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Cultural Technological Synergy in the Age of AI: A Conceptual Framework for Understanding Adaptive Modernization in Transitional Societies

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Abstract

As Artificial Intelligence evolves into public infrastructure, this paper advances the Cultural–Technological Synergy framework—a meso-level diagnostic model explaining how cultural conditions enable or constrain the shift. The framework rests on four established principles: (1) shared cultural values shape the behaviour of individuals and institutions; (2) new technologies diffuse through social learning and demonstrable benefits; (3) durable systems depend on public legitimacy and consent; and (4) effective cross-institutional coordination is essential to scale pilots into operational infrastructure. Drawing on these principles, the Cultural–Technological Synergy framework elucidates how cultural dynamics influence the capacity, incentives, and legitimacy required for Artificial Intelligence to evolve from experimental applications into essential public infrastructure. While recognizing economic, technological, infrastructural, and governance drivers, the framework adds cultural, societal, and psychological dimensions—operationalized through norms, values, identities, and risk perceptions—to be measured and compared on equal footing. It defines four interacting dimensions—Heritage Adaptability, Cross-Civilizational Competence, Innovation Ethos, and Strategic Determination—that shape the progression from pilots and sectoral deployments to public infrastructure. These dimensions interface directly with the companion frameworks: AI as Public Infrastructure, which theorizes when Artificial Intelligence attains infrastructural status, and the Infrastructure Status Index, which operationalizes that status. In diagnostic use, the Cultural–Technological Synergy framework offers a lens for (i) evaluating cultural readiness, (ii) identifying bottlenecks, and (iii) supporting prioritization through analysis of how cultural factors condition capacity, incentives, and legitimacy in transitions to public infrastructure. Positioned at the meso level, the framework specifies how cultural architectures enable or constrain institutional pathways across successive phases defined by AI as Public Infrastructure and the Infrastructure Status Index. The Azerbaijan case illustrates this logic—explaining ambition formation, legitimacy dynamics, and early coordination gains.

***Keywords*:** Cultural–Technological Synergy (CTS); AI as Public Infrastructure (AIPI); Infrastructure Status Index (ISI); Infrastructural Transition; Transitional Societies; Culture–Institution Interaction

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1. Introduction

Technological transformation is never purely technical. Successive general-purpose technologies—steam power, electricity, telephone, digital computing, internet, and now AI—reconfigure economic structures, state capacity, human-capital formation, and international

competitiveness [22]. Yet trajectories diverge widely across countries, even among those with similar resource endowments and institutional frameworks.

Much of this variance reflects differences in cultural architectures—shared frameworks of meaning, norms, and expectations through which societies interpret innovation, negotiate trade-offs, and legitimate institutional change [41].

This paper treats cultural architectures not as autonomous determinants but as interactional infrastructures. They shape how institutional frameworks absorb, coordinate, and legitimate technological transitions. In this sense, culture provides the interpretive bandwidth within which institutional reforms become feasible and publicly acceptable. In this formulation, cultural capacity is treated as a critical enabling condition for sustainable and legitimate institutionalization, though not sufficient on its own—its influence intensifies where institutional rules are fluid and coordination costs high.

Historical cases illustrate this pattern. Religious and communal networks—Quakers in early industrial Britain, Jewish professional networks in Europe, Confucian-influenced East Asia, and Latter-day Saint communities in the U.S.—combined high trust, education, and ethical norms to legitimize innovation and sustain long-horizon investment [10]. Such cases suggest that culture functions as a coordination infrastructure: a cognitive-normative layer that reduces transaction costs and stabilizes expectations during technological transitions.

Recent scholarship on AI as infrastructure [18] demonstrates how computational systems migrate from specialized tools to essential utilities. The author's companion frameworks [12] —AI as Public Infrastructure (AIPI)—a framework for managing the interface between globally produced AI systems and domestic institutions—and the Infrastructure Status Index (ISI)—a metric of essentiality, embeddedness, legitimacy, and governance—operationalize this shift across four dimensions: Essentiality, Embeddedness, Legitimacy, and Governance. AIPI indicates when societies move from discretionary use to public infrastructural dependence, while ISI quantifies maturity at each stage.

What remains underexplored is a complementary driver-side framework explaining why some societies advance faster along these stages—achieving AI-native infrastructural integration—while others stall at experimentation. This paper addresses that gap by developing the Cultural–Technological Synergy (CTS) framework—a meso-level diagnostic model that clarifies how cultural conditions enable or constrain a society's capacity, incentives, and legitimacy in transforming AI from experimental tools, pilots, and sectoral deployments into essential public infrastructure.

The AIPI and CTS frameworks, respectively, treat governance dependence and cultural readiness as management conditions, not intrinsic properties, required to sustain legitimate and durable infrastructural development. Higher cultural readiness can enable durable infrastructuralization, but it may also accelerate dependence, amplify coordination power, or mask capture if institutions lag or accountability is weak.

The paper proceeds as follows: Section 2 situates CTS within existing frameworks and clarifies its contribution as a conceptual synthesis rather than a novel theory. Section 3 develops the four CTS dimensions and auxiliary concepts. Section 4 develops the CTS–Institutional Capacity Quadrant, specifies how Cultural Readiness—the cultural share of AIPI's Societal Readiness—interacts with institutional capacity, and demonstrates CTS as a diagnostic tool that functions as the meso-level explanatory layer within the AIPI–CTS–ISI architecture. Section 5 details the methodology and case selection. Section 6 applies CTS to Azerbaijan's AI development, highlighting both insights and limitations. Section 7 offers critical reflexivity, framework limitations, and policy implications. Section 8 outlines a research agenda for empirical validation. Section 9 concludes with critical reflections on the framework's scope and blind spots.

1.1 Nature and Scope of This Contribution

This article advances a concept—a heuristic analytical lens—rather than a testable theory. Its purpose is to scaffold subsequent operationalization, comparative study, and eventual theorization. Synthesizing insights from cultural modernization theory [11, 17, 40], technology-diffusion research [30], and infrastructure studies [18, 27, 33], it proposes a meso-level framework for analyzing cultural drivers of AI infrastructure development and complements institutional analysis: cultural architectures shape ambition formation and legitimacy; institutional capacity determines execution and consolidation.

The CTS framework is not a new theory requiring empirical falsification but a heuristic device for mapping culture–institution interaction across infrastructural trajectories—foregrounding how interpretive and governance layers co-evolve during technological transition.

While Hofstede's cultural dimensions and Rogers' diffusion model focus on adoption (i.e., whether a technology is accepted), CTS addresses the cultural determinants of infrastructuralization, framed through the ISI dimensions of Essentiality, Embeddedness, Legitimacy, and Governance. Adoption frameworks [11, 30, 39] explain whether individuals or organizations accept AI tools. CTS explains how and when societies convert accepted tools into public infrastructure—linking cultural architectures to institutional pathways and ISI outcomes. In short: adoption predicts uptake; CTS diagnoses the transition to durable, governed infrastructure—or why some contexts stall in perpetual pilots.

By connecting cultural dimensions to the AIPI–ISI frameworks of infrastructural maturity, CTS provides a meso-level account linking cultural enablers to institutional performance — specifying how interpretive conditions mediate institutional trajectories toward infrastructural consolidation.

CTS has greatest explanatory power in three contexts: (1) Early-to-middle infrastructuralization stages (AIPI Stages 1-3), where institutional pathways remain fluid and cultural legitimacy is contested; (2) Transitional societies with heterogeneous cultural repertoires and evolving governance structures; (3) Discretionary adoption contexts where technology deployment requires societal consent rather than state mandate.

CTS explanatory power is constrained when: (a) Institutional capacity reaches extreme levels (very high or very low), creating floor/ceiling effects; (b) External shocks dominate (war, economic crisis, natural disasters), overwhelming cultural dynamics; (c) Technology is mandated without adoption choice, removing cultural mediation from the pathway.

Practically, CTS is a diagnostic framework with multiple use cases: (a) bottleneck detection—identifying which cultural dimensions (e.g., Innovation Ethos vs. Strategic Determination) are binding at a given stage; (b) policy sequencing and prioritization—mapping which cultural enablers must be strengthened first to make later institutional reforms viable; (c) cross-sector comparison—contrasting CTS profiles across health, education, fintech, etc., to identify where pilots are most likely to consolidate; and (d) stakeholder-legitimacy mapping—pinpointing narratives and norms needed to secure consent for scaling.

