TIR as a Complementary Governance Mechanism in Seaport–Dry Port Multimodal Corridors under the Maritime Silk Road

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Abstract: This paper conceptualises the Transports Internationaux Routiers (TIR) system as a complementary governance mechanism in seaport–dry port multimodal corridors under the Maritime Silk Road. The paper argues that TIR can alleviate selected coordination failures at customs, institutional, digital and resilience interfaces. The research constructs a corridor-level analytical framework and qualitatively anchors the analysis in China–Central Asia corridor developments. The paper makes three contributions. To begin with, it outlines the boundary conditions in which TIR can be beneficial to seaport-dry port systems. Second, it clarifies the reason why TIR is to be conceptualized as an interface-governance tool that is complementary to maritime and rail scale economies. Third, it elucidates managerial implications for the planners of the corridors, port authorities, dry ports, customs administrations and platform operators who aim to achieve scale, reliability and flexibility in the new Eurasian corridors.

Keywords:TIR; Seaport–Dry Port Corridor; Maritime Silk Road; Multimodal Transport; Complementary Governance; Dry Port.

Аннотаци: В данной статье система международных маршрутных перевозок (TIR) рассматривается как дополнительный механизм управления в мультимодальных коридорах «морской порт — сухой порт» в рамках Морского Шелкового пути. В статье утверждается, что TIR может смягчить некоторые проблемы координации на таможенном, институциональном, цифровом уровнях и в контексте устойчивости. В исследовании построена аналитическая

структура на уровне коридора, а качественный анализ основан на развитии коридора Китай — Центральная Азия. Статья вносит три вклада. Во-первых, она описывает граничные условия, при которых TIR может быть полезен для систем «морской порт — сухой порт». Во-вторых, она разъясняет причину, по которой TIR следует рассматривать как инструмент управления, дополняющий масштабную экономию морских и железнодорожных перевозок. В-третьих, она разъясняет управленческие последствия для планировщиков коридоров, портовых властей, сухих портов, таможенных администраций и операторов платформ, стремящихся к достижению масштаба, надежности и гибкости в новых евразийских коридорах.

Ключевые слова: TIR; Коридор «морской порт — сухой порт»; Морской Шелковый путь; Мультимодальные перевозки; взаимодополняющее управление; сухой порт

Annotatsiya: Ushbu maqola Transports International Routiers (TIR) tizimini Dengiz Ipak yo'li bo'ylab dengiz porti-quruq port multimodal yo'laklarida qo'shimcha boshqaruv mexanizmi sifatida ko'rib chiqadi. Maqolada TIR bojxona, institutsional, raqamli va moslashuvchanlik interfeyslaridagi tanlangan muvofiqlashtirishdagi kamchiliklarni bartaraf etishi mumkinligi ta'kidlangan. Tadqiqot koridor darajasidagi analitik asosni yaratadi va tahlilni Xitoy-Markaziy Osiyo yo'laklari rivojlanishida sifat jihatidan mustahkamlaydi. Maqolada uchta hissa qo'shiladi. Avvalo, u TIR dengiz porti-quruq port tizimlari uchun foydali bo'lishi mumkin bo'lgan chegara sharoitlarini bayon qiladi. Ikkinchidan, u TIRni dengiz va temir yo'l miqyosidagi iqtisodiyotga qo'shimcha bo'lgan interfeys-boshqaruv vositasi sifatida ko'rib chiqish sababini aniqlaydi. Uchinchidan, u yangi Yevroosiyo yo'laklarida miqyos, ishonchlilik va moslashuvchanlikka erishishga intilayotgan yo'laklarni rejalashtiruvchilar, port ma'muriyatlari, quruq portlar, bojxona ma'muriyatlari va platforma operatorlari uchun boshqaruv oqibatlarini tushuntiradi.

Kalit so'zlar: TIR; Dengiz porti-quruq port yo'lagi; Dengiz Ipak yo'li; Multimodal transport; Qo'shimcha boshqaruv; Quruq port.

1. Introduction

Eurasian freight systems are rapidly coming to rely on corridor governance, rather than on physical transport capacity. Maritime gateways, railways, inland dry ports, road carriers, customs administration and digital logistics platforms are connected across different institutional boundaries. Here, the investment in infrastructure is one of the factors that determine the performance of a corridor. The other factor is the capacity to coordinate procedures, information and responsibilities of modes and jurisdictions.

