standardization	Compatible rules enable interface standards.	Working process and operating use.	Documentation without joint operations.
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Dimension and indicator	Operational focus	Evidence example	Exclude
OI Relational governance	Actors can interpret and resolve issues jointly.	Joint planning and resolvedescalation records.	Meeting frequency alone.
RV Routing flexibility	Feasible alternative paths are prepared.	Qualified routes, modes and usage rules.	Unusable nominal options.
RV Capacity flexibility	Relevant capacity can be mobilized.	Commitments, drills and availability records.	Unavailable nameplate capacity.
RV Partner flexibility	Qualified partners can be activated or substituted.	Contracts and prior qualification records.	Unqualified supplier lists.
RV Activation readiness	Triggers and routines connect plans to execution.	Playbooks and prior mobilization exercises.	Focal-episode execution time.

Each record should identify the ecosystem, focal task, observation period, source location, relevant actors, observed arrangement, provisional anchor, evidence confidence and missingness status. Indicator families should be content-validated before any dimension is labeled adequate. Alternative arrangements that fulfill the same function should be retained for analysis.

C2 Coding and confidence

Table C2. Provisional ordinal anchors and observation states

Code	Evidence requirement	Meaning
0	Affirmative evidence of absence within the defined task.	Absent.
1	Isolated or actor-specific arrangement.	Limited reach.
2	Operational across several actors, with material coverage gaps.	Partial coverage.
3	Broad, routine use across relevant actors.	Institutionalized capability.
4	Demonstrated coverage and readiness across the defined actor set.	Extensive capability; not a claim of universal excellence.
Missing	Insufficient evidence of presence or absence.	Uncoded; never recode as zero.
Contested	Sources conflict materially.	Retain conflict and its provenance.

The 0-4 anchors are ordinal proposals. The distance between adjacent anchors is unknown. Do not sum them, treat missing values as zero, or create a PEL classification from the descriptive network tables. Record low, moderate or high confidence separately using directness, date, actor coverage and independent corroboration; retain contradictory observations.

C3 Event record and falsification safeguards

Before observing an outcome, specify the protected service measure and its tolerance, t0 rule, W0 rule, actor boundary and candidate capability measures. During the episode, record recognition, authorization, activation and effective-execution timestamps with their sources. Record concurrent tasks and prerequisites, including informal or nondigital substitutes. Afterward, measure service outcomes and response quality independently of the timing definitions.

For an intervention, retain its cost, intended mechanism, achievable time reduction and comparison condition. A reduction in the longest observed interval does not automatically establish constraint migration. Recalculate dependencies and compare prospective improvement opportunities under a stated rule. Censoring, unresolved episodes, deadline revisions and missing timestamps must remain visible in the event dataset