International Transport Forum

SIPA
Sustainable Infrastructure Programme in Asia

Enhancing freight transport connectivity through analytical frameworks

Applications to Central and Southeast Asia

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The Sustainable Infrastructure Programme in Asia

This paper is part of the Sustainable Infrastructure Programme in Asia (SIPA), funded by the German International Climate Initiative (IKI) and led by the OECD. SIPA aims to support countries in Central and Southeast Asia in their transition towards energy, transport and industry systems aligned with the Paris Agreement and Sustainable Development Goals.

The ITF leads the transport component of the SIPA programme (SIPA-T). The SIPA-T project helps decision makers in Central and Southeast Asia by identifying policy pathways for enhancing the efficiency and sustainability of regional transport networks. Project outputs include two regional studies that explore opportunities to improve the connectivity, sustainability, and resilience of freight transport systems in Central and Southeast Asia.

This paper is the first in a series of four ITF expert working papers that collectively provide the methodological foundation for the two SIPA-T regional freight transport studies. The full series includes the following papers:

1. *Enhancing freight transport <u>connectivity</u> through analytical frameworks* (Ruth Banomyong)
2. *Enhancing freight transport <u>decarbonisation</u> through analytical frameworks* (Alan McKinnon)
3. *Enhancing freight transport <u>resilience</u> through analytical frameworks* (Jasper Verschuur)
4. *Evaluating the relationships between connectivity, decarbonisation and resilience in freight transport* (Alan McKinnon)

Access these papers, more information and other SIPA-T project deliverables:
https://www.itf-oecd.org/sustainable-infrastructure-programme-asia-transport

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Summary

This paper explores the essential role of regional freight transport connectivity in enhancing economic growth, improving productivity, and furthering supply chain efficiency. It provides a methodological framework focused on identifying and addressing freight transport connectivity gaps using both infrastructure development (or "hard" policy measures) and regulatory harmonisation (or "soft" policy measures). The methodological framework is then applied to offer recommendations for strengthening regional connectivity in Central Asia and Southeast Asia, two regions that are crucial hubs for international trade. Enhanced connectivity could revitalise the historic Silk Road through Central Asia, facilitating access to European and East Asian markets, while Southeast Asia's location along major global shipping lanes and growing status as a production and consumption centre has created a surge in demand for international trade.

To visualise the components of connectivity and the interactions between them, a conceptual framework for regional freight connectivity is proposed. The conceptual framework includes the inter-relationship between the four main dimensions of freight connectivity: (1) infrastructure, (2) institutional framework, (3) service providers, and (4) shippers and consignees.

The quality of each dimension individually and the strength of the connections between them is what ultimately determines the level of connectivity. This conceptual framework can be used in practice to classify individual connectivity challenges and then develop targeted policy measures that address them.

Regional freight transport networks are highly complex. Therefore, it is necessary to develop a systematic approach to identify and prioritise the specific connectivity gaps that have an outsized impact on performance. This paper proposes several quantitative and qualitative assessment tools to analyse the transport and logistics performance of countries (macro-level), corridors (meso-level) and individual nodes and links (micro-level) in a regional freight transport network.

An important macro-level methodology for assessing connectivity is developed herein. The freight connectivity scorecard is a tool that can help quantify and compare connectivity across the four key dimensions. The scorecard can be further combined with a detailed multimodal transport cost model for mapping logistical activities and assessing the efficiency of freight corridors with respect to cost, time, and operational hurdles.

Resolving connectivity gaps requires transparent, consistent, and data-driven policy measures. These are typically categorised into either hard or soft measures:

- Hard measures: Physical infrastructure or fleet-based interventions such as the development of a new rail corridor or the purchase of new maritime vessels. These measures are tangible, involving construction, expansion, or refurbishment.
- Soft measures: These are institutional policies, regulations, and collaborative efforts that complement hard measures to enhance connectivity. The three typical categories of soft measures include (1) Harmonisation of logistics, transport regulations and standards, (2) trade and transport facilitation measures, and (3) collaboration and co-operation among freight transport stakeholders.

Both Central and Southeast Asia face significant challenges with respect to infrastructure and institutional frameworks. By addressing both the physical and regulatory aspects of connectivity, the paper outlines a comprehensive strategy for enhancing regional freight transport in these regions. It suggests a multi-level approach that includes significant infrastructure development, regulatory reform, and international co-operation to overcome the current challenges and leverage the economic potential of improved freight connectivity in these strategically important regions.