Dry ports have been examined as port extensions inland, consolidation and customs points, and devices to alleviate congestion at busy coastal ports. At the same time, trade facilitation research shows that border time, documentary complexity and procedural uncertainty can operate as significant trade barriers. TIR is relevant to this interface because it provides a recognised customs-transit logic for the international road leg and can support a more continuous door-to-door chain when aligned with maritime, rail and inland-node coordination.

The paper asks: how can TIR be conceptualised as a complementary governance mechanism in seaport–dry port multimodal corridors? The answer developed here is deliberately bounded. TIR is not presented as a universal replacement for rail, sea transport or dry port platforms. Its value lies in supporting selected corridor interfaces where a flexible road leg, predictable customs transit and cross-border procedural continuity can reduce coordination failures.

The contribution is therefore conceptual and managerial. The paper synthesises peer-reviewed work on dry ports, port governance, trade facilitation, supply chain integration and resilience, then translates that literature into an analytical framework for TIR complementarity. The argument is especially relevant to Maritime Silk Road corridors where seaports and inland hubs must connect large-scale maritime and rail services with dispersed, time-sensitive and institutionally complex inland flows.

2. Literature Review and Analytical Gap

2.1 Seaport regionalization and dry port development

Seaport regionalization research provides the first foundation for this paper. Notteboom and Rodrigue (2005) argued that port development evolves beyond the

port perimeter toward wider hinterland integration. In that process, inland nodes and corridor connections become part of the competitive structure of maritime gateways. Dry port studies extend this logic by showing how inland terminals, logistics hubs and port-centric strategies reshape the spatial relationship between ports and inland markets (Cullinane et al., 2012; Khaslavskaya & Roso, 2020; Monios & Wilmsmeier, 2012; Nguyen & Notteboom, 2019; Varese et al., 2020).

The weakness is that dry port studies tend to consider customs transit as a backdrop situation as opposed to a regime. A dry port can support consolidation and storage and value-added logistics and rail-road interchange but cannot perform its corridor role without the reliability of the legal and procedural chain. This is where TIR comes in to play an analytical role.

2.2 Governance, collective action and integration

The second foundation is governance and collective action. The study conducted by De Langen and Visser (2005) demonstrated that seaport clusters use collective action regimes since individual companies cannot solve common infrastructure, information and coordination issues individually. Governance arrangements that are conducive to both commercial competition and collective efficiency (Song, 2003), and the port governance of China demonstrates how the institutional layering of corridors can evolve over the years (Notteboom & Yang, 2017).

There are varied objectives of corridor actors. The seaport operator wants throughput and hinterland access, the dry port wants cargo concentration and service enhancement, the road carrier wants flexibility and asset utilisation, the rail operator wants scale and predictability, the customs authority wants compliance and risk management. A mechanism of governance is important in minimizing the incompatibility of these objectives without compelling a mode or a single power to have control of the corridor.

It is particularly acute in the case of the collective-action problem when the corridors cross the jurisdictions and control points. In these contexts, TIR could be considered not only as the document of transportation, but as the institutional tool

that standardises some of the transit process and provides a higher predictability in the coordination of the commercial and public actors.

2.3 Trade facilitation, logistics performance and time

Trade facilitation studies provide a reason as to why soft infrastructure is important. Bilateral trade is affected by port efficiency and maritime transport costs (Clark et al., 2004), trade performance is directly impacted by time delays (Djankov et al., 2010; Hummels & Schaur, 2013), and an upgrade of the transit system can also lead to improved trade by mitigating the effects of border-processing frictions (Carballo et al., 2024). Reliability, quality of services and administrative potentials are also ways that logistics performance influences trade (Hausman et al., 2013; Zaninović & Bugarčić, 2023).

This strand of research confirms the main assumption of the paper: the importance of transit arrangements as not secondary administrative information. Provided that the international road leg is still procedurally unclear, port efficiency, rail capacity and dry port investment benefits may be compromised at the border and documentation interfaces.

According to Portugal-Perez and Wilson (2009), both transport infrastructure and information technology have an impact on the performance of exports. This confirms the impression that the possible contribution of TIR is not only physical mobility; but the integration of simplification of procedures, control of risks and coordination of information.