One of the most practical applications of CTS is to interpret and explain AIPI–ISI outputs by tracing how cultural configurations shape scores, trends, and phase-to-phase transitions. Building on this role, two testable propositions follow: (i) higher CTS scores should predict higher subsequent ISI scores; and (ii) strong CTS accompanied by low ISI indicates binding institutional or governance constraints. Within the broader triad, CTS provides the cultural mechanism, AIPI defines infrastructural status, and ISI measures it (see Section 4.3 for the CTS↔ISI crosswalk and diagnostic sequence). This division of labor positions CTS not as derivative but as the interpretive driver linking cultural conditions to institutional trajectories and infrastructural outcomes.

We illustrate CTS through an interpretive case study of Azerbaijan, a post-Soviet transitional society with explicit AI modernization ambitions. This is not validation but demonstration—showing what the framework reveals about a complex case where policy ambitions, cultural conditions, and institutional constraints interact.

2. Culture as Latent Infrastructure: Conceptual Foundations

2.1 From Cultural Traits to Coordination Systems

Reframing Culture as Adaptive Infrastructure for AI

As outlined in Section 1 (see also 17, 41], classical work links cultural value orientations to economic and institutional outcomes. Here we move beyond trait-based accounts to culture-as-coordination, which underpins CTS.

In the AI era, societies confront opaque, rapidly evolving socio-technical systems whose legitimacy and risks are deeply interpretive [18]. The digital era intensifies this dynamic through virtual globalization—cross-border interdependence generated by digital platforms, data flows, and algorithmic coordination—creating connections often tighter than traditional, physically mediated integration. Under these conditions, culture operates more directly as an adaptive virtual layer that modulates expectations, legitimacy, and routines under uncertainty. It functions as a learning system, updating norms and coordination routines through feedback loops—audits, incident registries, change-control processes, professional training, and participatory design.

A nation may be likened to a living organism: its culture, history, collective preferences, and interpretive habits function as a cognitive system—the "national brain" that perceives, interprets, and learns. When societies engage externally—through communication, trade, alliances, or technological exchange—these cognitive layers interact first: cultures initiate contact, interpret signals, and negotiate meaning long before formal institutions or material infrastructures respond. Only after this cultural learning does the national body—the economy, bureaucracy, and policy apparatus—adapt and act.

CTS formalizes this role, conceptualizing culture not merely as attitudes but as adaptive coordination: it (i) reduces coordination costs via shared interpretive cues (common language, norms, role expectations), (ii) anchors expectations under uncertainty through familiar symbols and narratives that render emerging technologies intelligible enough for collective investment, and (iii) authorizes organizational and regulatory change by embedding new rules in culturally legitimate forms, thereby sustaining social consent. Together, these mechanisms condition how institutions respond and shape the transition from experimentation to infrastructure.

The CTS framework identifies four interacting dimensions: Heritage Adaptability (reinterpretation of traditions to support reform), Cross-Civilizational Competence (absorptive openness without social dislocation), Innovation Ethos (legitimacy[1] of experimentation and error-correcting learning), and Strategic Determination (capacity to sustain reform across political cycles). Different configurations generate distinct threshold dynamics: some societies convert pilots into standards; others stall despite resources and intent.

Terminology. We use "adaptive virtual infrastructure" to denote culture's substantive coordination system (mechanisms that modulate expectations, legitimacy, and routines), and reserve "layer" solely to indicate its position within the AIPI–CTS–ISI architecture (i.e., the cultural *layer* alongside institutional and infrastructural layers).

2.2 Positioning CTS: From Value Orientations to Societal Adaptation

CTS draws on three complementary literatures. Modernization scholarship [17, 41] links cultural value orientations to economic and institutional evolution, supplying the long arc from ethos to development. Diffusion theory [30] explains how innovations spread through social systems, introducing micro-level mechanisms of adoption and imitation. Cultural-dimensions research (Hofstede and successors) classifies relatively stable value orientations that shape authority, risk, and coordination. CTS synthesizes these literatures by translating trait-oriented cultural values and diffusion dynamics into meso-level coordination capacities that explain how

[1] Legitimacy is used in two senses: as cultural acceptance (CTS) and as institutionalized trust (ISI).

societies transform AI from experimental pilots into public infrastructure. Within this synthesis, Hofstede's framework remains a useful point of departure because its dimensions map most directly onto the coordination patterns relevant to infrastructuralization.

CTS Dimension	Hofstede Dimension(s)	Continuity / Derived Logic	How CTS Extends It
Innovation Ethos	Uncertainty avoidance	Low uncertainty avoidance → greater comfort with ambiguity → easier experimentation and iteration.	Translates individual tolerance for ambiguity into collective learning capacity—the institutionalization of experimentation, iteration, and adaptive feedback in AI governance and R&D.
Strategic Determination	Long-term orientation	Long-term orientation → sustained planning horizon, deferred gratification.	Moves from personal or managerial time horizons to system-level durability—the persistence of policy, investment, and reform cycles required for infrastructural consolidation.
Heritage Adaptability	Indulgence/restraint and traditionalism (implicit in Hofstede's cultural conservatism)	Balancing change and continuity → ability to reframe reform as preservation of values.	Elevates from value orientation to cultural legitimation of modernization—how societies reinterpret technological reform as continuity rather than disruption, maintaining identity coherence.
Cross-Civilizational Competence	Power distance and individualism–collectivism	Moderate power distance and balanced collectivism facilitate cross-boundary collaboration.	Recasts these traits as inter-societal interoperability—the cognitive and normative capacity to collaborate across governance systems, standards, and epistemic cultures in global AI ecosystems.

Table 1. Conceptual alignment between CTS dimensions and Hofstede's cultural dimensions. *CTS extends Hofstede's micro-level traits into meso-level coordination capacities relevant to infrastructuralization.*

To explain how cultural coordination shapes infrastructural consolidation—and to trace when and to what extent this occurs—CTS is aligned with the Infrastructure Status Index (ISI), as elaborated in the companion AIPI–ISI framework [12], which quantifies outcomes across Essentiality, Embeddedness, Legitimacy, and Governance.

Building on the CTS↔Hofstede alignment, Table 2 presents the heuristic CTS→ISI correspondence, showing how each CTS dimension conditions a distinct infrastructural property: Strategic Determination → Essentiality; Innovation Ethos → Embeddedness; Heritage Adaptability → Legitimacy; Cross-Civilizational Competence → Governance Capacity.

CTS dimension	ISI indicator (conceptual property)	Alignment rationale
Strategic Determination	**Essentiality** = *degree of societal dependence and indispensability*	Durable commitment and multi-cycle investment make AI services functionally non-optional.
Innovation Ethos	**Embeddedness** = *depth of technical, procedural, and institutional integration*	Normalized iteration and learning routines hard-wire AI into workflows, standards, and budgets.
Heritage Adaptability	**Legitimacy** = *breadth and durability of normative/public acceptance*	Culturally consonant narratives and practices stabilize consent for continued operation and scaling.
Cross-Civilizational Competence	**Governance** = *maturity and adaptability of rules, oversight, and coordination*	Interoperability with external standards and epistemic cultures strengthens credible, adaptive oversight.

Table 2. Heuristic CTS→ISI correspondence (conceptual alignment)

Methods note. *Heuristic mapping based on conceptual alignment; empirical validation left to Section 8 agenda.*

From a heuristic lens, the picture is as follows:

- Innovation Ethos aligns with low uncertainty avoidance: collective comfort with ambiguity enables societies to institutionalize innovation cycles—embedding "learning by doing" into governance and infrastructure—an essential adaptation in the AI era, where platform opacity and model updates often lie beyond public or national control;
- Strategic Determination aligns with long-term orientation: sustained commitment to multi-year goals enables societies to institutionalize reform cycles. This orientation is essential in the AI era, where capability building (skills pipelines, data infrastructure, assurance tooling) and governance maturation require durability beyond single projects, and where technological dependencies demand long-horizon contracting and oversight to avoid sudden shifts in policy priorities and dependence on a single provider;
- Heritage Adaptability aligns with a continuity-through-reform orientation: the capacity to reframe change as continuity enables societies to absorb new technologies without triggering disruptions to national identity. This orientation allows innovation to be interpreted as an extension of long-standing values rather than a rupture with them—linking modernization to cultural familiarity. In the AI era, where automation and data governance reforms can challenge collective identity and social trust, Heritage Adaptability transforms potential resistance into acceptance by embedding new systems in culturally legible narratives, languages, and institutions;
- Cross-Civilizational Competence aligns with collaborative governance across boundaries: the capacity to work across legal, linguistic, and organizational cultures enables societies to integrate external capabilities without breakdowns at the interfaces. Practically, this means multilingual operations, managed power-distance in joint work, participation in standards bodies [15, 16], mutual recognition of certifications, interoperable APIs/protocols, shared incident-response playbooks, and contract mechanisms that create reciprocity and predictability. In the AI era—where platforms, models, and data supply chains are transnational—this competence reduces interface

friction (procurement, data sharing, assurance), de-risks compliance (privacy, safety, export controls), and improves interoperability with vendor ecosystems.

