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Article

Infrastructure-induced political stabilization: Interdependence and embeddedness in multi-state energy corridors

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Abstract: Large-scale cross-border infrastructure corridors increasingly shape regional economic integration, energy security, and geopolitical alignment. Yet, the literature has devoted comparatively limited attention to the ways in which infrastructure architecture itself may influence the durability of interstate cooperation. This article develops a structural framework explaining how corridor design may contribute to political stabilization in multi-state infrastructure systems. It introduces two complementary analytical constructs: the Interdependence-by-Infrastructure Mechanism (IIM), which explains how corridor topology, domestic offtake integration, industrial node anchoring, and governance coupling generate structural interdependence among participating states; and Atlantic Embeddedness for Irreversibility (AEI), which explains how integration into broader international markets, maritime-logistical networks, and industrial ecosystems reinforces corridor stability. Building on these mechanisms, the article proposes an analytical model linking infrastructure architecture to defection costs, governance coupling, renegotiation probability, and political stabilization. The framework is illustrated through the Nigeria-Morocco Gas Pipeline as an empirical anchor and is complemented by an exploratory comparative dataset of cross-border energy corridors. The article contributes to infrastructure governance, international political economy, and interdependence theory by reconceptualizing infrastructure systems as potential generators of political stabilization rather than passive economic assets.

Keywords: infrastructure governance; energy corridors; political stabilization; cross-border infrastructure; interdependence; embeddedness; corridor governance; megaprojects

1. Introduction

Large-scale cross-border infrastructure corridors increasingly play a central role in shaping regional economic integration, energy security, and geopolitical alignment. Energy pipelines, transport corridors, and transnational infrastructure systems connect multiple national economies through long-term capital investments and shared operational infrastructures. Due to these infrastructures operating across sovereign jurisdictions, their development requires sustained coordination among governments, regulators, investors, and industrial actors. As a result, infrastructure corridors function not only as technical assets but also as institutional systems that reshape economic geography and interstate relations.

Existing scholarship on cross-border infrastructure has primarily examined these systems through the lenses of economic efficiency, logistics performance, and infrastructure finance. Research in development economics and transport studies has emphasized how corridor infrastructures reduce trade costs, improve connectivity, and facilitate market access (World Bank, 2018; Roberts *et al*., 2018). Parallel research in infrastructure governance and megaproject management has focused on investment risks, financing structures, and institutional coordination mechanisms required for large-scale infrastructure development (Flyvbjerg, 2014; Ansar *et al*., 2016). While these approaches provide important insights into the economic and financial dynamics of infrastructure investment, they devote comparatively limited attention to the political implications of infrastructure architecture.

Empirical experience suggests that cross-border infrastructure projects can generate markedly different political outcomes. Some infrastructure systems contribute to sustained institutional cooperation and long-term regulatory alignment among participating states. In contrast, other projects experience repeated renegotiation, governance breakdowns, or geopolitical disruption. These divergent trajectories raise an important analytical question: why do some multi-state infrastructure megaprojects generate durable political cooperation while others remain vulnerable to instability and coordination failure?

This article advances the argument that infrastructure architecture itself may function as a structural generator of political stabilization. Rather than viewing infrastructure as a passive asset operating within pre-existing political environments, the study conceptualizes infrastructure corridors as institutional systems capable of reshaping interstate incentives through the generation of material interdependence and systemic embeddedness. When infrastructure networks create deep economic integration and shared operational dependencies among participating states, the costs associated with unilateral defection increase, thereby strengthening incentives for sustained cooperation.

To explain this mechanism, the article introduces two complementary analytical constructs. The first is the Interdependence-by-Infrastructure Mechanism (IIM), which explains how corridor topology, domestic offtake integration, industrial node anchoring, and governance coordination generate structural interdependence among participating states. Through these mechanisms, infrastructure systems embed participating countries within shared economic and institutional structures, increasing the economic and political costs associated with unilateral disruption.

The second construct is Atlantic Embeddedness for Irreversibility (AEI). This concept explains how infrastructure systems may become embedded within broader regional and global economic networks through external market integration, maritime connectivity, and industrial ecosystem development. Such systemic embeddedness expands the network of actors dependent on corridor stability and increases the broader economic consequences associated with infrastructure disruption.

Building on these mechanisms, the article develops a structural analytical framework linking infrastructure architecture to political stabilization in multi-state corridor systems. The framework identifies how corridor design characteristics generate interdependence among participating states and alter the incentive structures governing cooperative infrastructure governance.

To illustrate the empirical plausibility of this framework, the study examines the Nigeria-Morocco Gas Pipeline as an empirical anchor while situating it within a broader comparative landscape of cross-border energy corridors. In addition, the article introduces a comparative dataset of transnational pipeline systems to explore whether variations in infrastructure architecture are associated with differences in corridor governance stability.

The article makes three contributions to the literature on infrastructure governance and international political economy. First, it reconceptualizes cross-border infrastructure systems as potential generators of political stabilization rather than passive economic assets. Second, it introduces the Interdependence-by-Infrastructure Mechanism as a material extension of classical interdependence theory, highlighting how physical infrastructure networks can generate durable forms of interstate dependency. Third, it develops the concept of Atlantic Embeddedness for Irreversibility, emphasizing how infrastructure corridors become integrated within broader economic and geopolitical systems that reinforce cooperative stability.

More broadly, the study contributes to an emerging research agenda examining the geopolitical and institutional implications of large-scale infrastructure development. As transnational infrastructure investment expands across regions such as Africa, Eurasia, and Southeast Asia, understanding the political economy of infrastructure architecture becomes increasingly important.

2. Literature review

2.1. Infrastructure corridors and economic integration

Infrastructure corridors have long been studied as critical instruments for regional economic integration and development. In development economics and transport geography, corridor infrastructure is commonly conceptualized as a spatial platform that reduces transport costs, facilitates trade flows, and improves connectivity between production centers and markets (World Bank, 2018; Roberts *et al*., 2018). By lowering logistical barriers and expanding market access, infrastructure systems can stimulate trade, attract investment, and enhance economic productivity across connected regions.

Empirical research has demonstrated how large-scale infrastructure investments reshape economic geography by linking previously fragmented markets. Transport networks in particular influence patterns of industrial agglomeration, labor mobility, and regional specialization (Limao & Venables, 2001; Donaldson, 2018). More recent studies emphasize the concept of economic corridors as integrated development platforms combining transport, logistics, and energy infrastructures to support industrialization and regional value chains (Asian Development Bank, 2014).

In the African context, corridor development strategies have been widely promoted as mechanisms for overcoming structural connectivity constraints and facilitating regional economic integration. Infrastructure corridors connecting ports, industrial zones, and inland markets are expected to stimulate regional production networks and support industrial development strategies across multiple countries (African Development Bank, 2018). However, despite these economic benefits, many corridor initiatives face persistent coordination challenges among participating states, including regulatory fragmentation, governance inconsistencies, and investment uncertainties.

While the economic impacts of infrastructure corridors are well documented, much of the literature focuses primarily on efficiency gains, trade facilitation, and regional development outcomes. Comparatively limited attention has been devoted to the political and institutional dynamics that shape the long-term stability of cross-border infrastructure systems.

2.2. Infrastructure governance and megaproject risk

A second body of literature examines the governance challenges associated with large-scale infrastructure megaprojects. Infrastructure megaprojects are typically characterized by high capital intensity, long investment horizons, and complex coordination requirements involving multiple stakeholders across institutional levels (Flyvbjerg, 2014). These characteristics expose projects to significant risks, including cost overruns, delays, regulatory uncertainty, and political intervention.

Research on megaproject governance emphasizes the importance of institutional arrangements capable of managing these risks. Governance mechanisms, such as intergovernmental agreements, joint regulatory frameworks, and specialized corridor management institutions, are often required to ensure operational continuity and investment security (Ansar *et al*., 2016). The presence of credible governance structures can reduce uncertainty for investors and facilitate coordination among participating actors.

Cross-border infrastructure systems introduce additional layers of complexity because they involve multiple sovereign jurisdictions with distinct regulatory systems, political priorities, and economic interests. Coordination failures may arise when participating states face incentives to renegotiate agreements, delay implementation, or pursue unilateral policy adjustments. These dynamics may undermine the long-term viability of infrastructure corridors, particularly when institutional governance arrangements remain fragmented.

Although the megaproject governance literature provides valuable insights into the management of infrastructure investment risks, much of this research focuses on project management and financial governance rather than on the broader political dynamics generated by shared infrastructure systems. The structural political consequences of cross-border infrastructure architecture, therefore, remain insufficiently explored.