2.4 Resilience and digital interoperability

The fourth foundation is resilience and digitalization. Supply chain resilience research argues that viable systems need redundancy, visibility and adaptive capacity (Ivanov & Dolgui, 2020). Digital supply chain research further emphasises that visibility and data integration can reduce disruption risks when decision makers can access timely and trusted information (Ivanov & Dolgui, 2021). In the specific TIR context, Liao et al. (2023) also show that TIR-based sea-road multimodal logistics can be discussed through resilience improvement and risk-management lenses.

For seaport–dry port corridors, these insights imply that TIR's role is conditional. It can add value when it improves procedural continuity, creates an alternative service option, or enables road-based information to be integrated into wider corridor-control systems. It adds less value where cargo flows are stable, high-volume and already efficiently handled by rail or maritime services.

2.5 Analytical gap

The literature review reveals a gap at the intersection of dry port studies, port governance, trade facilitation and resilience. Existing studies explain why inland ports matter, why time and logistics performance affect trade, and why digital visibility improves supply chain resilience. Less attention has been paid to how a customs-transit system such as TIR may function as a complementary governance mechanism inside seaport–dry port corridors.

Table 1. Literature streams and the analytical gap addressed by this paper

Literature stream	Core contribution	What remains under-explained for this paper
Dry ports / port regionalization	Explains inland gateway functions, hinterland extension, and terminal restructuring	Limited treatment of customs transit as an embedded corridor-governance device
Port governance / collective action	Shows why coordination, integration, and institutional layering matter	Rarely isolates customs transit systems as specific coordination mechanisms
Trade facilitation / logistics performance	Demonstrates the trade effects of time, documentation, and soft infrastructure	Usually operates at the national or macro level rather than the port–dry port corridor level
Resilience / digital logistics	Highlights redundancy, viability, and interoperability	Does not usually explain how TIR complements maritime–rail organisation in corridor design

3. Analytical Framing and Research Design

3.1 TIR as complementary governance

A governance mechanism is an institutional arrangement that reduces coordination failures among actors, procedures and information flows. From this perspective, TIR can be conceptualised as complementary because it does not create a complete corridor by itself. Rather it facilitates specific interfaces in a current

multimodal path: the road leg, the process of customs-transit, the interface to the border and the linkage between dispersed shippers and inland hubs.

This is a different framing as compared to a substitution approach. One of the substitution strategies poses the question of how fast and cheaper TIR is compared to rail. TIR can enhance the coordination of a corridor which already relies on the scale economies of the maritime, rail capacity, dry port functions and platform-based information exchange.

3.2 Five dimensions of complementarity

There are five dimensions of the analytical framework. To start with, TIR is able to decrease border friction, as it forms a more continuous logic of customs-transit. Second, it can enhance modal complementarity, through enabling flexible road segments, which link with maritime and rail services. Third, it can help in the development of inland gateways by increasing the functional range of dry ports. Fourth, it has the ability to enhance digital interoperability where road-transit data is marshalled with the port, dry port and customs platforms. Fifth, it can enhance resilience by having a back-up route to time-constrained or broken flows.

The integration of ports involves the need to have information systems, value-added services and multimodal operations (Panayides & Song, 2009). The inland ports operate based on actors and services, as opposed to location (Rodrigue et al., 2010). Barriers to supply chain integration demonstrate institutional and organisational barriers to portcentric logistics (Venkatesh et al., 2020). TIR, therefore, needs to be evaluated within the context of this broader governance system.

3.3 Research design

The design of the paper is qualitative-analytical. The former one is a critical review of peer-reviewed research to provide the conceptual boundary of TIR complementarity. The second aspect is a corridor interpretation connecting this boundary with the developments within China-Central Asia within the framework of the Maritime Silk Road. The third ingredient is translated into managerial and policy implications of the design of the corridor.

The framework does not purport that TIR necessarily enhances any given corridor. Rather, it lays down conditions under which TIR can be anticipated to be value adding. The initial one is that the corridor has a cross-border road interface which is not entirely served by rail. The second one is that the cargo segment enjoys the flexibility, time reliability or direct delivery. The third is that road-transit information can be integrated into more comprehensive corridor coordination by customs and platform systems.