2.3 Mechanisms of Cultural Coordination Under Uncertainty

Three mechanisms explain how culture, understood as adaptive virtual infrastructure, coordinates collective action during technological transition:

1. **Coordination-cost reduction.** Shared narratives, clear role norms, and routinized interfaces lower search, bargaining, and monitoring costs, enabling cross-agency AI initiatives to move faster and with less friction.
2. **Expectation anchoring.** Public values, professional standards, and procedural fairness stabilize expectations under outcome uncertainty. Anchoring operates through transparency, predictability, and reciprocity. Societies with strong expectation anchoring can scale pilots without triggering legitimacy crises—errors become learning opportunities rather than trust-destroying events.
3. **Authorization of adaptation.** Where iterative learning is legitimized, organizations can adjust routines without losing public consent, converting errors into constructive feedback. Without such authorization, societies become rigid—either avoiding deployment or deploying without learning.
4. These mechanisms operate across two levels: (a) **societal drivers** (collective ambition, institutional trust, national identity narratives, mobilization capacity) and (b) **individual capabilities** (learning agility, digital fluency, adaptive resilience, collaborative competence).

Alignment between levels produces reinforcing loops—visible success builds legitimacy, which enables sustained investment, which produces more success. Misalignment yields frustrated mandates (high ambition, low execution capacity) or scattered adoption (skilled individuals without policy coherence).

3. The Cultural–Technological Synergy Framework

The Cultural–Technological Synergy (CTS) framework treats culture as a four-dimensional vector space of adaptive capacity. Its dimensions—Heritage Adaptability (continuity through reform), Cross-Civilizational Competence (managed external interface), Innovation Ethos (legitimized iteration and learning), and Strategic Determination (long-horizon commitment)—are orthogonal axes, not causal stages. Societies vary by both the direction and magnitude of their composite position in this space. It is the combined strength of these independent capacities—rather than inter-dimension causality—that conditions whether technological adoption consolidates as legitimate, durable public infrastructure.

3.1 Four Dimensions of Cultural–Technological Synergy

Heritage Adaptability refers to a society's capacity to reinterpret cultural traditions, identities, and narratives to support technological innovation without experiencing heritage loss or social fragmentation. This is not abandonment of tradition but active translation—framing innovation as consonant with cultural values. Indicators include curriculum reforms linking traditional values to STEM education, public communications framing AI as continuity rather than rupture, and multilingual/local-norm accommodations in service design. High Heritage Adaptability enables reform without polarization; low adaptability produces either stagnation (rejection of change) or dislocation (modernization at the cost of social cohesion).

Cross-Civilizational Competence captures a society's openness to external knowledge systems and ability to absorb international best practices without triggering defensiveness or imitation without adaptation. It involves active participation in global knowledge networks (research collaborations, standards bodies, educational exchanges), rapid import-adaptation

cycles for proven practices, and institutional frameworks that reward rather than punish learning from abroad. Indicators include intensity of international research links, co-authorship of technical standards with foreign partners, and speed of adapting imported methodologies to local contexts. Societies with strong Cross-Civilizational Competence avoid both isolationist stagnation and uncritical transplantation of foreign models.

Innovation Ethos reflects the social legitimacy of experimentation, error-correcting learning, and iterative improvement. It manifests in incident registries that treat failures as learning opportunities, documented rollback procedures indicating comfort with course correction, structured post-incident reviews that separate accountability from stigma, and change-control protocols with audit trails showing continuous refinement. High Innovation Ethos societies normalize that 'first versions fail' and build institutional memory from errors. Low Innovation Ethos societies either avoid deployment (risk aversion) or deploy without feedback mechanisms (learning disability). This dimension closely relates to Hofstede's uncertainty avoidance (inverted) but focuses specifically on institutional practices rather than general risk tolerance.

Strategic Determination denotes capacity to sustain reform initiatives across political cycles, budget volatility, and leadership transitions. It requires recurrent (not one-time project) budget lines for oversight and workforce development, multi-year roadmaps with publicly tracked milestones, standards stability across administrations, and civil service competency frameworks embedding new skills. High Strategic Determination insulates essential functions from political turbulence; low Strategic Determination produces pilot proliferation without consolidation—each new administration restarts rather than builds on previous work. This dimension resonates with Hofstede's long-term orientation but emphasizes institutional mechanisms over general cultural patience.

3.2 Auxiliary Concepts: Two-Level Engine and Identity-by-Design

CTS operates through a two-level engine linking macro societal conditions to micro individual capacities. At the **societal level**, CTS dimensions create enabling environments—Strategic Determination funds training programs; Innovation Ethos legitimates professional experimentation; Cross-Civilizational Competence provides access to global knowledge. At the **individual level**, these translate into learning agility (updating skills rapidly), digital fluency (comfort with AI tools), adaptive resilience (managing technological change), and collaborative competence (working across technical-policy boundaries). Misalignment between levels produces failure modes: high societal ambition without individual capacity yields frustrated mandates; high individual capacity without societal support yields brain drain or scattered adoption.

Identity-by-design refers to embedding cultural and linguistic identities into technological systems to reduce adoption friction and enhance legitimacy. Examples include Estonia's X-Road multilingual interfaces, Singapore's culturally contextualized Smart Nation services, and UAE's Arabic-English e-government platforms. When AI systems 'speak the language' (literally and metaphorically) of users, trust increases and coordination costs decrease. For Azerbaijan specifically, multilingual digital services in Azerbaijani, Turkish, English, and Russian enhance both domestic inclusivity and regional connectivity—an operational expression of Heritage Adaptability and Cross-Civilizational Competence. Identity-by-design is not window-dressing but substantive infrastructure: error messages, documentation, training materials, and help systems that reflect local languages and norms build user confidence and enable broader adoption across educational and generational divides.

4. The CTS-Institutional Capacity Quadrant: A Diagnostic Tool

In the AIPI framework [12], Societal Readiness denotes the aggregate societal preconditions for AI infrastructuralization (culture, incentives, social authorization). CTS does not redefine that construct; it decomposes its cultural component into four diagnostic dimensions—Heritage Adaptability, Cross-Civilizational Competence, Innovation Ethos, and Strategic Determination—used within the CTS–Institutional Capacity Quadrant as the Cultural Readiness input. The companion AIPI Societal × Institutional AI Readiness Quadrant identifies critical imbalances in AI infrastructure development—particularly governance lag, where societal adoption outpaces institutional capacity. CTS extends this diagnosis by specifying the cultural subcomponents of societal AI readiness, explaining why societies differ in their capacity to absorb, legitimize, and institutionalize AI at scale.

Whereas AIPI's Societal AI Readiness summarizes observed adoption patterns, digital literacy, and public expectations, CTS's Cultural Readiness assesses the underlying interpretive infrastructure—Heritage Adaptability, Cross-Civilizational Competence, Innovation Ethos, and Strategic Determination—that enables those patterns to emerge and stabilize; in short, CTS reads readiness through sociological and psychological lenses. This distinction matters: two societies may display similar Societal Readiness scores (e.g., high AI adoption, digital-native populations) yet differ fundamentally in their cultural architectures, which in turn determine whether adoption consolidates into durable infrastructure or remains fragmented and unstable.

The CTS-Institutional Capacity Quadrant therefore provides a causal explanatory layer beneath AIPI's descriptive framework, positioning culture and institutions as interacting determinants of infrastructural capacity. By mapping these dimensions orthogonally, the quadrant identifies which constraint binds—cultural enablers or institutional execution—and clarifies intervention priorities.

4.1 Framework Structure

The quadrant positions societies across two dimensions:

CTS-Cultural Readiness (Y-axis): Composite CTS score reflecting the strength and balance of Heritage Adaptability, Cross-Civilizational Competence, Innovation Ethos, and Strategic Determination. High scores indicate societies possess interpretive frameworks, coordination norms, and legitimacy structures that facilitate AI infrastructuralization. Low scores signal cultural fragmentation, resistance to external knowledge, risk aversion, or short-termism that constrain consolidation even when technical and economic capacity exists.

Operationalization draws from cultural and interpretive evidence: national value surveys, public discourse analysis (framing of AI in official communications, media narratives), professional learning norms (incident-response cultures, change-control practices), international collaboration intensity (co-authorship, standards participation), and curriculum integration (STEM-heritage linkages, multilingual service design).

AIPI-Institutional Capacity (X-axis). The ability of governance structures, regulatory agencies, and public institutions to execute, monitor, and sustain AI infrastructure development. This encompasses enforcement capability, judicial effectiveness, budgetary stability, civil-service competence, and regulatory coherence. High scores indicate that states can translate policy into practice; low scores reflect capacity gaps, risks of capture, or political volatility that prevent consolidation.