2.3. Interdependence and infrastructure-based cooperation

A third stream of literature examines how economic interdependence may influence cooperation among states. Classical theories of international political economy suggest that shared economic interests and mutual dependence can reduce incentives for conflict and encourage cooperative behavior (Keohane & Nye, 1977). Economic interdependence increases the potential costs associated with the disruption of cooperative arrangements, thereby altering the strategic incentives of participating actors.

While most empirical studies focus on trade and financial integration as sources of interdependence, physical infrastructure systems may generate particularly durable forms of structural dependency. Energy pipelines, electricity transmission networks, and transport corridors connect national economies through geographically fixed infrastructures characterized by high capital intensity and long operational lifecycles. These features create material linkages among participating countries that are difficult to replicate or reverse.

Infrastructure networks may therefore generate forms of interdependence that extend beyond conventional economic exchanges. Shared infrastructure systems require continuous operational coordination, regulatory alignment, and long-term investment commitments among participating states. These characteristics may strengthen incentives for sustained cooperation, particularly when disruptions impose high economic costs on multiple actors simultaneously.

Despite these potential stabilizing effects, existing research rarely examines how the architectural design of infrastructure systems influences the formation of interdependence. Infrastructure is typically treated as a background enabling condition rather than as an institutional structure capable of shaping interstate incentives and governance dynamics.

2.4. Research gap

Taken together, existing literature offers valuable insights into the economic returns of infrastructure corridors, the governance complexities of megaprojects, and the role of economic interdependence in fostering international cooperation. However, these strands of research remain largely disconnected. The literature has not sufficiently examined how infrastructure architecture itself may generate structural political stabilization among participating states.

Specifically, limited attention has been devoted to the ways in which corridor design characteristics, including territorial connectivity, domestic industrial integration, and institutional governance arrangements, may generate material and institutional interdependence capable of stabilizing long-term cooperation.

This article addresses this gap by developing a structural framework linking infrastructure architecture to political stabilization in multi-state corridor systems. The framework integrates two complementary mechanisms: the Interdependence-by-Infrastructure Mechanism (IIM) and Atlantic Embeddedness for Irreversibility (AEI). Together, these mechanisms explain how infrastructure systems may generate structural interdependence and systemic embedding capable of reinforcing cooperative governance arrangements across participating states.

3. Theoretical framework: Infrastructure-induced interdependence and embeddedness

3.1. Interdependence-by-infrastructure mechanism (IIM)

Large-scale cross-border infrastructure systems do more than connect territories. When infrastructure networks span multiple national jurisdictions and require long-term operational coordination, they reshape economic incentives, institutional relationships, and patterns of interdependence among participating states. Infrastructure corridors, therefore, operate not only as transport or energy transmission systems but also as institutional architectures that structure cooperation among participating actors.

This article conceptualizes this process through the Interdependence-by-Infrastructure Mechanism (IIM). The IIM framework explains how the physical and institutional configuration of infrastructure corridors can generate structural interdependence among participating states. Unlike conventional approaches that treat infrastructure as a passive enabling condition for economic exchange, the IIM mechanism emphasizes the capacity of infrastructure architecture to shape the strategic environment in which interstate cooperation takes place.

Infrastructure assets possess several characteristics that make them particularly relevant for understanding political stabilization dynamics. First, large-scale infrastructure systems require substantial sunk investments and long planning horizons. Second, infrastructure networks are geographically fixed and difficult to replicate or relocate once constructed. Third, cross-border infrastructure systems require sustained coordination among multiple actors responsible for regulation, operation, and maintenance.

These features create material linkages among participating countries that extend beyond conventional economic exchanges. Once operational, infrastructure systems embed participating states within shared operational dependencies and institutional coordination structures. As a result, disruption of the infrastructure system imposes economic and political costs on multiple actors simultaneously. The IIM framework, therefore, proposes that infrastructure architecture may generate political stabilization by increasing the costs associated with unilateral defection from cooperative arrangements.

The mechanism operates through four structural dimensions of corridor architecture: corridor topology, domestic offtake integration, industrial node anchoring, and governance coupling.

3.2. Structural dimensions of infrastructure interdependence

3.2.1. Corridor topology

The first dimension concerns the physical configuration of the infrastructure network. Multi-state infrastructure corridors connect multiple national territories through continuous physical systems such as pipelines, electricity transmission networks, or transport corridors. As these infrastructures function as integrated networks, the performance of the system depends on the operational stability of each segment.

In such configurations, disruption in one segment of the corridor may affect the functioning of the entire infrastructure system. Transit states, supplier countries, and destination markets, therefore, become structurally linked through shared operational dependencies. The resulting infrastructure topology creates mutual vulnerabilities that increase the incentives for coordination among participating states.

The degree of territorial connectivity generated by the corridor is captured in this study through the concept of Infrastructure Interdependence Depth (IID). Corridors connecting multiple countries across long distances with large transmission capacity generate deeper forms of infrastructure interdependence than shorter bilateral systems.

3.2.2. Domestic offtake integration

The second dimension concerns the integration of domestic demand within the corridor system. Infrastructure corridors may serve not only as transit systems connecting supply and export markets but also as platforms supplying energy or transport services to domestic users along the route.

When domestic industries, electricity systems, or urban energy networks become dependent on corridor infrastructure, the corridor becomes embedded within national economic systems. Domestic stakeholders develop economic interests in the continuity of corridor operations.

This domestic integration expands the number of actors affected by infrastructure disruption and increases the domestic political costs associated with instability. Infrastructure systems that supply domestic markets generate stronger forms of interdependence than corridors functioning purely as export routes.

3.2.3. Industrial node anchoring

The third dimension concerns the development of industrial activities and economic clusters along the corridor route. Large-scale infrastructure corridors frequently stimulate downstream investments such as petrochemical facilities, logistics hubs, fertilizer production plants, and energy-intensive manufacturing clusters.

These investments transform infrastructure corridors from simple transmission systems into spatial development platforms linking multiple industrial nodes. The resulting industrial ecosystems generate localized economic dependencies on the infrastructure network.

Industrial anchoring strengthens the stabilizing dynamics identified in the IIM framework. As economic activity expands, disruption of the infrastructure system would generate widespread economic consequences, reinforcing incentives for maintaining cooperative governance arrangements. This dimension is captured through the concept of Node Deployment and Anchoring (NDA).

3.2.4. Governance coupling

The fourth dimension concerns the institutional arrangements governing corridor operations. Cross-border infrastructure systems require sustained coordination among regulatory authorities, infrastructure operators, and government institutions responsible for tariffs, standards, and maintenance.

Governance arrangements may include bilateral agreements, multilateral frameworks, joint operating institutions, and dispute-resolution mechanisms. These structures generate repeated interactions among participating actors, conceptualized as Governance Coupling Intensity (GCI).

Frequent institutional interaction strengthens cooperation by facilitating coordination, information exchange, and dispute resolution. Governance coupling complements the material interdependence generated by infrastructure configuration.

3.3. External embeddedness and irreversibility (AEI)

While the IIM framework explains how internal corridor architecture generates structural interdependence, infrastructure systems may also acquire stability through their integration within broader regional and global economic networks.

Cross-border infrastructure corridors rarely operate as isolated technical systems. Instead, they are embedded within wider economic, financial, and logistical networks extending beyond the immediate corridor.

To capture this dimension, this article introduces the concept of Embeddedness for Irreversibility (AEI). AEI refers to the process through which infrastructure corridors become integrated into transnational economic systems, thereby reinforcing the durability of cooperative arrangements.

3.3.1. External market integration

Infrastructure corridors often connect production regions with major external demand centers. Integration into international markets expands the number of actors dependent on corridor operations, including external consumers, corporations, and supply chains.

This increases the systemic importance of the corridor and amplifies the consequences of disruption.

3.3.2. Maritime and logistical connectivity

Infrastructure corridors frequently intersect with ports and global logistics systems. These connections link regional infrastructure to global trade routes, extending their economic reach and embedding them within transnational supply chains.

3.3.3. Industrial ecosystem expansion

Infrastructure systems often attract downstream industrial investment, creating networks of firms and economic activities dependent on corridor functionality. These industrial ecosystems reinforce the economic stakes associated with infrastructure continuity.

3.4. Embeddedness and structural irreversibility

As infrastructure corridors become integrated into global markets, logistics networks, and industrial ecosystems, the costs of disruption increase significantly. This process generates forms of structural irreversibility, where reversing or destabilizing the system would produce widespread economic consequences.

The AEI framework complements the IIM mechanism by extending stabilization dynamics beyond internal corridor structure to broader transnational embedding.