4. How TIR Adds Value to Seaport–Dry Port Corridors

4.1 Border-friction reduction

The first one is border-friction reduction provided by TIR. Research on how time and documentary complexity and efficiency of ports directly impact trade (Carballo et al., 2024; Clark et al., 2004; Djankov et al., 2010; Hummels & Schaur, 2013) indicates that these two factors have direct effects on trade. These effects do not only occur in the port in a seaport-dry port corridor. They are also found at crossing the borders, at the customs-transit and in the transfer points inside the country.

TIR will solve this problem by providing the road-transit segment with a similar procedural logic. Predictability is the most important governance impact. Having the ability to plan more steady transit process, actors can devise more trustworthy pickup windows, delivery plans inland and alternative routes.

4.2 Modal complementarity

The second contribution is modal complementarity. Maritime and rail services offer scale, scheduled capacity/costs of large volumes of flow. TIR is more effective in cases where cargo is time sensitive, scattered, irregular or linked to nodes which cannot be effectively served by a single rail timetable. It thus contributes to the corridor by sealing the service gaps as opposed to substituting with the backbone modes.

This is a difference that is critical to the Maritime Silk Road. A marine gateway can be an efficient way to process the maritime leg, and a railway can be an efficient way to process the main inland leg, but the entire chain can still be afflicted by

inflexible timescales, lack of inland coverage or uncertainty at the border. TIR could offer a combined layer on those interfaces that is flexible, particularly under conditions of road transit that is synchronized with dry port services and platform visibility.

4.3 Inland gateway formation

The third contribution is with regard to inland gateway formation. Dry ports are able to offer customs assistance, merging, rail-road exchange, documentation, tracking and distribution services within a nation (Cullinane et al., 2012; Khaslavskaya & Roso, 2020; Nguyen & Notteboom, 2019; Rodrigue et al., 2010; Varese et al., 2020).

TIR would facilitate the upgrade of dry ports as it would enable linking of inland hubs to a recognised transit procedure. It particularly applies to inland nodes, which process mixed cargo, smaller consignments or customers who need their products to be delivered directly. The dry port in these instances can serve as a coordination platform that can interconnect maritime gateways, rail services, road carriers and customs-transit procedures.

4.4 Digital interoperability

The fourth contribution is digital interoperability. The modern corridors are organized with data as well as infrastructure. Digital supply chain studies point out that disruption management needs visibility and prompt information (Ivanov & Dolgui, 2021). Similar results have been revealed in the port integration research where information exchange in logistics performance is central (Panayides & Song, 2009).

Where there is digital interoperability, TIR has an opportunity to be integrated into an expanded virtual corridor-control logic. The road leg can become visible to port, dry port and platform actors rather than remaining an independent operation outside the main data environment.

4.5 Resilience and boundary conditions

The fifth contribution is resilience. Efficient corridors can still be fragile if they depend on a single route, mode or administrative process. Resilience-oriented

research emphasises viability, redundancy and adaptive capacity (Ivanov & Dolgui, 2020). TIR can contribute to resilience when it offers a credible road-based option for urgent, disrupted or irregular flows.

The boundary conditions are equally important. TIR is most valuable for time-sensitive, irregular or dispersed flows; it is less relevant for stable, high-volume, rail-dominant traffic. It works best when customs capacity, carrier qualifications, inland hub services and digital information exchange are sufficiently developed. Figure 1 summarises this bounded complementarity.