Operationalization relies on established governance measures, including international governance indicators (government effectiveness, regulatory quality, rule of law), fiscal management scores, administrative-capacity assessments, and procurement-transparency metrics. These indicators are distinct from CTS's cultural measures and from ISI's infrastructural outcomes, ensuring the quadrant captures interaction effects rather than circular dependencies.

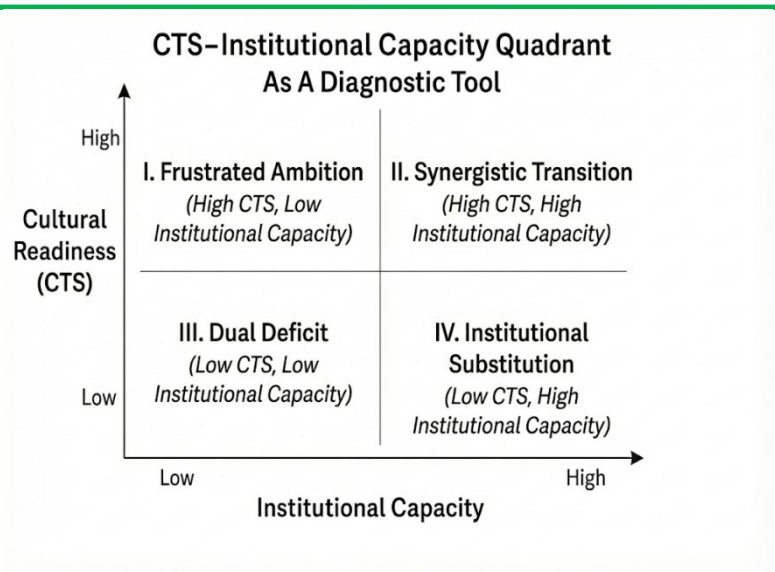

Figure 1. The CTS-Cultural Readiness × AIPI-Institutional Capacity Quadrant

4.2 Quadrant Descriptions and Policy Implications

Quadrant I: Frustrated Ambition *(High CTS + Low Institutional Capacity)*

Characteristics: Cultural foundations for infrastructuralization exist—public narratives legitimate AI-driven modernization, multilingual populations facilitate identity-by-design, scientific heritage supports learning-oriented norms, policy ambition signals Strategic Determination—but weak institutional capacity constrains translation into outcomes. Governance quality, judicial effectiveness, regulatory enforcement, or fiscal management gaps prevent consolidation despite societal readiness.

AIPI–ISI trajectory. Societal Readiness (AIPI) is moderate to high, generating demand and pilot adoption, but institutional readiness lags, producing the governance-lag pattern AIPI flags as high-risk. ISI scores remain modest despite cultural potential: Essentiality and Embeddedness may rise via market-driven adoption, yet Governance and durable Legitimacy stall due to implementation failures, capacity gaps, or divergent political priorities. Pilots proliferate without consolidation; each administration restarts rather than builds.

Governance Lag (High CTS / Low Institutional Capacity). In this configuration, cultural readiness outpaces institutional capacity. CTS scores exceed institutional indicators, revealing the presence of favorable cultural architectures but insufficient institutional mechanisms. The diagnostic value of CTS lies in its ability to pinpoint which cultural dimensions are strong, clarifying that the binding constraint is institutional rather than cultural.

Policy focus. Institution-building is the priority. Strengthen governance quality through legislative modernization, civil-service professionalization, and well-funded policy implementation, coupled with investment attraction and incentives (e.g., transparent procurement, stable rules, targeted tax/grant programs). Cultural assets (multilingualism, openness to external knowledge, scientific norms) can then accelerate progress—once institutions are capable of execution.

Risks: Frustrated ambition can erode public trust if repeated policy announcements yield limited results. Brain drain accelerates when skilled individuals find domestic opportunities blocked by institutional dysfunction. Cultural openness (Cross-Civilizational Competence) may facilitate emigration rather than domestic development.

Examples: India – vibrant democracy with high digital literacy and strong Innovation Ethos, yet persistent bureaucratic fragmentation and regulatory lag; **Brazil** – culturally dynamic and technologically capable, but inconsistent policy implementation; **Philippines** – open,

English-speaking society with strong human capital, but limited state capacity and coordination across agencies; **Indonesia** – culturally adaptive and digitally expanding, but local–national coordination and regulatory consistency remain limited.

Quadrant II: Synergistic Transition *(High CTS + High Institutional Capacity)*

Characteristics: Cultural enablers align with strong institutional capacity, creating reinforcing dynamics. Heritage Adaptability legitimizes change without polarization; Cross-Civilizational Competence enables rapid absorption of international best practices; Innovation Ethos normalizes iterative learning and error correction; Strategic Determination fosters programs with clearly defined goals, sustained resources, and consistent policy support. In parallel, effective governance structures translate ambition into implementation: procurement systems embed AI systematically, regulatory agencies monitor adaptively, the civil service builds competencies, and budgets sustain multi-year commitments. The result is consolidation of pilots into standards and routine, infrastructure-grade services.

AIPI–ISI trajectory: Rapid progression through AIPI stages (Tool → Infrastructural Adoption → Public Infrastructure) with high ISI scores across Essentiality, Embeddedness, Legitimacy, and Governance. Cultural legitimacy and institutional execution co-evolve, minimizing friction and enabling efficient consolidation. These societies become reference cases and standard-setters.

Mature Readiness (High Societal, High Institutional). CTS explains WHY societal readiness is high—not merely digital literacy but deeper cultural architectures enabling coordination, legitimacy, and adaptation.

Policy focus. Maintain momentum through continuous investment in both dimensions. Address emerging equity gaps (urban–rural, generational, sectoral) before they fragment consensus. Lead international standard-setting and capacity-building partnerships. Avoid complacency—cultural coherence and institutional quality require active, ongoing maintenance.

Examples: Estonia (e-governance tradition, digital identity infrastructure, participatory policymaking culture, strong rule of law); **Singapore** (strategic state capacity, multicultural adaptation norms, long-term planning orientation, rigorous procurement); **South Korea** (rapid technology absorption, strong innovation culture, high state capacity, coordinated industrial policy).

Quadrant III: Dual Deficit *(Low CTS + Low Institutional Capacity)*

Characteristics: Neither cultural foundations nor institutional capacity are developed. AI adoption remains experimental, fragmented, or absent. Low Heritage Adaptability produces resistance to technological change framed as cultural threat; weak Cross-Civilizational Competence limits absorption of external knowledge; low Innovation Ethos produces risk aversion or deployment without learning; weak Strategic Determination yields policy instability and short-termism. Simultaneously, governance structures lack enforcement capability, regulatory coherence, or resources.

AIPI–ISI trajectory: Early-stage or pre-infrastructural. Societal and institutional readiness both low. ISI scores minimal across all dimensions—AI remains discretionary tool in narrow niches. Infrastructuralization unlikely without external intervention (donor programs, technical assistance) or crisis-driven reform.

Early Stage (Low Societal, Low Institutional). Cultural readiness and institutional capacity are both weak; adoption is sporadic and reversible, with low trust, thin skills, and minimal coordinating structures. Priority actions include seeding micro-pilots with visible benefits, investing in baseline digital/AI skills and multilingual service design, and putting in place simple change-control and incident-reporting routines alongside a locally relevant "why now" narrative.

Policy focus: Foundational capacity-building across both dimensions. On culture: digital literacy campaigns, STEM education expansion, professional exchange programs to build Cross-Civilizational Competence, public communications linking technology to national

development (Heritage Adaptability). On institutions: basic governance reforms (transparency, rule of law), initial regulatory frameworks, procurement system development, civil-service training.

Risks: Dual deficits create path dependencies—weak institutions cannot build cultural capacity (no quality education, no professional exchange); weak culture cannot demand institutional improvement (low civic engagement, low trust). External assistance can help but must avoid dependency traps.

Examples: Low-capacity states with limited digital infrastructure, conflict-affected regions, fragile states with weak governance and traditional social structures resistant to technological change.

Quadrant IV: *Institutional Substitution (Low CTS + High Institutional Capacity)*

Characteristics. Strong state capacity achieves technical deployment despite weak cultural embedding. This configuration can arise through (a) centralized modernization, where state directives override public readiness; (b) resource-rich importation, where turnkey solutions are adopted without building domestic interpretive capacity; or (c) reactive regulation, where institutions respond to crises with robust frameworks absent underlying cultural legitimacy. Innovation Ethos may be weak (risk aversion or deployment without learning), Heritage Adaptability low (modernization framed as rupture from tradition, provoking backlash), and Cross-Civilizational Competence limited (imitation without adaptation).