3.5. Generalization of embeddedness dynamics

Although the concept of AEI is developed in the context of Atlantic-oriented corridors, its underlying analytical logic is not geographically restricted. Rather, it captures a broader mechanism of systemic embeddedness applicable to infrastructure systems across different regions, including Eurasian and Indo-Pacific contexts.

The “Atlantic” dimension reflects the empirical focus of this study rather than a limitation of the theoretical framework.

3.6. Asymmetry and coercive interdependence

Infrastructure-induced interdependence does not automatically produce stabilization. In configurations where dependency is unevenly distributed, control over critical nodes or supply flows may generate asymmetric relationships.

These asymmetries may enable strategic leverage or coercive dynamics, particularly when governance mechanisms are weak. These outcomes should be understood as variations within the same interdependent system rather than contradictions of the theoretical framework.

Infrastructure thus creates structured interdependence whose outcomes depend on the distribution of dependency and the governability of the system.

In such configurations, infrastructure may not only generate instability but may also become an instrument of deliberate strategic leverage, allowing dominant actors to influence or constrain the behavior of more dependent partners.

3.7. Synthesis of theoretical mechanisms

Taken together, the IIM and AEI frameworks provide a comprehensive explanation of how infrastructure systems shape interdependence and influence political outcomes.

IIM captures internal structural interdependence, while AEI highlights external embeddedness within global systems. The inclusion of asymmetry further refines the framework by identifying conditions under which interdependence may generate either stabilization or vulnerability.

4. Analytical model of infrastructure-induced political stabilization

4.1. Conceptual structure of the model

Building on the Interdependence-by-Infrastructure Mechanism (IIM) and Atlantic Embeddedness for Irreversibility (AEI), this section develops an analytical model linking infrastructure architecture to political stabilization in multi-state systems.

The model is designed as a mechanism-based framework rather than an econometric specification. Its purpose is to clarify how structural characteristics of infrastructure systems shape the incentives and interactions of participating actors.

For clarity, the model can be understood as a sequential process structured around three analytical layers:

- structural variables, describing infrastructure configuration;
- mediating mechanisms, shaping strategic incentives;
- outcome variables, capturing governance stability.

In simplified terms, the model follows the logic:

Infrastructure design → Interdependence → Defection costs & governance coupling → Political stabilization

4.2. Structural variables

The first layer of the model captures the structural characteristics of infrastructure systems.

- Infrastructure Interdependence Depth (IID) reflects the degree of territorial, economic, and operational integration generated by the corridor. Higher IID values indicate deeper multi-state entanglement and stronger system-wide dependencies.
- Node Deployment and Anchoring (NDA) captures the extent to which industrial activities and domestic economic systems become embedded along the corridor. Higher NDA values indicate stronger local economic dependence on infrastructure continuity.
- Atlantic Embeddedness Index (AEI) reflects the degree to which the corridor is integrated into broader international economic systems, including external markets, global supply chains, and transnational actors.

Together, these variables define the structural configuration of infrastructure-induced interdependence.

4.3. Mediating mechanisms

The second layer captures the mechanisms through which infrastructure architecture influences political outcomes.

- Defection Cost (DC) represents the economic and political costs associated with unilateral disruption or withdrawal. These costs increase with deeper interdependence and broader systemic embedding.
- Governance Coupling Intensity (GCI) reflects the density and effectiveness of institutional coordination among participating actors, including regulatory frameworks, joint institutions, and operational agreements.

These mechanisms translate structural interdependence into strategic constraints and incentives.

4.4. Outcome variables

The final layer captures the implications for corridor governance.

- Renegotiation Probability (RP) represents the likelihood of conflict, disruption, or contractual revision within the system.
- Political Stabilization (PS) reflects the durability of cooperative arrangements governing the infrastructure system.

Higher defection costs and stronger governance coupling are expected to reduce renegotiation risks and increase political stabilization.

4.5. Causal structure and endogeneity

The relationship between infrastructure and cooperation is not purely unidirectional. While the model emphasizes the role of infrastructure architecture in shaping stabilization, it also acknowledges that initial forms of cooperation often precede infrastructure development.

Political alignment, strategic interests, and diplomatic coordination may constitute enabling conditions for the initiation of large-scale infrastructure projects.

However, this study argues that infrastructure plays a distinct and transformative role. Once established, infrastructure systems embed cooperation into material and institutional structures, increasing the costs of defection and constraining unilateral behavior.

The causal relationship is therefore asymmetric:

- cooperation enables infrastructure development;
- infrastructure transforms and stabilizes cooperation through structural interdependence.

This perspective addresses potential endogeneity by distinguishing between:

- enabling conditions (pre-existing cooperation), and
- transformation mechanisms (infrastructure-induced interdependence).

4.6. Dynamic interaction and feedback effects

The interaction between infrastructure and cooperation can be understood as a co-evolutionary process.

Initial cooperation enables infrastructure development, which in turn generates structural interdependence. This interdependence increases the costs of disruption and reinforces cooperative incentives. Over time, stabilized cooperation may facilitate further integration and expansion of infrastructure systems.

This feedback loop can be represented as:

Cooperation → Infrastructure → Interdependence → Stabilization → Reinforced cooperation

Such dynamics highlight the cumulative nature of infrastructure-induced stabilization.

4.7. Threshold effects and non-linearity

The stabilizing effects of infrastructure are not expected to operate linearly. At low levels of interdependence, infrastructure systems may remain politically fragile, as the costs of disruption are relatively limited.

However, once interdependence exceeds a critical threshold, the system may enter a phase of structural entanglement in which disruption becomes significantly more costly.

Beyond this threshold, additional increases in interdependence and embeddedness may generate disproportionately stronger stabilization effects.

4.8. Summary of the analytical framework

The analytical model developed in this section offers a structured account of how infrastructure architecture shapes political stabilization in multi-state systems. By linking structural variables (IID, NDA, AEI) to mediating mechanisms (DC, GCI) and governance outcomes (RP, PS), the framework elucidates the causal pathways through which infrastructure-induced interdependence reconfigures strategic incentives.

Crucially, the model underscores that stabilization is not an automatic consequence of infrastructure development. Rather, it is contingent upon the configuration of interdependence, the distribution of dependency, and the quality of governance arrangements.

The conceptual sequence shown in **Figure 1** summarizes the core causal logic of the article: infrastructure architecture shapes defection costs and governance coupling, which in turn affect renegotiation probability and political stabilization.

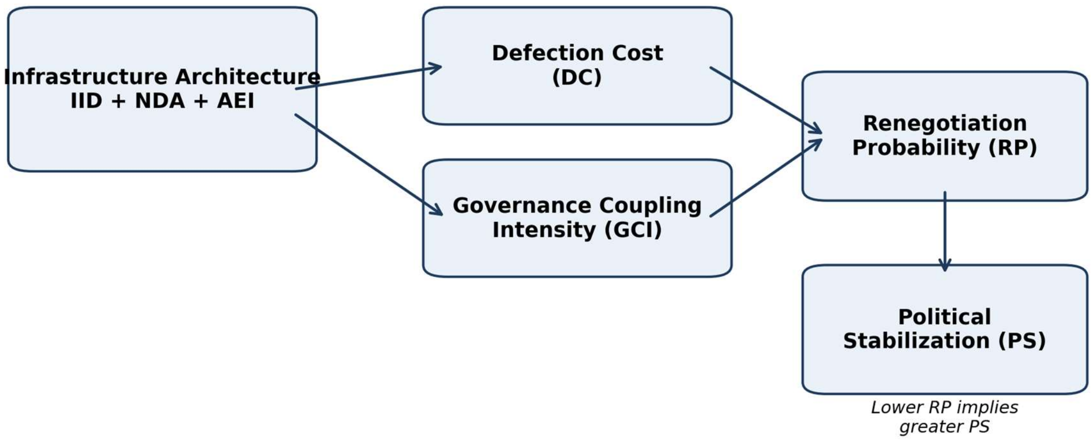

Figure 1. Analytical architecture linking infrastructure design to political stabilization.

Table 1. Core analytical variables and interpretive definitions.

Code	Variable	Definition/interpretation
IID	Infrastructure Interdependence Depth	Composite expression of territorial reach, transmission scale, and structural operational entanglement across participating states.
NDA	Node Deployment and Anchoring	The extent to which industrial nodes and corridor-linked economic activity are spatially anchored along the route.
AEI	Atlantic Embeddedness Index	Degree of corridor integration into broader international markets, maritime-logistical systems, and transnational economic networks.
DC	Defection Cost	Expected economic and political costs associated with unilateral withdrawal or disruption.
GCI	Governance Coupling Intensity	Density of corridor-related regulatory, institutional, and operational coordination among participating actors.
RP	Renegotiation Probability	Likelihood of contract revision, regulatory conflict, supply interruption, or governance disruption.
PS	Political Stabilization	Durability of cooperative governance arrangements associated with the corridor system.