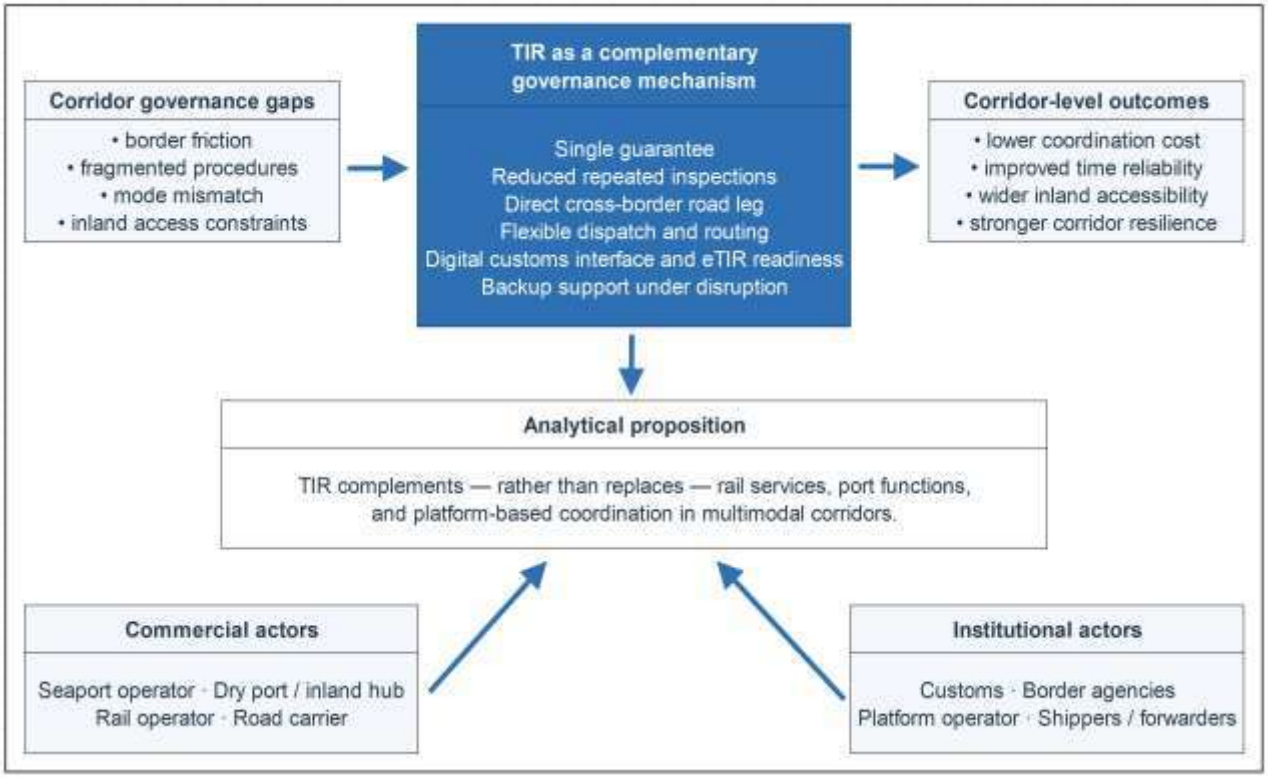

Figure 1. Conceptual positioning of TIR in seaport–dry port multimodal corridors.

Source: author's conceptual synthesis based on the reviewed literature.

Table 2. Boundary conditions of TIR complementarity in seaport–dry port corridors

Dimension	When TIR is strategically valuable	When maritime/rail remain dominant	Implication for corridor design
Procedural continuity	Multiple borders; repeated documentary friction; need for unified	Single-jurisdiction domestic flows or stable direct rail	Use TIR to govern cross-border interfaces rather than entire

	transit logic	blocks	corridor
Cargo profile	Time-sensitive, irregular, dispersed, or medium-batch cargo	Large-scale, regular, volume-intensive cargo	Segment cargo by service logic rather than mode ideology
Network structure	Need for door-to-door flexibility or feeder continuation beyond rail reach	Strong fixed-schedule line-haul with concentrated destinations	Use TIR as a flexible complement to the scale-oriented trunk mode
Resilience	Disruption, congestion, or need for rapid rerouting	Stable, high-frequency, low-variance operations	Maintain TIR as an option within the corridor governance toolkit
Digital interface	Pre-arrival data exchange and interoperable customs/terminal coordination are improving	Poor data visibility and fragmented institutional systems	TIR value rises when embedded in wider digital interoperability

Figure 2 synthesises how border-friction reduction, service flexibility, digital interoperability and resilience support combine into corridor-level effects.