AIPI–ISI trajectory: Institutional readiness high, enabling technical deployment and formal governance. However, societal readiness lags—creating the "institutional substitution" or "top-down deployment" patterns AIPI identifies. ISI scores may be mixed: Governance strong (state mandates, oversight agencies), Embeddedness moderate (systems deployed in public services), but Legitimacy weak (public skepticism, shallow adoption) and Essentiality uncertain (systems may be bypassed informally if not trusted). This configuration is brittle—high ISI scores mask legitimacy deficits that can trigger backlash or non-compliance.

Institutional Substitution (Low Societal, High Institutional). Institutions move ahead of society: rules, units, and budgets are in place, but public trust, professional norms, and everyday practices have not caught up. CTS clarifies that low societal readiness reflects deficits in cultural architecture, not merely a lack of information or awareness.

Policy focus. Build cultural legitimacy to sustain institutional gains. Invest in Heritage Adaptability (frame AI as compatible with cultural values rather than externally imposed), participatory design (engage civil society in governance frameworks), and Innovation Ethos (be transparent about failures; treat errors as learning with real redress mechanisms). Avoid over-reliance on mandates—compliance without acceptance creates fragility. Medium term: shift from top-down execution to distributed legitimacy by empowering professional associations, conducting meaningful community consultations, and enabling local adaptation.

Risks: Deployment without legitimacy generates: (a) shallow adoption (formal use, informal resistance); (b) backlash when systems fail (trust collapse without cultural cushioning); (c) cultural dislocation (modernization at cost of social cohesion). If institutions weaken (political transition, economic crisis), lack of cultural embedding means systems cannot be sustained through distributed social support.

Examples: Saudi Arabia/UAE (2015-2020): High state capacity from resource wealth enabled large-scale technical deployment (smart cities, AI systems), but cultural conservatism and limited civic participation constrained Innovation Ethos and Heritage Adaptability. Infrastructure advanced through state mandate rather than cultural legitimacy—creating adoption without deep societal embedding; **China (selective sectors)**: Strong institutional capacity in technology deployment, but Innovation Ethos constrained by risk-averse bureaucracy in some domains; Cross-Civilizational Competence limited by language barriers and regulatory restrictions; **Rwanda, Vietnam, and Malaysia** may exhibit Quadrant IV characteristics in specific sectors, but systematic CTS measurement is required for definitive positioning. These placements remain illustrative pending empirical validation.

4.3 Integration with AIPI-CTS-ISI Architecture

CTS dimensions may manifest differently across governance styles. In market-led systems, Innovation Ethos often appears through venture capital, startup culture, and sandboxed procurement; in state-led systems, through public R&D programs and designated experimentation zones. In hybrid systems, Cross-Civilizational Competence may operate via multi-stakeholder standards bodies, while in state-led contexts it can take the form of bilateral technology-transfer arrangements.

The CTS–Institutional Capacity Quadrant serves as the meso-level analytical bridge within a three-layer diagnostic architecture:

Layer 1 — AIPI AI Readiness Quadrant [12]. Positions societies on Societal × Institutional AI Readiness, identifying readiness imbalances and governance risks. Answers: *What is the current state of AI preparedness?*

Layer 2 — CTS–Institutional Capacity Quadrant. Decomposes AIPI's Societal AI Readiness dimension, revealing the cultural architectures—Heritage Adaptability, Cross-Civilizational Competence, Innovation Ethos, and Strategic Determination—that enable or constrain societal capacity to absorb and institutionalize AI. Answers: *Why does societal readiness vary, and which constraint binds—cultural or institutional?*

Layer 3 — ISI Measurement. Quantifies infrastructural outcomes across Essentiality, Embeddedness, Legitimacy, and Governance, validating whether readiness and enablers translate into consolidation. Answers: *What infrastructure resulted, and where do gaps persist?*

Together, these tools enable evidence-based diagnosis and intervention prioritization:

1. **Diagnostic sequence:** Assess AIPI position → Identify CTS and institutional strengths/weaknesses → Measure ISI outcomes → Iterate.
2. **Causal inference:** Societies in AIPI's Governance Lag quadrant with high CTS scores (Quadrant I: Frustrated Ambition) require institution-building; those with low CTS scores require cultural capacity-building before institutions can consolidate gains.
3. **Policy targeting:** CTS quadrant position clarifies whether to invest in (a) cultural modernization (education, narratives, professional norms), (b) institutional capacity (governance, procurement, oversight), or (c) both.
4. **Risk identification:** Quadrant IV (Institutional Substitution) cases may show high institutional scores in both AIPI and ISI but remain vulnerable due to cultural legitimacy deficits—a risk standard metrics miss.

4.4 Operationalization and Validation

Positioning societies in the CTS-Institutional Capacity Quadrant requires:

For CTS (Y-axis): Systematic measurement—value surveys, discourse analysis, professional practice documentation, international collaboration mapping. Composite score or balanced minimum (to detect bottlenecks) determines vertical placement.

Institutional Capacity (X-axis). Derived from a synthesis of governance indices—including the Worldwide Governance Indicators [43], Country Policy and Institutional Assessment [42], UN E-Government Development Index [35], UNDP Human Development Report / Governance Composite Indicators [36], UNESCO Science, Technology & Innovation Governance Metrics [37, 38], OECD Government at a Glance (G@G) indicators [23], Regulatory Policy Outlook [24], and the World Economic Forum's Global Competitiveness Index [44]. Complementary evidence is drawn from fiscal indicators [14] and sector-specific capacity assessments (regulatory maturity, procurement quality, civil-service competence). Together, these measures capture the ability of state institutions to formulate, coordinate, and implement AI-related policies effectively and consistently.

Current limitations. The quadrant reflects illustrative positioning pending systematic data collection. CTS measurement protocols still require implementation, and while institutional indices are available, they need standardization for cross-national comparison.

Figure 1 placements are provisional, informed by secondary sources and expert judgment rather than validated empirical scores. Advancing the research agenda (Section 8) will refine both measurement and positioning through staged data collection, harmonization, and validation.

4.5 Analytical Contribution

The CTS–Institutional Capacity Quadrant operationalizes the framework's central analytical proposition: cultural architectures are necessary for the *durable and legitimate* infrastructuralization of technology, even though technical systems can be deployed without them on a temporary or instrumental basis. This section outlines that diagnostic logic; its broader implications for governance strategy and long-term sustainability are developed in Section 9.

This positions CTS within a broader tradition of meso-level institutional analysis—neither cultural determinism (CTS alone predicts outcomes) nor institutional reductionism (formal structures fully explain performance), but interaction effects where cultural and institutional factors co-determine capacity. The quadrant thus extends infrastructure studies by specifying cultural preconditions, complements comparative institutional frameworks by foregrounding technology-specific dynamics, and advances AI governance scholarship by integrating cultural alongside technical and regulatory dimensions.

5. Methodology and Case Selection

This study employs an interpretive case study design [46] to illustrate the CTS framework's application rather than validate its predictive power. Azerbaijan was selected as a revelatory case for several reasons: (1) It exhibits pronounced cultural hybridity—Caucasian, Turkic, Persian, Russian, Soviet, and European influences—enabling the examination of Heritage Adaptability and Cross-Civilizational Competence; (2) it articulates explicit AI modernization ambitions through recent policy initiatives; (3) it represents transitional post-Soviet political economies—a context underrepresented in AI governance literature despite comprising significant global population; (4) it faces some governance constraints that test CTS's explanatory scope.

Evidence derives from secondary sources: academic literature on Azerbaijan's development trajectory (2010-2025), official policy documents [2, 3], international assessments [26, 43, 44], and publicly available program descriptions. The goal is analytical generalization (refinement of the CTS framework by showing what it illuminates and where it fails to explain) rather than statistical generalization or empirical validation.

Methodological limitations must be acknowledged explicitly. First, reliance on secondary sources limits deep understanding of implementation realities—policy documents state intentions; actual practices may diverge. Second, single-case design cannot test comparative propositions about CTS dimensions predicting outcomes. Third, the Azerbaijan case is examined at a specific historical moment (2024-2025); longitudinal analysis would better capture dynamics. Fourth, no primary data collection with stakeholders (policymakers, tech entrepreneurs, civil society, public users) limits insight into cultural factors as lived experience versus official narratives.

Advancing this agenda requires multi-case comparative designs, primary interview data, quantitative operationalization of CTS dimensions, and longitudinal assessment of movement through AIPI stages. Our goal here is generative, not adjudicative: the paper suggests a conceptual lens to delimit questions and scope for later empirical testing.