4.9 Research propositions

Building on the analytical model developed in the previous section, this study derives a set of analytical propositions linking infrastructure architecture to political stabilization in multi-state corridor systems. These propositions clarify the structural mechanisms through which infrastructure interdependence and systemic embeddedness influence renegotiation dynamics and the durability of cooperative arrangements among participating states. Together, the propositions specify how variations in corridor architecture may reshape the strategic incentives governing interstate cooperation.

Proposition 1 (P1): *Interdependence Depth and Stabilization. Higher levels of Infrastructure Interdependence Depth (IID) are associated with increased political stabilization, as they raise the economic and operational costs of disruption*.

Proposition 2 (P2): *Node Anchoring and Defection Costs. Greater Node Deployment and Anchoring (NDA) increases defection costs by embedding infrastructure within domestic economic systems, thereby reinforcing cooperative incentives*.

Proposition 3 (P3): *Embeddedness and Systemic Impact. Higher levels of external embeddedness (AEI) expand the range of stakeholders affected by the infrastructure system, increasing the systemic consequences of disruption and strengthening stabilization dynamics*.

Proposition 4 (P4): *Governance Coupling and Stability. Higher Governance Coupling Intensity (GCI) reduces renegotiation risks and enhances political stabilization by facilitating coordination and institutional predictability*.

Proposition 5 (P5): *Asymmetry and Vulnerability. High interdependence combined with asymmetric dependency structures may generate strategic vulnerability and reduce stabilization effects in the absence of adequate governance mechanisms*.

5. Empirical illustration—the Nigeria-Morocco energy corridor

The following section illustrates the empirical plausibility of the analytical framework through a combination of prospective and operational corridor cases.

5.1. Corridor overview

The Nigeria–Morocco Gas Pipeline (NMGP) represents a large-scale transnational infrastructure project designed to transport natural gas from Nigeria through multiple West African countries to Morocco, with potential integration into European energy markets.

The project is expected to involve a significant number of participating states along the Atlantic coastline and is supported by key institutional actors, including national energy companies (notably NNPC and ONHYM) as well as regional organizations such as ECOWAS. The corridor combines both transit and domestic supply functions and is projected to extend over several thousand kilometers.

Although the NMGP remains under development, its structural design characteristics provide a relevant empirical basis for illustrating the mechanisms proposed in this study.

5.2. Analytical mapping of infrastructure characteristics

To strengthen the empirical grounding of the framework, the structural characteristics of the corridor are explicitly mapped to the analytical variables introduced in the previous sections.

5.2.1. Infrastructure interdependence depth (IID)

The NMGP exhibits a high potential level of infrastructure interdependence. This is reflected in its extended geographic coverage across multiple national territories, the number of participating states, and the scale of projected gas transmission.

The configuration creates strong territorial and operational entanglement, as the functionality of the system depends on the coordinated performance of interconnected segments across different jurisdictions.

5.2.2. Node deployment and anchoring (NDA)

The corridor is designed not only as a transit infrastructure but also as a platform for domestic energy supply and industrial development.

Planned uses include electricity generation, expansion of national energy systems, and support for energy-intensive industries such as fertilizer production and gas-based manufacturing. These elements suggest the emergence of corridor-linked industrial nodes and localized economic ecosystems.

This form of domestic integration increases the economic stakes associated with the continuity of infrastructure operations and reinforces structural interdependence.

5.2.3. Atlantic embeddedness index (AEI)

The NMGP is expected to be embedded within broader international energy systems through its connection to Morocco and potential integration with European gas markets.

This embeddedness is further reinforced by the corridor's alignment along the Atlantic coastline, its proximity to major maritime trade routes, and its potential role in connecting regional production to global demand centers.

The external integration expands the range of stakeholders affected by the infrastructure system and increases the systemic consequences of disruption.

5.2.4. Governance coupling intensity (GCI)

The project involves multiple layers of institutional coordination, including bilateral and multilateral agreements, cooperation between national energy companies, and engagement with regional organizations.

While governance arrangements remain evolving due to the project's prospective nature, the presence of these coordination mechanisms indicates the emergence of structured institutional interaction among participating actors.

5.3. Implications for political stabilization

Taken together, these structural characteristics suggest that the NMGP has the potential to generate significant levels of infrastructure-induced interdependence.

High IID creates mutual operational dependency across participating states. NDA embeds the infrastructure within domestic economic systems, increasing local reliance on its continuity. AEI extends the system's impact to international markets, while GCI supports institutional coordination.

These combined effects contribute to increasing the economic and political costs associated with disruption, thereby reinforcing incentives for sustained cooperation among participating actors.

5.4. Analytical limits of a prospective case

It is important to note that the NMGP remains a prospective project. As such, this case primarily illustrates the potential operation of the mechanisms identified in the analytical framework rather than providing direct empirical validation.

To address this limitation and strengthen empirical grounding, the analysis is complemented by a brief examination of operational infrastructure systems.

5.5. Empirical extension: Evidence from operational corridors

To further assess the empirical plausibility of the framework, selected operational cross-border energy corridors are examined using the analytical variables proposed in this study.

5.5.1. Nord stream: Interdependence and asymmetry

The Nord Stream pipeline system illustrates a configuration of high infrastructure interdependence combined with asymmetric dependency structures.

Infrastructure interdependence is high due to large-scale gas flows and the significant reliance of certain European economies on pipeline supply. However, governance arrangements remain partially asymmetric, with uneven distribution of control over supply and limited diversification of dependency.

This configuration demonstrates that high interdependence does not automatically produce stabilization. Instead, asymmetry in dependency may create conditions for strategic leverage and vulnerability.

5.5.2. Southern gas corridor: Diversified interdependence

The Southern Gas Corridor provides a contrasting configuration characterized by multi-state coordination and more diversified dependency structures.

The system connects production, transit, and consumption regions across multiple countries, generating high levels of interdependence. At the same time, governance arrangements involve multiple stakeholders and institutional frameworks, contributing to more balanced coordination.

This configuration illustrates how diversified interdependence and stronger governance coupling may reduce renegotiation risks and support more stable cooperative outcomes.

5.6. Comparative implications

The comparison of prospective and operational corridors highlights a key implication of the analytical framework.

Infrastructure interdependence constitutes a necessary but not sufficient condition for political stabilization. The distribution of dependency and the quality of governance arrangements critically shape outcomes.

Corridors characterized by balanced interdependence and coordinated governance are more likely to support sustained cooperation. In contrast, systems marked by strong asymmetry and limited coordination may generate instability or strategic vulnerability.

6. Methodological approach

6.1 Mechanism-based analytical strategy

This study adopts a mechanism-based analytical approach to examine how infrastructure architecture may influence political stabilization in multi-state corridor systems. Mechanism-based explanation focuses on identifying the underlying processes through which structural conditions generate observable outcomes (Hedstrom & Ylikoski, 2010). Rather than attempting to estimate causal effects through large-scale statistical identification, this approach seeks to clarify the intermediate mechanisms linking explanatory variables to outcomes.

In the context of cross-border infrastructure systems, this approach is particularly appropriate. Infrastructure corridors involve complex interactions among physical networks, institutional arrangements, and geopolitical dynamics that evolve over long time horizons. These systems are characterized by multiple actors and long investment cycles, making purely econometric approaches difficult to apply in early stages of research.

The objective of this study is to develop and illustrate a structured analytical framework explaining how infrastructure design may reshape the incentive structures governing interstate cooperation.

6.2. Analytical model operationalization

To operationalize the conceptual framework developed in this article, the model identifies six analytical variables describing the structural and institutional characteristics of cross-border infrastructure systems.

The first group of variables captures the structural architecture of the corridor system: Infrastructure Interdependence Depth (IID), Node Deployment and Anchoring (NDA), and the Atlantic Embeddedness Index (AEI). These variables describe how infrastructure networks generate interdependence across territorial, industrial, and international economic dimensions.

The second group of variables represents the mediating mechanisms linking infrastructure architecture to political stabilization outcomes: Defection Cost (DC) and Governance Coupling Intensity (GCI). These mechanisms capture how infrastructure interdependence influences the incentives of participating states by increasing the economic and political costs associated with unilateral disruption.

Finally, the model includes two outcome variables describing corridor governance stability: Renegotiation Probability (RP) and Political Stabilization (PS). These variables reflect the durability of cooperative governance arrangements associated with infrastructure systems.