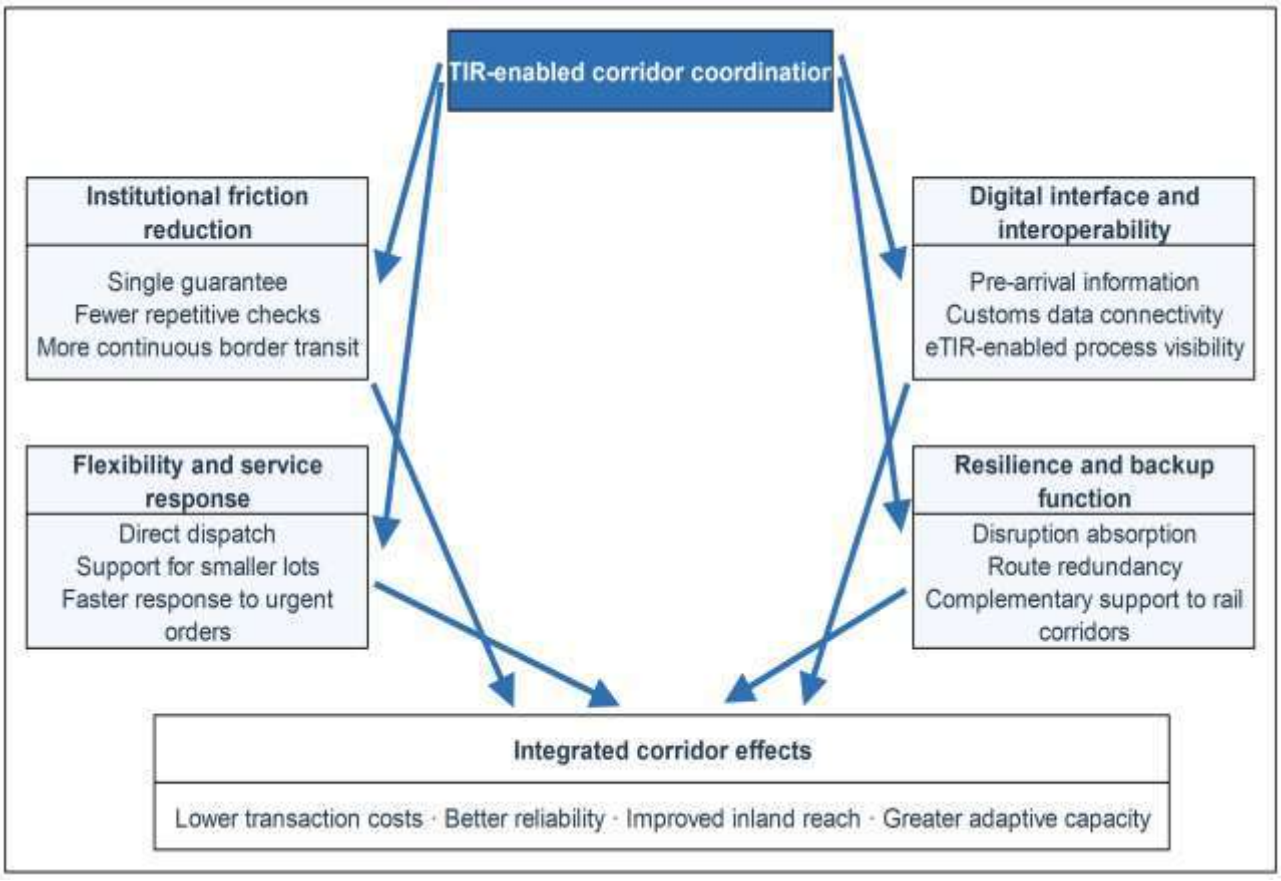

Figure 2. Mechanism pathways through which TIR strengthens corridor coordination.

Source: author's analytical framework.

5. China-Central Asia Evidence under the Maritime Silk Road

5.1 Empirical relevance

China–Central Asia is an appropriate qualitative setting because it combines maritime gateway functions, inland dry port development, rail corridor expansion and cross-border road-transit demand. The setting also contains institutional diversity, border interfaces and inland market dispersion, all of which make complementary governance mechanisms relevant.

This setting clarifies why TIR should be understood as complementary. Large-scale rail and maritime services provide the backbone. TIR can support interfaces where service flexibility, direct inland access and customs-transit continuity matter. It is therefore analytically useful for explaining how road-transit arrangements can be incorporated into a seaport–dry port corridor rather than treated as a separate logistics market.

5.2 From route activation to corridor integration

The contextual evidence in Table 3 shows three patterns. First, route activation bridges inland and border spaces which are not necessarily well covered by a single rail schedule. Second, the development of intermodal TIR implies that multimodal chains can be provided with road transit located inside them. Third, the fact that policymakers are paying attention to cross-border road transport means that road-transit facilitation may be part of a more comprehensive portfolio on corridor governance.

Especially significant is the intermodal-TIR logic as a conceptual one. It states that TIR is able to take part in a multimodal chain and not just on its side. In this type of chain, the port, dry port, road carrier and railway as well as the customs players should coordinate modal responsibilities.