6. Azerbaijan: Illuminating Tensions Between Ambition and Constraints

6.1 Cultural Context and Heritage Adaptability

Azerbaijan's cultural landscape reflects centuries of Turkic, Persian, Russian, Soviet, and European influence. Its multilingualism—Azerbaijani, Turkish, English, and Russian competencies among educated cohorts—and cosmopolitan urban centers, especially in Baku, foster interpretive flexibility, a potential foundation for Heritage Adaptability. Historical traditions of literary modernization (early-twentieth-century script reforms), Soviet-era mass literacy campaigns, and post-independence emphasis on multilingual education demonstrate a recurring capacity to frame educational change as cultural preservation through advancement rather than rupture.

These cultural patterns were reinforced by a pronounced scientific–industrial endowment during the Soviet period. Azerbaijan functioned as a core design-and-production hub for oil and gas extraction machinery, supplying equipment across the USSR; in petrochemistry and oil–gas field geology, the republic served as a recognized center of expertise with international visibility. Beyond hydrocarbons, Baku and allied institutes contributed to industrial chemistry, materials science, semiconductor physics, and industrial mechanization and automation, while maintaining strong schools in mathematics, physics, and chemistry. By informal reputation and relative ratios of scientific personnel to population, Azerbaijan ranked among the USSR's leaders in the mathematical and physical sciences, and careers in research and higher education carried high prestige.

Read through CTS, these legacies contribute enabling conditions for, rather than direct formation of, the Innovation Ethos and Strategic Determination dimensions. Long-standing norms that valorize scientific accomplishment can legitimize iterative learning (e.g., incident analysis, audited change-control) as professional excellence rather than fault-finding—lowering the social cost of "learning by doing." Yet these traditions alone do not automatically generate the institutional habits that sustain an Innovation Ethos; they provide a cultural foundation that must be reactivated through modern mechanisms such as credentialed AI competencies, transparent audit routines, and cross-sector learning platforms.

However, Heritage Adaptability remains uneven. Urban–rural access gaps, generational differences in digital fluency, and institutional bottlenecks complicate translation from pilots to routine practice, indicating the need for targeted capability-building. Official modernization initiatives frame technology as a national development imperative and mobilize civil society to anchor legitimacy and consent at scale. While CTS surfaces the limits of the present approach, fully explaining them requires closer examination of cultural and institutional architectures.

6.2 Strategic Ambition and Measured Reality

On March 19, 2025, Azerbaijan approved its Artificial Intelligence Strategy for 2025-2028 [3], representing explicit Strategic Determination at the policy level. The strategy emphasizes AI integration across government services, development of national AI capacity, international partnerships, and regulatory frameworks. Multi-year planning horizons and inter-ministerial coordination mechanisms (to be established) suggest awareness of infrastructural requirements beyond pilot projects.

However, strategic ambition at the policy level does not automatically translate to infrastructural consolidation. International assessments reveal significant challenges:

- **AI Readiness (Oxford Insights)**: Despite notable advances in AI, Azerbaijan's readiness index signals the need to strengthen technology-oriented governance, modernize data infrastructure, and scale skills development to match stated policy ambitions
- **Global Innovation Index (WIPO)**: Azerbaijan's 94th-place [45] standing in the WIPO assessment indicates underperformance relative to its GDP level, underscoring the need for urgent improvements to the national innovation system.
- **Technology outputs**: The country's high-technology and ICT trade volumes remain limited, reflecting the early stage of diversification within its innovation and digital sectors.

These data create a puzzle for the CTS framework: if Strategic Determination exists at the policy level (multi-year strategies, budget commitments, institutional coordination), why do outcome measures decline? Several interpretations emerge:

First, Strategic Determination requires sustained implementation beyond policy approval—the March 2025 strategy, approved only eight months prior to this analysis, has not yet had sufficient time to produce measurable outcomes in international indices, which typically lag policy implementation by 12-24 months

Second, declining rankings may reflect faster progress elsewhere rather than absolute stagnation in Azerbaijan—a relative-positioning issue rather than absence of effort.

Third, and most importantly for CTS refinement, cultural enablers are often necessary but not sufficient when political-economy dynamics set binding limits. In such cases, governance arrangements may decisively shape trajectories. CTS addresses cultural coordination; explaining outcomes driven chiefly by institutional structure requires complementary theories.

Governance-lag interpretation. In the AIPI–ISI logic, governance is not a precursor but the culminating dimension of infrastructural consolidation: cultural and organizational embeddedness must first stabilize before governance institutions can codify, standardize, and enforce them. A temporary gap—high Embeddedness and Legitimacy with lower Governance—is therefore expected in early consolidation phases. Once institutional routines harden, governance becomes both an outcome of prior coordination and a driver of subsequent efficiency, producing the "governance-lag" pattern observed in many transitional contexts.

6.3 What CTS Illuminates and What It Obscures

The framework's value: CTS identifies cultural factors worth examining—Azerbaijan's multilingual capabilities (Heritage Adaptability through identity-by-design), historical experience adapting to successive empires (potential Cross-Civilizational Competence), and explicit policy commitments (Strategic Determination signals). It generates productive questions: Can Heritage Adaptability compensate for Innovation Ethos weaknesses? Can Strategic Determination at the state level succeed without grassroots innovation culture? Does Cross-Civilizational Competence differ meaningfully across similar post-Soviet societies?

The framework's limitations: CTS cannot fully explain why policy ambitions fail to translate to measured outcomes when institutional structures constrain implementation. The analysis shows that Azerbaijan seeks AI infrastructural development; however, explaining performance gaps requires attention to governance quality, market openness, judicial effectiveness, data-access arrangements, and related constraints on creativity and innovation—domains that lie beyond CTS's cultural focus.

6.4 Azerbaijan in the CTS-Institutional Capacity Quadrant

Applying the diagnostic framework from Section 4.3, Azerbaijan appears positioned in Quadrant I (Frustrated Ambition): moderate cultural readiness constrained by institutional capacity gaps. This positioning explains the pattern observed in Sections 6.1–6.2, where explicit policy ambition and identifiable cultural assets do not translate into measured outcomes commensurate with stated goals.

6.4.1 Assessment of Cultural Readiness (CTS Dimensions)

Heritage Adaptability (HA): Moderate to High (60–65)

Azerbaijan exhibits multiple indicators of HA. Its history of repeated script reforms (Arabic → Latin → Cyrillic → Latin), sustained intergenerational multilingualism, and the framing of educational modernization as cultural advancement rather than rupture together demonstrate a capacity to reinterpret tradition in support of reform. Since independence in 1991,

education policy has explicitly linked national identity to technological competence, with multilingual digital services in Azerbaijani, Turkish, English, and Russian serving as operational expressions of identity-by-design (Section 3.2).

Limits and variation. This adaptability remains uneven: urban–rural divides, generational gaps in digital fluency, and differential exposure to global knowledge networks create within-country heterogeneity.

Indicative score. Synthesizing these signals, the country's HA is heuristically scored at 60–65.

Cross-Civilizational Competence (CCC): Moderate (55–60)

Azerbaijan's Soviet-era scientific–industrial infrastructure cultivated sustained collaboration with external research communities, standards bodies, and multinational industrial partners. This legacy underpins a baseline capacity to absorb and adapt external knowledge. The country's positioning at the intersection of multiple civilizational spheres (Turkic, Persian, Russian, European) and its participation in regional economic frameworks create structural incentives for cross-civilizational engagement.

Limits and variation. Contemporary evidence is mixed: international research co-authorship, participation in standards organizations, and scholar mobility remain below peer benchmarks for countries at similar GDP levels. The Global Innovation Index (2025, rank ≈94) reflects limited integration into global knowledge networks. While policy documents emphasize international partnerships, operational mechanisms for rapid import-adaptation cycles—absorbing international best practices and tailoring them to local contexts—require strengthening. The gap between stated openness and executed collaboration suggests that Cross-Civilizational Competence exists more as latent potential than as fully activated capacity.

Indicative score. Synthesizing these signals, the country's CCC is heuristically scored at 55–60.

Innovation Ethos (IE): Moderate to Low (40–45)

This area appears to be the principal cultural constraint. Although the scientific tradition highlighted in Section 6.1 values research excellence, it does not automatically generate the institutional habits associated with an Innovation Ethos.

Signals and gaps. Current signs—limited public incident-learning mechanisms, low transparency about pilot failures and course corrections, and risk-averse routines typical of post-Soviet bureaucracies—indicate that the Innovation Ethos is less developed than the other CTS dimensions. The cultural acceptance of "learning by doing" and iterative improvement—essential for agile AI deployment—has not yet been embedded at scale. This creates a bottleneck: without normalizing early failures and building institutional memory from mistakes, it is difficult to progress from trials to stable, scalable adoption.