Operationalization of Composite Indices

To reduce potential subjectivity in the interpretation of the analytical variables, the main structural indices used in this study are operationalized through simplified composite indicators derived from observable infrastructure characteristics. These indices do not aim to provide precise econometric measurement but rather to ensure transparent and replicable approximation of the conceptual constructs introduced in the analytical framework.

Infrastructure Interdependence Depth (IID) is operationalized as a normalized composite index combining three structural dimensions of corridor architecture: corridor length, number of participating countries, and transmission capacity.

$$IID = (Ln + Cn + Kn)/3$$

where:

Ln represents the normalized corridor length

Cn represents the normalized number of participating countries

Kn represents the normalized transmission capacity

This formulation captures the degree to which infrastructure systems generate territorial reach, operational scale, and multi-state entanglement.

Node Deployment and Anchoring (NDA) is approximated through a composite indicator capturing the degree of domestic industrial integration and the presence of corridor-linked economic nodes.

$$NDA = (Industrial\ Node\ Density + Domestic\ Offtake\ Integration)/2$$

Atlantic Embeddedness Index (AEI) captures the extent to which the corridor is embedded within broader international economic networks.

$$AEI = (Export\ Market\ Integration + Maritime\ Connectivity + International\ Investor\ Participation)/3$$

Finally, Renegotiation Probability (RP) is approximated using documented evidence of governance instability across operational corridors, including supply interruptions, contractual renegotiations, regulatory disputes, and geopolitical disruptions.

These indices should therefore be interpreted as analytical approximations designed to support theory-building rather than precise econometric measurement.

The construction of these composite indices follows established practices in infrastructure and development studies, where complex multidimensional phenomena are approximated through normalized indicator-based frameworks.

6.3. Empirical illustration strategy

The empirical component of this study follows a theory-building illustration strategy. Rather than attempting a full econometric test of the proposed model, the analysis combines a detailed case illustration with a comparative dataset of cross-border energy corridors.

The Nigeria-Morocco Gas Pipeline is used as an empirical anchor to illustrate how infrastructure architecture may generate structural interdependence and systemic embeddedness among participating states. This case demonstrates the plausibility of the mechanisms identified in the analytical framework.

In addition, the study introduces a comparative dataset of cross-border energy corridors representing multiple geopolitical regions. By comparing variations in infrastructure architecture across corridor systems, the dataset provides exploratory empirical insights into the relationship between infrastructure interdependence and governance stability.

This mixed strategy, combining mechanism-based theorization, case illustration, and comparative corridor analysis, allows the study to bridge conceptual modeling with empirical observation. It also provides a foundation for future research aimed at testing the proposed stabilization mechanisms using larger datasets and more detailed governance indicators.

7. Theoretical contribution

This article advances the study of cross-border infrastructure systems by proposing a structural framework explaining how infrastructure architecture may contribute to political stabilization in multi-state corridor systems. While existing scholarship has extensively examined infrastructure corridors in terms of logistics performance, trade facilitation, and infrastructure finance, comparatively limited attention has been devoted to the ways in which infrastructure architecture itself may reshape the political dynamics governing interstate cooperation.

7.1. Infrastructure as a generator of political stabilization

First, the article reconceptualizes infrastructure systems as potential generators of political stabilization rather than passive assets operating within pre-existing political environments. The existing literature implicitly assumes that political stability constitutes a prerequisite for successful infrastructure investment. By contrast, the framework proposed in this study suggests that infrastructure architecture itself may contribute to generating political stabilization under certain structural conditions. When infrastructure corridors create deep economic interdependence and sustained institutional coordination among participating states, they may reshape the incentive structures governing interstate cooperation.

7.2. Extending interdependence theory through infrastructure networks

Second, the article introduces the concept of the Interdependence-by-Infrastructure Mechanism (IIM). Classical theories of international interdependence have primarily focused on trade and financial linkages as sources of mutual dependence among states (Keohane & Nye, 1977). The IIM framework extends this perspective by highlighting the role of physical infrastructure systems in generating durable forms of structural interdependence. Infrastructure networks possess characteristics such as geographical fixity, high capital intensity, and long operational lifecycles that embed economic cooperation within material systems.

7.3. Systemic embeddedness and infrastructure irreversibility

Third, the article introduces Atlantic Embeddedness for Irreversibility (AEI) as a complementary mechanism explaining how infrastructure systems may acquire structural stability through integration within broader economic and geopolitical networks. The AEI concept highlights how infrastructure corridors may progressively integrate into international commodity markets, global financial networks, and transnational production systems. As this integration deepens, the economic consequences of infrastructure disruption extend across multiple sectors and jurisdictions.

7.4. Toward a structural theory of infrastructure stabilization

Taken together, these contributions advance a structural perspective on infrastructure governance. By integrating the Interdependence-by-Infrastructure Mechanism with Atlantic Embeddedness for Irreversibility, the analytical framework developed in this article identifies the pathways through which infrastructure architecture may influence renegotiation dynamics and the long-term stability of cross-border infrastructure cooperation. More broadly, the study contributes to a growing research agenda examining the geopolitical and institutional implications of global infrastructure development.

8. Analytical scenario exploration framework for corridor governance

8.1. From analytical model to scenario-based exploration

Beyond its theoretical contribution, the Infrastructure-Induced Political Stabilization Model (IIPSM) can be extended as a structured analytical tool for exploring how alternative infrastructure configurations may shape governance outcomes in transnational corridor systems.

Rather than constituting a fully computational simulation, this section develops a scenario-based analytical framework that allows systematic comparison of stylized infrastructure configurations. The objective is to examine how variations in corridor design influence interdependence formation, governance coupling, and ultimately political stabilization.

This approach is particularly relevant in early-stage infrastructure planning, where decision-makers must evaluate alternative configurations under conditions of uncertainty and limited empirical data

8.2. Analytical mapping of scenario variables

The framework builds directly on the structural and mediating variables introduced in the analytical model:

- Infrastructure Interdependence Depth (IID) captures the territorial and operational entanglement of the system;
- Node Deployment and Anchoring (NDA) reflects the degree of domestic industrial integration along the corridor;
- Embeddedness (AEI) captures integration into broader international economic systems;
- Defection Cost (DC) and Governance Coupling Intensity (GCI) represent the key mediating mechanisms;
- Renegotiation Probability (RP) and Political Stabilization (PS) capture governance outcomes.

Within this framework, infrastructure design choices are interpreted as configurational inputs that influence these variables and their interactions.

8.3. Scenario logic: Infrastructure design as strategic choice

The analytical framework conceptualizes infrastructure corridors as the outcome of strategic design choices across three key dimensions:

1. Territorial configuration (number of participating states, routing complexity);
2. Domestic economic integration (extent of local offtake and industrial anchoring);
3. External embedding (integration into international markets and logistics systems).

Different combinations of these dimensions generate distinct interdependence structures, which in turn shape governance dynamics.

The framework allows analysts to explore how alternative configurations influence:

- the distribution of dependency;
- the magnitude of defection costs;
- the intensity of governance coordination;
- the likelihood of renegotiation or disruption.

8.4. Comparative scenario exploration

To illustrate the analytical potential of the framework, two stylized corridor configurations are considered.

8.4.1. Scenario A: Multi-state terrestrial corridor with strong domestic anchoring

This configuration involves a corridor crossing multiple national territories, combined with significant domestic integration and industrial node development along the route.

- High IID due to multi-country territorial entanglement;
- High NDA reflecting strong domestic economic dependence;
- Moderate to high AEI, depending on external market integration;
- High DC, as disruption affects multiple states and domestic industries;
- High GCI, due to the need for sustained multi-level coordination.

This configuration is expected to generate strong stabilization dynamics, provided that governance mechanisms remain sufficiently robust to manage coordination complexity.

8.4.2. Scenario B: Offshore backbone with limited domestic integration

This configuration reduces the number of transit states by relying on offshore infrastructure and prioritizes direct connection between supply and export markets.

- Moderate IID, due to reduced territorial complexity;
- Low NDA, as domestic integration remains limited;
- High AEI, reflecting strong integration into international markets;
- Moderate DC, driven primarily by external market dependence;
- Lower GCI, as fewer jurisdictions are involved.

This configuration may reduce governance complexity but generate weaker domestic interdependence, potentially limiting stabilization effects despite strong external embedding.

8.5. Comparative implications

The comparison highlights a central implication of the analytical framework:

Infrastructure design involves a trade-off between depth of interdependence and governance complexity.

- Configurations with high IID and NDA generate stronger stabilization potential but require robust governance structures;
- Configurations emphasizing AEI over domestic anchoring may achieve efficiency and market integration but generate weaker internal stabilization dynamics.