5.3 Governance implications of the evidence

The implications of the evidence of the China-Central Asia are three. To begin with, TIR is turning into a corridor-relevant as opposed to shipment-specific. When TIR is connected to ports, dry ports, inland distribution, it is able to affect the way the corridors divide cargo flows. Second, TIR is able to facilitate the dry port operation to enhance the continuity of transit on inland roads. Third, institutional readiness, digital interoperability and actor coordination are effective traits of TIR.

This interpretation will minimise the risk of over-generalisation. A small number of milestones cannot prove a general performance effect, but they can reveal the direction of institutional experimentation. The stronger claim made here is not that TIR is superior to rail or maritime transport. The claim is that TIR can perform a complementary governance function in specific corridor conditions.

Figure 3 places TIR between core transport modes and governance instruments. The figure emphasises two points. TIR should not be treated as a universal corridor solution; it is strongest where its customs-transit function, road flexibility and digital-interface potential complement existing maritime, rail and dry port systems.

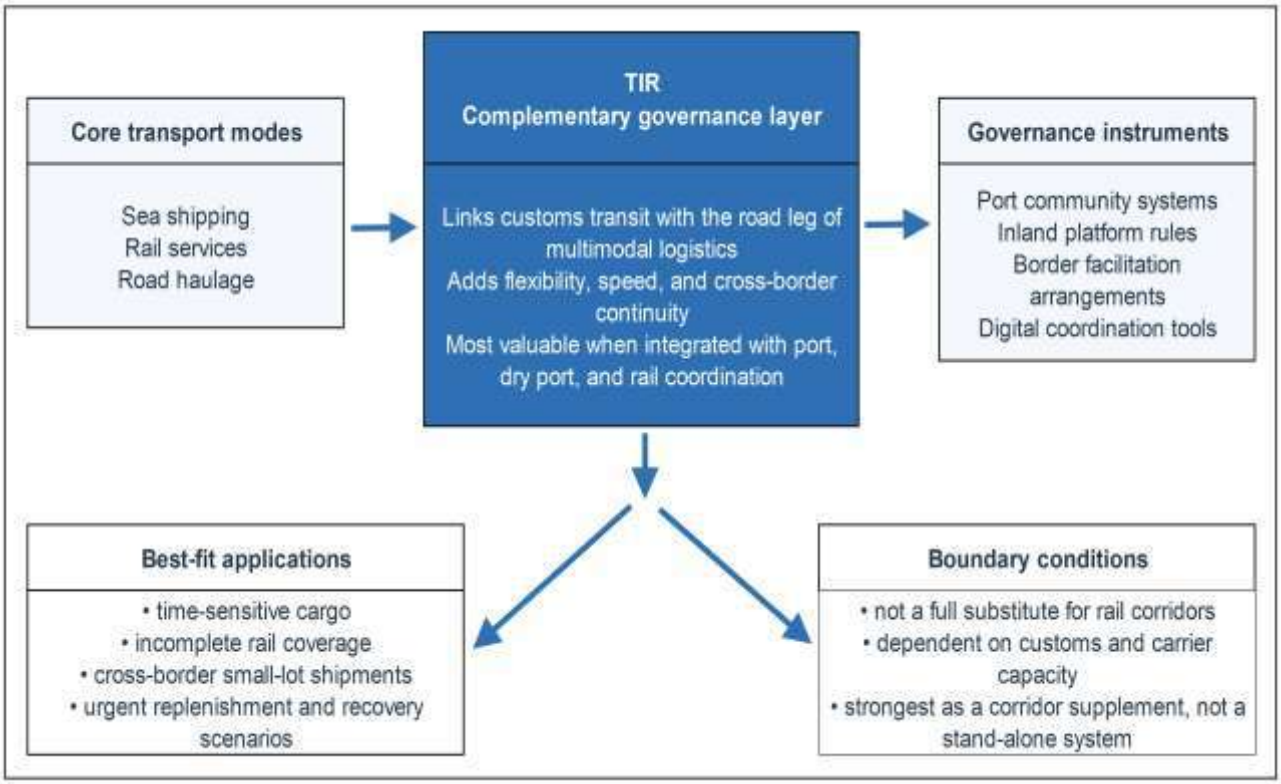

Figure 3. Positioning TIR relative to core transport modes and governance instruments.

Source: author's synthesis.