Indicative score. Synthesizing these signals, the country's IE is heuristically scored at 40–45.

Strategic Determination (SD): Moderate (50–55)

The approval of the Artificial Intelligence Strategy 2025–2028 [3], with multi-year planning horizons and inter-ministerial coordination mechanisms, signals policy-level commitment to AI. This indicates capacity to set direction and initiate programs beyond one-off pilots.

Durability tests still pending. Strategic Determination requires more than strategy documents: recurrent (not one-time) budget lines, publicly tracked milestone achievement, standards stability across political cycles, and civil-service competency frameworks that embed new skills. Given the strategy's recency, evidence of sustained implementation remains preliminary.

Limits and risks. Historical patterns in national development initiatives show mixed continuity across multiple cycles. Political-economy factors—including resource dependence, centralized decision-making, and exposure to external economic shocks—can disrupt long-term commitments despite stated intentions. Until budget execution, institutional capacity-building,

and milestone tracking demonstrate durability beyond initial announcements, Strategic Determination should be judged moderate rather than high.

Indicative score. Synthesizing these signals, the country's SD is heuristically scored at 50–55.

CTS Composite Assessment: 51–56 (Moderate)

Aggregating the four CTS dimensions—HA, CCC, IE, and SD—with equal weights (0.25 each) yields a moderate overall profile for Azerbaijan: a composite of ≈ 51–56 on a 0–100 scale (midpoint ≈ 54).

$$CTS\_composite = 0.25 \times HA + 0.25 \times CCC + 0.25 \times IE + 0.25 \times SD$$

This "moderate" positioning matters: it suggests cultural enablers are present and usable, not missing or requiring wholesale construction. The society shows interpretive flexibility, openness to external knowledge, and policy-level ambition. The main constraint lies elsewhere.

6.4.2 Institutional Capacity within the AIPI–ISI Consolidation Framework

Multiple independent assessments highlight institutional capacity challenges that limit Azerbaijan's ability to translate cultural potential and policy ambition into infrastructural outcomes. The World Bank Governance Indicators [43] report moderate scores for government effectiveness and regulatory quality—factors that directly shape AI infrastructure development. The WIPO Global Innovation Index [45] ranks Azerbaijan 94th, indicating systemic underperformance in both inputs (institutions, human capital, infrastructure) and outputs (knowledge creation, technology diffusion) relative to GDP. Key bottlenecks include limited venture capital availability, weak linkages between research institutions and industry, and insufficient intellectual property protection. The Oxford Insights Government AI Readiness Index [26] further signals the need to strengthen technology-oriented governance and modernize data infrastructure, citing fragmented data governance frameworks, low open-data availability, and capacity gaps within regulatory agencies overseeing AI.

While oil and gas revenues provide fiscal space for AI-related investment, effective implementation requires more than budgetary resources. It demands procurement systems capable of managing complex technology contracts, civil service competencies in AI governance and evaluation, and monitoring infrastructure that supports evidence-based adaptation. These administrative capabilities remain underdeveloped and represent a key constraint on translating policy ambition into durable infrastructural outcomes.

Institutional Capacity Assessment: 35–45 (Low to Moderate)

Synthesizing available assessments, Azerbaijan's institutional capacity (within the AIPI–ISI framework) is low to moderate—sufficient to articulate strategy and launch pilots, but insufficient to consolidate at scale, enforce accountability, or sustain programs across political and economic cycles. This corresponds to AIPI's Governance Lag (high societal, low institutional readiness) and constitutes the binding constraint preventing moderate CTS cultural readiness from converting into high ISI outcomes (Essentiality, Embeddedness, Legitimacy, Governance).

6.4.3 Quadrant I Positioning: Implications and Dynamics

Azerbaijan's positioning in Quadrant I (Frustrated Ambition) clarifies the pattern observed in Sections 6.1–6.2: cultural assets exist but remain underutilized because institutional execution capacity cannot leverage them effectively. The frustration is precisely that potential exists—multilingual populations could enable sophisticated identity-by-design, scientific heritage could support learning-oriented governance, strategic positioning could facilitate cross-civilizational knowledge transfer—but institutional barriers prevent activation.

This creates a characteristic dynamic: repeated policy announcements generate initial optimism, pilots launch with ambition, international partnerships are signed—but consolidation stalls when implementation requires sustained governance capacity. Each incomplete initiative erodes trust, making subsequent efforts harder. Brain drain accelerates as skilled individuals conclude domestic opportunities are blocked not by lack of vision but by institutional dysfunction. Cultural openness (Cross-Civilizational Competence) that could enable development instead facilitates emigration.

Azerbaijan's Quadrant I positioning in the CTS framework corresponds to AIPI's "Governance Lag" quadrant (High Societal, Low Institutional Readiness). The CTS framework adds precision to this diagnosis:

- AIPI observes that societal adoption/readiness outpaces institutional capacity
- CTS specifies *why* societal readiness exists (cultural architecture with moderate strengths in Heritage Adaptability and Cross-Civilizational Competence)
- CTS identifies *which cultural dimension* constrains further (Innovation Ethos weakness)
- CTS clarifies that the primary binding constraint is institutional, not cultural

This precision matters for intervention design. Generic "capacity building" recommendations miss the specific dynamics: Azerbaijan does not primarily need cultural change campaigns (awareness-raising, values education) but rather institutional development (governance reform, procurement modernization, regulatory capacity) combined with targeted strengthening of Innovation Ethos through concrete practices (incident registries, documented learning protocols, transparent failure analysis).

Quadrant I positioning predicts a specific ISI pattern that aligns with observed outcomes:

1. **Essentiality (Expected: Low to Moderate):** Without sustained implementation and consolidation, AI capabilities remain discretionary rather than essential. Market-driven adoption by early-adopter firms may create pockets of dependence, but withdrawal would not cause society-wide disruption. This matches current state: AI use is growing but not yet infrastructural.
2. **Embeddedness (Expected: Low to Moderate):** Institutional capacity constraints limit deep integration across systems. Pilots exist but do not scale into cross-sector dependencies. Vendor concentration risks emerge because weak procurement capacity cannot sustain competitive ecosystems. This aligns with observed limited technology outputs and ICT trade volumes.
3. **Legitimacy (Expected: Moderate, but fragile):** Policy-level framing and cultural heritage provide initial legitimacy, but repeated implementation gaps erode trust. Legitimacy becomes vulnerable—contingent on visible progress rather than self-sustaining. This explains the need emphasized in Section 6.1 for "targeted capability-building" and "mobilizing civil society to anchor legitimacy."
4. **Governance (Expected: Low):** As AIPI−ISI frameworks predict, governance is typically the lagging dimension, and in Quadrant I contexts, this lag is exacerbated. Weak institutional capacity prevents the codification, standardization, and enforcement functions that constitute infrastructural governance. These matches observed governance quality indicators and regulatory capacity gaps.
5. **Composite ISI prediction: 40–50 (Early Stage AIPI / High-End Tool)**, with significant variance depending on sector. This is precisely the frustrated outcome Quadrant I positioning generates: enough capability to imagine infrastructuralization, insufficient execution capacity to achieve it.

6.4.4 Comparative Context: Learning from Quadrant I Trajectories

Azerbaijan's Quadrant I positioning invites comparison with societies that successfully transitioned from similar starting points to Quadrant II (Synergistic Transition):

Estonia's Trajectory

Estonia in the early 1990s faced some analogous challenges: post-Soviet institutional inheritance, need for governance modernization, building legitimacy for digital transformation. Key factors in Estonia's success:

- **Institutional reform prioritization:** E-governance and digital identity infrastructure were built *alongside* broader rule-of-law and anti-corruption reforms, not in isolation.
- **Cultural narrative construction:** Digital identity framed as sovereignty and modernity compatible with Estonian national identity—Heritage Adaptability operationalized deliberately.
- **Participatory design:** Civil society engagement in e-governance design built distributed legitimacy from the start.
- **Long-term consistency:** Cross-partisan consensus sustained digital infrastructure investment across multiple administrations—Strategic Determination institutionalized.

Key lessons: Institutional and cultural development can advance together when reforms are holistic. Digital infrastructure can drive governance modernization when transparency and accountability are built in from the start.

Singapore's Model

Singapore demonstrates high state capacity (institutional strength) combined with deliberate cultural cultivation—Innovation Ethos built through education system design, Cross-Civilizational Competence through managed multiculturalism and international talent attraction, Strategic Determination through long-term planning institutions insulated from electoral cycles.