This suggests that optimal corridor design is not purely a function of economic efficiency but also of institutional capacity and political coordination.

8.6. Interpretation and analytical scope

The scenario-based framework developed in this section should be interpreted as a conceptual decision-support tool rather than a predictive simulation model.

Its purpose is to:

- clarify the structural implications of infrastructure design choices;
- identify key trade-offs in corridor configuration;
- provide a structured basis for comparative analysis.

Future research may extend this framework through computational simulation techniques such as system dynamics modeling or agent-based approaches, enabling more precise evaluation of infrastructure governance dynamics over time.

The Nord Stream scenarios provide a critical illustration of the limits of infrastructure-induced stabilization. Despite high levels of infrastructure interdependence (IID) and strong external embeddedness (AEI), the absence of significant domestic anchoring (low NDA), combined with asymmetric dependency structures and geopolitical escalation, leads to elevated renegotiation probability and reduced political stabilization.

This case highlights a central implication of the analytical framework: interdependence alone is not sufficient to ensure stabilization. Rather, the stabilizing effects of infrastructure depend on the distribution of dependency, the presence of robust governance mechanisms, and the degree of domestic economic integration. When these conditions are not met, infrastructure systems may shift from stabilizing arrangements to sources of strategic vulnerability.

The implications of these configurations are further illustrated through a parametric scenario analysis of the Nord Stream system, as presented in **Table 2**.

Table 2. Parametric Scenario Simulation: Nord Stream 1/2.

Scenario	IID	NDA	AEI	GCI	ASYM	Geopolitical Shock	Expected RP	Expected PS	Interpretation
Scenario 1: Normal operation	High	Low	High	Medium	Medium	Low	Low–Medium	Medium–High	Strong infrastructure and market embeddedness support stability under normal conditions.
Scenario 2: Asymmetric dependence	High	Low	High	Medium	High	Medium	Medium–High	Medium–Low	Interdependence becomes vulnerable when dependency is uneven and supply control is concentrated.
Scenario 3: Geopolitical rupture/sabotage	High	Low	High	Low	High	Very High	Very High	Very Low	Extreme geopolitical shocks override stabilizing effects of interdependence and embeddedness.

9. Boundary conditions and potential failure cases

9.1. Boundary conditions and structural limits of infrastructure-induced stabilization

While the analytical framework and scenario exploration developed in Section 8 demonstrate how infrastructure configurations may generate political stabilization, these effects are inherently conditional. The relationship between infrastructure architecture and political stabilization depends on the interaction between structural variables, Infrastructure Interdependence Depth (IID), Node Deployment and Anchoring (NDA), Atlantic Embeddedness (AEI), and Governance Coupling Intensity (GCI), and contextual variables such as asymmetry (ASYM) and geopolitical shocks (GS).

9.2 Interdependence distribution and asymmetry (IID, ASYM)

The stabilizing effect of infrastructure interdependence depends not only on its intensity (IID) but also on its distribution across participating actors. When IID is unevenly distributed, asymmetry (ASYM) increases, altering the functional role of interdependence.

When ASYM exceeds moderate levels:

- interdependence ceases to operate as a mutual constraint mechanism;
- highly dependent actors face increased exposure to supply disruption;
- less dependent actors retain strategic flexibility and leverage.

Under these conditions, the system transitions from reciprocal interdependence to asymmetric dependence, increasing renegotiation probability (RP) and reducing political stabilization (PS).

9.3. Governance coupling under geopolitical stress (GCI, GS)

Governance Coupling Intensity (GCI) is a central mediating variable linking infrastructure design to stabilization outcomes. However, its effectiveness depends on its resilience to external shocks.

When geopolitical shocks (GS) increase:

- coordination costs rise;
- institutional trust deteriorates;
- enforcement mechanisms weaken.

If GCI is insufficiently robust relative to GS, governance coordination may collapse, even in systems characterized by high IID. In such cases, infrastructure interdependence amplifies systemic exposure rather than stabilizing cooperation.

9.4. Institutional capacity and operationalization of GCI

The level of GCI is itself conditioned by the institutional capacity of participating states. Weak institutional environments constrain the ability to sustain coordination, enforce agreements, and manage complex interdependencies.

When institutional capacity remains low:

- GCI cannot reach levels required to sustain coordination;
- agreements remain incomplete or weakly enforced;
- long-term cooperation becomes unstable.

Thus, institutional capacity operates as an underlying constraint on the effectiveness of governance coupling, directly affecting stabilization outcomes.

9.5. Embeddedness as a dual condition (NDA, AEI)

The stabilizing mechanism further depends on the joint effect of domestic anchoring (NDA) and external embeddedness (AEI).

When NDA is low:

- domestic economic integration remains limited;
- local stakeholders have weak incentives to sustain the system;
- defection costs (DC) remain moderate.

When AEI is low:

- integration into international markets is shallow;
- long-term economic incentives for cooperation weaken.

Stabilization emerges only when NDA and AEI jointly reach sufficient levels, generating dense multi-scalar interdependence. Partial embeddedness, where one dimension is developed without the other, produces structurally fragile systems.

9.6. Systemic misalignment and structural fragility

Even when individual variables reach moderate levels, stabilization may fail if the system exhibits structural misalignment.

This occurs when:

- IID is high but NDA remains low (weak domestic anchoring);
- AEI is high but GCI remains weak (insufficient governance);
- ASYM is high despite strong interdependence.

Such configurations produce partial interdependence without systemic coherence, resulting in elevated renegotiation probability and unstable equilibrium.

9.7. Threshold dynamics and conditional stabilization

The interaction between IID, NDA, AEI, and GCI suggest the existence of threshold dynamics in the emergence of stabilization.

Stabilization is unlikely to occur when:

- IID remains low or shallow;
- NDA and AEI are insufficient to generate defection costs;
- GCI does not sustain coordination under stress.

Conversely, once these variables exceed certain critical levels, the system transitions from shallow connectivity to dense systemic entanglement, significantly increasing stabilization potential.

These thresholds should be interpreted as analytical constructs, providing a structured way to understand how incremental changes in infrastructure design may produce non-linear governance effects.

9.8. Analytical formalization of boundary conditions

The conditional nature of infrastructure-induced stabilization can be expressed in a simplified functional form:

$$PS = f(IID, NDA, AEI, GCI, -ASYM, -GS)PS = f(IID, NDA, AEI, GCI, -ASYM, -GS)PS = f(IID,NDA,AEI,GCI,-ASYM,-GS)$$

where:

- political stabilization (PS) increases with IID, NDA, AEI, and GCI;
- and decreases with asymmetry (ASYM) and geopolitical shocks (GS).

The model implies that stabilization emerges only when the combined effect of interdependence, embeddedness, and governance coupling exceeds a critical threshold, while asymmetry and external shocks remain within manageable bounds.

9.9. Synthesis: Conditional and non-linear nature of stabilization

Taken together, these boundary conditions indicate that infrastructure-induced stabilization is neither automatic nor linear. It depends on the alignment and interaction of multiple structural and contextual variables.

The framework suggests that:

- interdependence alone is insufficient for stabilization;
- embeddedness and governance are necessary complements;
- imbalance, weak institutions, or external shocks may reverse stabilizing dynamics.

This conditional perspective provides a more precise understanding of when infrastructure corridors function as stabilizing mechanisms and when they become sources of vulnerability.

The transition from shallow interdependence to dense systemic entanglement can be conceptualized as a threshold dynamic, as illustrated in **Figure 2**.

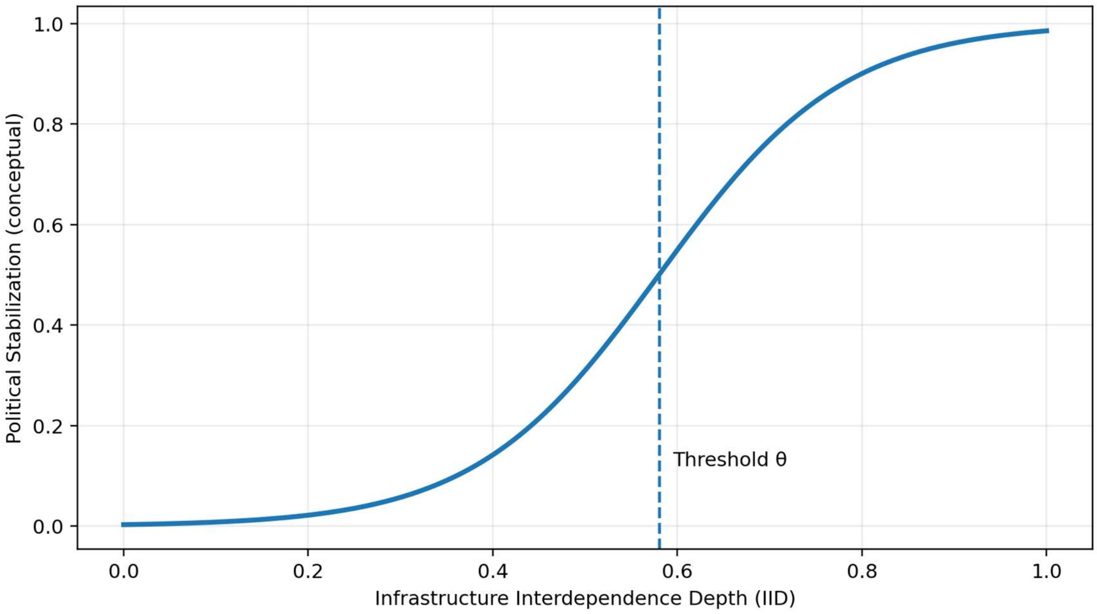

Figure 2. Conceptual threshold dynamic: once IID exceeds theta, stabilizing effects intensify.