Table 3. China-Central Asia TIR milestones and their corridor-governance significance

Contextual development	Corridor-governance significance	Use in this paper
Activation of China–Central Asia road-transit routes	Shows that international road transit can extend the reach of seaport–dry port corridors beyond fixed rail schedules.	Supports the claim that road-transit procedures matter at corridor interfaces.
Linkage between inland origins and maritime gateways	Indicates that TIR can support inland access to Maritime Silk Road gateways when coordinated with dry ports and platforms.	Connects TIR with hinterland access and gateway extension.
Emergence of inland TIR-supporting hubs	Strengthens the functional role of inland gateways by adding customs assistance, documentation and road-transit coordination.	Explains how TIR can reinforce dry port upgrading.
Scaling from pilot movements to wider corridor use	Suggests that TIR is moving from shipment-level facilitation toward corridor-level institutionalisation.	Shows why TIR should be analysed as governance, not only transport.
Intermodal use of TIR within multimodal chains	Supports the paper's core claim that TIR can complement maritime and rail systems rather than operate only beside them.	Provides the conceptual bridge to multimodal corridor optimisation.

6. Managerial and Policy Implications

The complementary-governance perspective has implications for port authorities, dry ports, customs administrations, platform operators and corridor coordinators. For port authorities, TIR should be considered as part of the hinterland access strategy, especially where customers require flexible inland delivery or where road transit can support rail and maritime schedules.

For dry ports and inland hubs, TIR can support functional upgrading. A dry port that combines customs support, documentation services, consolidation, tracking and road-transit coordination can become more than a storage or transfer location. It can operate as an inland governance interface for the seaport–dry port corridor.

The real world segmentation is a practical exercise for corridor planners. Not every cargo category should be routed through TIR, and not every inland terminal requires a complete TIR service package. Planners ought to know which cargo segments the impact of flexibility and time reliability or direct delivery is more beneficial than the loss of rail scale benefits.

In the case of customs administrations, system design is of priority. TIR will add the most value when transit facilitation is aligned with pre-arrival processing, digital risk management and interoperable data exchange. If customs procedures remain separate from corridor platforms, TIR's operational benefits may remain limited.

For corridor coordinators, the key implication is resilience. TIR should be treated as an option within a layered corridor design. It should not replace rail investment or port–dry port integration, but it can provide redundancy for specific cargo flows and disruption scenarios.

For researchers and policy analysts, the framework provides an optimisation agenda. TIR-related decisions can be incorporated into corridor models as conditional service options. Future models can compare rail-dominant, road-assisted and digitally integrated scenarios under different assumptions about time sensitivity, border delay, cargo dispersion and disruption risk.

7. Conclusion

This paper has argued that TIR should be conceptualised as a complementary governance mechanism in Maritime Silk Road seaport–dry port corridors. The argument does not claim that TIR is universally superior, nor that it should replace maritime or rail services. Its value is more specific: TIR can reduce selected border, institutional, digital and resilience-related coordination failures when the corridor context makes a flexible road-transit layer useful.

The theoretical contribution is to link customs-transit systems with dry port and corridor-governance research. The managerial contribution is to specify where TIR adds value: at border-friction interfaces, modal-complementarity interfaces, inland-gateway interfaces, digital-interoperability interfaces and resilience interfaces. The

policy contribution is to caution against treating TIR as a stand-alone transport policy; it should be embedded in a wider multimodal governance architecture.

Future research should test the framework with shipment-level data, border-time observations, platform records and comparative corridor cases. Particularly important questions include how TIR changes time reliability, which cargo segments benefit most from road-transit complementarity, and how digital customs interoperability affects seaport–dry port coordination.

Table 4. Managerial and policy agenda derived from the complementary-governance perspective

Actor	Priority action	Expected governance effect
Port authorities	Map cargo segments and inland destinations for which TIR adds interface value	Better hinterland service differentiation and corridor reach
Dry ports / inland hubs	Develop TIR-supporting service packages: customs assistance, documentation, consolidation, visibility	Stronger inland gateway functions
Customs administrations	Align TIR with multimodal facilitation reforms and pre-arrival processing	Reduced border fragmentation and greater procedural continuity
Platform operators	Integrate TIR workflows with terminal systems, booking systems, and tracking interfaces	Higher digital interoperability and service transparency
Corridor coordinators	Treat TIR as part of resilience design, not just a niche road mode	Greater redundancy and faster recovery under disruption

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