Key lessons: State capacity alone is insufficient (Quadrant IV risks); Singapore invested heavily in cultural dimensions alongside institutions. Particularly relevant: transparency about failures and course corrections (Innovation Ethos), multilingual service design (Heritage Adaptability), and international research linkages (Cross-Civilizational Competence) were actively cultivated, not assumed.

Divergent Outcome: Persistent Quadrant I Cases

Not all Quadrant I societies transition successfully. Some remain in frustrated ambition for decades, as institutional reforms prove politically difficult or cultural assets erode without utilization. The key differentiator appears to be political economy: whether elites have incentives to build effective institutions or benefit from weak governance that enables rent extraction.

Key lessons: Oil and gas dependence creates political economy dynamics that can either support or undermine institutional development, depending on how resource revenues are managed and whether governance reforms align with or threaten elite interests. CTS cannot predict these outcomes but can identify what becomes possible if institutional capacity improves.

6.4.5 Limitations of CTS Diagnosis

The Quadrant I diagnosis, while illuminating, has important limitations:

(1) Aggregate Positioning Masks Sectoral Variation

Azerbaijan is not uniformly positioned in Quadrant I across all sectors. Energy sector AI applications may have higher institutional capacity (established regulatory frameworks,

technical competence) than social-service AI. Education technology might have stronger Innovation Ethos (tolerance for experimentation) than public administration. Sectoral heterogeneity means interventions must be sector-specific.

(2) Static Snapshot vs. Dynamic Trajectory

The national AI strategy [3] requires a longer implementation period (18-36 months) before its effectiveness can be fully assessed through international indices and outcome measures. Azerbaijan's position may be in transition—stated Strategic Determination could strengthen if implementation follows through; Innovation Ethos could improve if governance reforms enable learning-oriented practices. The quadrant provides a snapshot, not a prediction. Longitudinal analysis would be required to assess movement over time and identify potential transitions between quadrants.

(3) CTS Cannot Specify Reform Pathways

CTS identifies that institutional capacity is the binding constraint but cannot prescribe *how* to build it. The political economy of governance reform—interest-group dynamics, elite incentives, geopolitical pressures, resource-curse dynamics—lies outside the framework's scope. Complementary analytical tools (institutional economics, comparative political economy, development studies) are required for actionable reform strategies.

(4) Measurement Uncertainty

All positioning is provisional, based on secondary sources and illustrative indicators. Systematic CTS measurement could shift Azerbaijan's assessed cultural readiness up or down by 10–15 points, potentially moving it toward the Quadrant I/II boundary or deeper into Quadrant I. The qualitative diagnosis (cultural potential constrained by institutions) is more robust than precise quantitative placement.

6.4.6 Conclusion: Frustrated Ambition as Generative Diagnosis

Positioning Azerbaijan in Quadrant I (Frustrated Ambition) within the CTS-Institutional Capacity framework accomplishes the goal articulated in Section 1.1: generating productive research questions and clarifying intervention priorities rather than providing definitive answers.

What CTS illuminates: Azerbaijan possesses moderate cultural readiness for AI infrastructuralization—multilingual capacity, scientific heritage, cross-civilizational positioning, and policy-level ambition exist as assets. The constraint is institutional capacity to execute, monitor, and sustain at scale.

What CTS obscures: The framework cannot fully explain *why* institutional capacity remains weak (political economy), *how* to reform institutions (governance transition pathways), or *whether* reforms will succeed (political feasibility). These questions require complementary analytical frameworks.

Policy implication: Interventions should prioritize institutional capacity-building (governance quality, regulatory capability, procurement modernization, fiscal durability) while selectively leveraging cultural strengths where institutional capacity permits (focused sectoral pilots, international partnerships, learning infrastructure development). Wholesale AI infrastructuralization awaits broader institutional strengthening; in the interim, strategic selectivity and external partnerships offer pathways to build capability incrementally.

Research implication: Azerbaijan serves as a boundary case testing CTS's scope—revealing both the framework's diagnostic value (clarifying *which* constraints bind) and its limits (inability to specify reform pathways when institutional factors dominate). Future comparative research should examine whether other Quadrant I societies share Azerbaijan's pattern and what factors enable successful transitions to Quadrant II.

The Frustrated Ambition diagnosis is neither pessimistic nor optimistic—it is realistic. Cultural potential exists; institutional barriers are real; outcomes depend on political economy factors CTS does not predict but that its diagnosis helps clarify. This is precisely the

contribution conceptual frameworks should make: structuring analysis, focusing attention, and generating questions that guide empirical inquiry and evidence-based policy.

7. Reflexivity and Implications

Echoing AIPI, we treat dependence and governance as conditions to be managed, not as inherently good or bad. CTS, therefore, aims to diagnose culture–institution configurations and anticipate trade-offs—including over-regulation, capture, exclusion, or brittle acceleration—rather than prescribe a single optimal cultural configuration. CTS, while integrative, remains bounded by several assumptions: it inherits traces of modernization bias and a state-centric perspective; it presumes partial cultural coherence where fragmentation often prevails; and it treats power asymmetries largely as exogenous. Rooted in Western epistemic traditions, it still interprets "progress" through governance and institutionalization lenses. These limitations do not invalidate the framework but define its analytic scope—CTS is a heuristic for diagnosing readiness, not a universal theory of modernization.

For policy and planning, reflexivity translates into practical guidance. Transitional societies can mitigate these biases by coupling cultural diagnostics with participatory design, multi-level governance, and iterative policy review. In Azerbaijan's context, embedding CTS insights into AI strategies means aligning capability building with local narratives of legitimacy and shared benefit, ensuring that infrastructural transition remains culturally grounded and socially inclusive.

8. Future Research Agenda

CTS is operationalized from cultural and interpretive evidence—values, narratives, learning routines—whereas AIPI–ISI rely on institutional and infrastructural artifacts such as laws, budgets, and implementations. CTS therefore precedes and conditions, but remains analytically distinct from, the outcomes captured by ISI.

Sectoral CTS scores (e.g., health, fintech, education) may diverge; for baseline reporting, a weighted average should preserve comparability with ISI, complemented by a bottleneck sensitivity test (mean – minimum sector score). A gap exceeding a modest threshold (≈ 0.25 SD) indicates intra-societal asymmetry in cultural readiness.

Detailed model specification, identification strategies, and data construction are left to future comparative research, which should employ multi-case designs, longitudinal tracking, and integration with institutional datasets. The present paper's contribution is to provide a conceptual map and testable propositions, not to exhaust methodological options.

9. Conclusion

The pace and legitimacy of AI-driven modernization depend on cultural architectures that act as adaptive infrastructures—coordination systems that align expectations, legitimacy, and routines under uncertainty. CTS framework integrates insights from cultural modernization theory, technology-diffusion research, and infrastructure studies to explain why some societies transform AI pilots into public infrastructure while others stall despite resources and intent.

Comprising four dimensions—Heritage Adaptability, Cross-Civilizational Competence, Innovation Ethos, and Strategic Determination—CTS provides a structured lens for assessing cultural drivers of infrastructural transition. Applied to Azerbaijan, it highlights multilingualism, historical adaptability, and strong policy commitment as cultural assets, yet also exposes the limits of institutional substitution: infrastructure can emerge without cultural readiness but remains brittle, prone to backlash or neglect when capacity weakens. Sustainable infrastructuralization depends on the interaction of cultural enablers and institutional strength.

These findings raise broader questions: Can state-level Strategic Determination offset weak societal Innovation Ethos? Does Cross-Civilizational Competence function differently in centralized versus plural systems? When do cultural factors yield to institutional constraints? Addressing such questions requires comparative, longitudinal research integrating CTS with AIPI–ISI datasets to test interaction effects and refine measurement protocols.

For policymakers in transitional contexts, CTS offers practical guidance: integrate cultural modernization into AI strategies, invest in Cross-Civilizational Competence, normalize learning-oriented governance, and cultivate legitimacy through participatory design. These interventions build the cultural infrastructure—trust, norms, and coordination routines—that convert technological capacity into public benefit.

Theoretical positioning and novelty. CTS moves beyond adoption models [11, 30] by asking not *whether* technologies are accepted but *how* they become legitimate, governed infrastructures. Operating at a meso level, it links cultural coordination capacities to infrastructural outcomes (Infrastructure Status Index), bridging micro-level adoption theories and macro-institutional analyses, and generating testable propositions on cultural–institutional interaction, governance lag, and bottleneck sensitivity.

Authors' Declaration

- **Author contributions**. Sole author; responsible for conceptualization, analysis, and writing.
- **Use of AI tools.** ChatGPT-5.1 and Claude-4.5 assisted with language editing, literature-scoping (identifying sources), and document consistency. These tools were not credited as authors and did not make independent claims; all analysis, judgments, and final text were reviewed and approved by the author, who takes full responsibility for the content.

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