The threshold logic is interpretive rather than econometric. It is included to formalize the expectation that stabilizing effects become stronger once infrastructure systems move from shallow connectivity to dense systemic entanglement.

10. Exploratory empirical analysis of cross-border energy corridors

10.1 Dataset construction

To complement the conceptual framework developed in the previous sections, this study introduces an exploratory comparative dataset of major cross-border energy corridors. The objective of this dataset is not to provide a definitive causal test, but to examine whether the structural relationships proposed in the Infrastructure-Induced Political Stabilization framework are consistent with observable patterns across real-world infrastructure systems.

The dataset was constructed using publicly available infrastructure information compiled from several international sources, including the Global Energy Monitor Global Gas Infrastructure Tracker, the Energy Institute Statistical Review of World Energy, and World Bank infrastructure documentation. These sources provide detailed information on pipeline length, transmission capacity, participating countries, and governance arrangements.

The dataset focuses on large-scale cross-border pipeline systems connecting multiple national energy markets. Such infrastructure systems require sustained coordination among participating states and therefore constitute relevant empirical cases for exploring the relationship between infrastructure architecture and corridor governance stability.

The boundary conditions and failure mechanisms of infrastructure-induced stabilization are summarized in **Table 3**.

Table 3. Boundary Conditions and Failure Mechanisms of Infrastructure-Induced Stabilization.

Dimension	Variable(s)	Critical Condition	Failure Mechanism	Observable Indicators / Proxies	Expected Effect on RP / PS
Interdependence Structure	IID + ASYM	High IID combined with high ASYM	Uneven dependency distribution transforms interdependence into strategic leverage	Dependency ratios (imports/consumption); concentration of supply control; bilateral asymmetry indices	↑ RP (renegotiation); ↓ PS (stabilization)
Governance Robustness	GCI + GS	GCI insufficient relative to GS	Governance breakdown under geopolitical stress weakens coordination and enforcement	Frequency of disputes; crisis episodes; existence/effectiveness of joint governance institutions	↑ RP; ↓ PS (especially under shocks)
Institutional Capacity	GCI (structural determinant)	Structurally low GCI due to weak institutions	Inability to sustain coordination and enforce agreements over time	Governance indicators; regulatory stability; administrative capacity metrics	Moderate to high RP; low PS
Domestic Embeddedness	NDA	Low NDA despite moderate/high IID	Limited domestic integration reduces defection costs and stakeholder commitment	Number of industrial nodes; domestic offtake share; sectoral integration along corridor	Moderate RP; weak PS (reversible cooperation)
External Embeddedness	AEI	Low AEI	Weak integration into global markets reduces long-term cooperation incentives	Export connectivity; integration into global energy markets; logistics/port connectivity	Moderate RP; limited PS
Systemic Configuration	IID + NDA + AEI + GCI	Misalignment across core variables	Partial interdependence without systemic coherence generates structural fragility	Divergence between infrastructure scale and domestic/external integration; governance gaps	High RP; unstable PS
Shock Sensitivity	GS + ASYM	High GS combined with high ASYM	External shocks amplify asymmetrical vulnerabilities and accelerate breakdown	Conflict intensity; sanctions; sabotage events; geopolitical tension indices	Very high RP; very low PS
Threshold Dynamics	IID + NDA + AEI + GCI	Sub-critical levels across variables	Interdependence remains shallow and insufficient to generate stabilizing effects	Low infrastructure density; weak cross-border integration; limited coordination mechanisms	

10.2 Operationalization of analytical variables

To translate the conceptual framework into an empirical structure, the core analytical variables are operationalized through a set of proxy indicators derived from available infrastructure and governance data. Given the exploratory nature of the dataset, these indicators should be interpreted as approximations rather than precise measurements.

Infrastructure Interdependence Depth (IID) is approximated through a composite index combining the number of participating countries, infrastructure length, and transmission capacity. This composite captures both the territorial reach and the structural intensity of the corridor system.

Node Deployment and Anchoring (NDA) reflects the degree of domestic economic integration along the corridor. It is approximated using available information on industrial nodes, domestic offtake structures, and the spatial distribution of energy-intensive activities connected to the infrastructure.

Atlantic Embeddedness (AEI) captures the extent to which corridor systems are integrated into global energy markets and international economic networks. This variable is approximated through indicators such as export orientation, connectivity to international markets, and integration into global energy supply chains.

Renegotiation Probability (RP) is used as a proxy for governance instability. It is approximated through documented cases of disputes, supply interruptions, regulatory conflicts, and contract renegotiations affecting corridor operations.

Political Stabilization (PS), as the outcome variable, reflects the durability of cooperative governance arrangements associated with corridor infrastructure. Given the complexity of directly measuring stabilization, PS is interpreted indirectly through the inverse relationship with RP and the persistence of coordinated operation over time.

While contextual variables such as asymmetry (ASYM) and geopolitical shocks (GS) are not directly quantified in this dataset, their effects are partially reflected in observed renegotiation dynamics and instability patterns.

Importantly, this operationalization is consistent with the boundary conditions identified previously, where the interaction between interdependence, embeddedness, governance capacity, and contextual stress factors determines stabilization outcomes.

10.3. Comparative insights

Preliminary comparison across the dataset suggests the existence of structured associations between infrastructure configuration and governance outcomes, particularly between Infrastructure Interdependence Depth (IID) and renegotiation probability (RP). Corridors such as the Central Asia-China pipeline, the Southern Gas Corridor, and the Power of Siberia system combine relatively high IID values with lower renegotiation probabilities. By contrast, corridors characterized by lower levels of infrastructure interdependence appear more vulnerable to governance instability. The West African Gas Pipeline, for example, exhibits relatively low IID and AEI values and has experienced several episodes of supply disruption and governance challenges. This configuration illustrates how limited interdependence and weak embeddedness reduce defection costs and weaken incentives for sustained cooperation.

These observations are consistent with the theoretical expectations derived from the Interdependence-by-Infrastructure Mechanism. Deeper infrastructure interdependence appears to increase the costs associated with defection and therefore strengthens incentives for sustained cooperation among participating states. Because the comparative dataset is exploratory and includes both operational and proposed corridors, it should be interpreted as pattern-oriented evidence rather than as a definitive causal test.

Table 4 presents the exploratory comparative dataset of cross-border energy corridors used to examine the relationship between infrastructure configuration and governance outcomes.

Table 4. Exploratory comparative dataset of cross-border energy corridors.

Corridor	**Region**	**IID**	**NDA**	**AEI**	**RP**
Nord Stream	Europe	0.72	0.20	0.85	0.50
TurkStream	Europe	0.65	0.30	0.80	0.35
Blue Stream	Europe	0.58	0.30	0.75	0.25
Yamal-Europe	Europe	0.70	0.35	0.82	0.40
Druzhba Pipeline	Europe	0.82	0.50	0.83	0.40
Southern Gas Corridor	Eurasia	0.77	0.50	0.84	0.25
TANAP	Eurasia	0.65	0.45	0.82	0.20
TAP	Europe	0.55	0.40	0.80	0.25
South Caucasus Pipeline	Eurasia	0.60	0.35	0.78	0.25
Baku-Tbilisi-Ceyhan	Eurasia	0.60	0.45	0.78	0.20
Central Asia-China Pipeline	Asia	0.81	0.45	0.78	0.20
Power of Siberia	Asia	0.75	0.40	0.82	0.20
Kazakhstan-China Pipeline	Asia	0.70	0.40	0.80	0.25
Myanmar-China Pipeline	Asia	0.68	0.35	0.75	0.30
ESPO Pipeline	Asia	0.72	0.35	0.82	0.25
Maghreb-Europe Pipeline	Africa-Europe	0.63	0.40	0.80	0.50
Medgaz	Africa-Europe	0.55	0.30	0.80	0.30
West African Gas Pipeline	Africa	0.38	0.30	0.45	0.75
Nigeria-Morocco Pipeline	Africa	0.88	0.70	0.85	NA
Trans-Saharan Pipeline	Africa	0.70	0.40	0.75	NA
East African Crude Oil Pipeline	Africa	0.62	0.35	0.70	0.35
Chad-Cameroon Pipeline	Africa	0.55	0.35	0.65	0.40
Arab Gas Pipeline	Middle East	0.60	0.35	0.70	0.60
EastMed Pipeline	Mediterranean	0.66	0.35	0.82	NA
Trans Mountain Expansion	North America	0.65	0.45	0.85	0.30
ESPO Pipeline	Asia	0.72	0.35	0.82	0.25
Maghreb-Europe Pipeline	Africa-Europe	0.63	0.40	0.80	0.50
Medgaz	Africa-Europe	0.55	0.30	0.80	0.30
West African Gas Pipeline	Africa	0.38	0.30	0.45	0.75
Nigeria-Morocco Pipeline	Africa	0.88	0.70	0.85	NA
Trans-Saharan Pipeline	Africa	0.70	0.40	0.75	NA
East African Crude Oil Pipeline	Africa	0.62	0.35	0.70	0.35
Chad-Cameroon Pipeline	Africa	0.55	0.35	0.65	0.40

Arab Gas Pipeline	Middle East	0.60	0.35	0.70	0.60
EastMed Pipeline	Mediterranean	0.66	0.35	0.82	NA
Trans Mountain Expansion	North America	0.65	0.45	0.85	0.30

Note. RP is unavailable for proposed or not-yet-operational corridors and is therefore marked NA. The dataset is intended as exploratory pattern-oriented evidence rather than a definitive causal test.

The relationship between infrastructure interdependence and governance instability can be further explored through a correlation-based visualization, as shown in **Figure 3**.

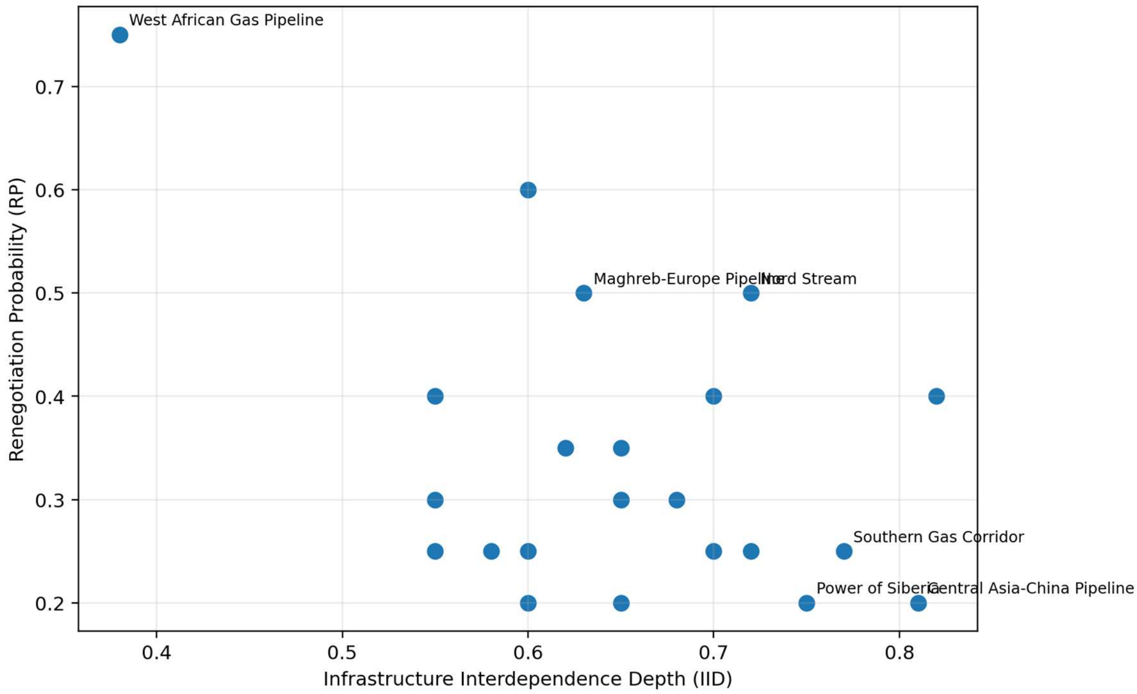

Figure 3. Exploratory association between IID and RP across operational corridors in the comparative dataset.

Preliminary Correlation Analysis

To explore the relationship between infrastructure architecture and governance stability, a preliminary correlation analysis was conducted across operational corridors included in the comparative dataset.

Table 5 reports pairwise correlations between the core structural variables and renegotiation probability.

Table 5. correlations between the core structural variables and renegotiation probability.

Variable	IID	NDA	AEI	RP
IID	1			
NDA	0.52	1		
AEI	0.61	0.55	1	
RP	−0.58	−0.42	−0.63	1

The results indicate a negative association between Infrastructure Interdependence Depth (IID) and renegotiation probability (RP). Corridors characterized by higher IID values tend to exhibit lower governance instability. Similarly, stronger international embeddedness appears to correlate with lower renegotiation risk. Similarly, Atlantic Embeddedness (AEI) exhibits a strong negative association with RP, suggesting that integration into broader international systems reinforces stabilization dynamics.

These correlations should be interpreted with caution and do not imply causal relationships. Rather, they highlight structural patterns consistent with the analytical framework and the boundary conditions identified in Section 9.

Overall, the exploratory empirical analysis provides initial support for the theoretical framework developed in this study. While not constituting a definitive causal test, the observed patterns suggest that infrastructure interdependence, embeddedness, and governance conditions jointly shape the stability of cross-border energy corridors. These findings reinforce the argument that infrastructure architecture plays a central role in structuring the conditions under which interstate cooperation becomes more or less durable.

11. Conclusion

This study has developed a conceptual and exploratory empirical framework linking infrastructure architecture to political stabilization in cross-border energy corridors. By introducing the Infrastructure-Induced Political Stabilization model, the paper demonstrates that large-scale infrastructure systems are not neutral economic assets but structured configurations that shape the conditions under which interstate cooperation emerges and persists.

The analysis highlights that infrastructure-induced interdependence operates through a set of interacting mechanisms. Infrastructure Interdependence Depth (IID), domestic anchoring (NDA), and external embeddedness (AEI) jointly contribute to increasing defection costs and reinforcing incentives for sustained coordination. However, the study also shows that these stabilizing effects are conditional. As demonstrated through the boundary conditions and failure configurations, interdependence does not automatically produce stability. Asymmetry in dependency structures, weak governance capacity, limited embeddedness, and geopolitical shocks may transform infrastructure systems into sources of vulnerability rather than stabilization.

The exploratory empirical analysis provides initial support for this framework. While not constituting a definitive causal test, the observed patterns across cross-border energy corridors are consistent with the theoretical expectations developed in the paper. In particular, higher levels of interdependence and embeddedness are associated with lower renegotiation risks, while weaker or unbalanced configurations exhibit greater instability. These findings reinforce the argument that infrastructure design plays a central role in structuring governance outcomes.

This paper contributes to the literature in three main ways. First, it extends interdependence theory by introducing infrastructure architecture as a structuring variable influencing political stabilization. Second, it integrates insights from infrastructure governance and political economy by conceptualizing corridors as multi-level systems combining physical, economic, and institutional dimensions.

Third, it provides a structured analytical framework that can support comparative analysis and future empirical investigation of cross-border infrastructure systems, particularly in non-Western contexts where such corridors are rapidly expanding.

From a policy perspective, the findings suggest that infrastructure planning should not be guided solely by efficiency or cost considerations. The distribution of dependency, the degree of domestic integration, and the strength of governance arrangements are critical factors shaping long-term stability. Corridor design represents not only an economic choice but also a strategic governance decision.

Finally, this study opens several avenues for future research. Further work may extend the framework through mixed-method approaches, including process tracing, stakeholder interviews, and in-depth case studies of specific corridors. Quantitative extensions using panel data or simulation-based modeling could also provide a more precise evaluation of the mechanisms identified in this study. Such developments would contribute to strengthening the empirical foundations of the relationship between infrastructure architecture and political stabilization.

Conflict of interest: The authors declare they have no competing interests.

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