Each region will require significant investment to modernise and expand freight and logistics infrastructure, yet there are constant challenges in mobilising financial resources and funding gaps are expected to grow larger in the future. Public-private partnerships and international funding should be explored as potential solutions to infrastructure funding. It is equally important for both regions to align new soft measures, such as regulatory harmonisation, with infrastructure development to maximise the potential benefit of the infrastructure in facilitating regional freight connectivity.

Introduction

At the heart of globalisation, freight connectivity is a vital component of international trade that supports the movement of goods and services across borders. Connectivity enables interactions, productivity, competition, and market opportunities between cities, countries and regions (Werner, 2020). Efficient freight networks permit rapid and cost-effective transportation of goods, thereby enhancing trade and economic growth within a region. The ability to establish and maintain economic connections has only become more important over time, as highlighted by the challenges encountered during the COVID-19 pandemic. The benefits of freight connectivity include sustained economic growth, supply chain efficiency and freight system resilience (UNESCAP, 2019).

Transport is a key element of freight connectivity; Iimi (2023) emphasises the role of transport in improving logistics efficiency at the regional level. Freight connectivity involves both physical infrastructure and policies, such as customs procedures (ITF, 2019). Infrastructure improvements can increase supply chain efficiency and bring economic benefits, but they also create externalities such as increased maintenance costs, congestion, pollution, and road safety issues. Non-infrastructure improvements such as trade, transit and transport facilitation measures help reduce travel costs and transit times while increasing reliability within the freight network.

Connectivity is a vital aspect of regional development and economic growth, especially in regions like Central and Southeast Asia. Central Asia, positioned between Europe and Asia, stands to gain significantly from enhanced trade routes, including the revival of the Silk Road, a major economic corridor connecting East Asia with Western Europe. Since Central Asia is rich in natural resources, improved connectivity will also allow these resources to be transported more efficiently to global markets. Southeast Asia's strategic location along major global shipping routes makes it a nexus for international trade. Enhancing connectivity within Southeast Asia and with major economies such as China, India, the European Union and North America would improve the access of regional businesses to global markets. This is particularly beneficial for Southeast Asia's export-driven economies.

This working paper establishes a methodological framework for assessing connectivity within regional freight corridors in these areas. It also defines and conceptualises connectivity, develops quantitative indicators to identify existing gaps in freight connectivity, and reviews potential solutions. This chapter includes discussions on the following topics:

1. Definitions of regional freight connectivity and connectivity performance indicators.
2. Conceptualisation of connectivity gaps and methodologies for their identification.
3. “Hard” measures for enhancing connectivity (e.g. infrastructure development).
4. “Soft” measures for enhancing connectivity (e.g. harmonisation of transport regulations and standards, trade facilitation measures, collaboration and coordination among stakeholders).
5. Implementation examples, both successful and unsuccessful, from Central and Southeast Asia.

Defining connectivity

Despite its widespread use, no single, universally accepted definition of connectivity exists in the context of freight transport. Oxera (2010) has provided an interesting holistic definition: "Connectivity is the availability of transport that enables people and goods to reach a range of destinations at a reasonable generalised cost." This definition captures the essence of connectivity, emphasising the ability to connect an origin point with various destinations and the efficiency of those connections. A systematic review on the topic of understanding connectivity (Calatayud et al., 2016) provides additional detail to the definition by identifying three theoretical perspectives on freight connectivity:

- <u>Connectivity, infrastructure and networks:</u> This is a narrow perspective focused on the availability and characteristics of infrastructure and transport services.
- <u>Connectivity, access to markets and international trade:</u> This is a broader perspective that includes trade facilitation procedures alongside infrastructure and transport services.
- <u>Connectivity and supply chain management:</u> This perspective captures the degree of information-sharing and collaboration throughout the supply chain, such as asset sharing.

However, the concept of connectivity is broader than just facilitating the flow of goods, people, services, and information between distinct locations. Angelopulo (2014) argued that connectivity is fundamental to understanding and addressing the complexities of modern social and institutional dynamics, enhancing productivity, performance, and overall competitive advantage. He further elaborated on the concept of connectivity by identifying three distinct categories of connectivity:

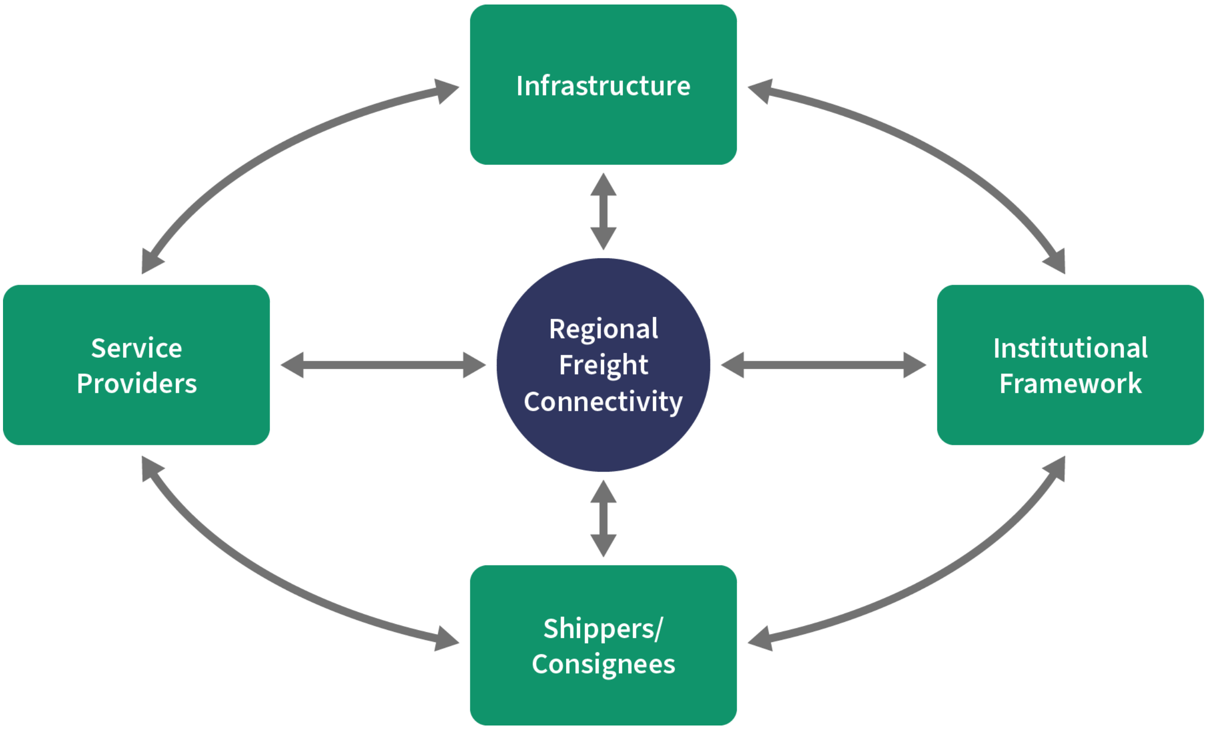
- <u>Physical Connectivity:</u> This category encompasses the physical infrastructure that facilitates the movement of people, goods, or information. It includes transportation networks, communication systems, and physical spaces for interaction. Examples include roads, railways, airports, telecommunications networks.
- <u>Virtual Connectivity:</u> This category refers to the digital infrastructure that enables online communication and interaction. It includes the internet, email, social media platforms, and other virtual spaces. Virtual connectivity allows for real-time communication, collaboration, and access to a vast array of information and services.
- <u>Social Connectivity:</u> This category signifies the establishment of interpersonal relationships and networks. It involves social interactions, shared interests, and community ties. Social connectivity fosters empathy, understanding, and collective action.

However, it is important to consider the role of institutional connectivity as a fourth type of connectivity. Institutional connectivity refers to conventions, regional frameworks, agreements, and mechanisms that facilitate co-operation and coordination among agencies in different countries, regions, or at the multilateral level. The fourth dimension is reflected in the Association of Southeast Asian Nations (ASEAN) Master Plan on ASEAN Connectivity 2025 (ASEAN, 2016), which describes connectivity in the region as comprised of three pillars: people, physical and institutional connectivity.

A conceptual framework for freight connectivity

To summarise the literature described above, freight connectivity can be referred to as a multi-faceted construct related to the efficiency and effectiveness of infrastructure and services that facilitates the movement of goods across various transport modes within and between countries. It encompasses physical infrastructure, policies, institutional frameworks, logistics services and freight owners' requirements for the movement of goods. The essential components of regional freight connectivity can be arranged into four dimensions: Infrastructure Connectivity, Institutional Framework, Service Providers, and Shippers / Consignees. The quality of each dimension individually and the strength of the connections between them is what ultimately determines the level of connectivity. These dimensions are illustrated as a conceptual framework in Figure 1, and each dimension is described in detail in the following subsections.

Figure 1. The conceptual framework for regional freight connectivity



The importance of infrastructure, market linkages (i.e. service providers, shippers and consignees), and regulatory frameworks in freight connectivity is a well-established concept in the transportation and logistics literature (Calatayud et al., 2016).

This conceptual framework can be used to identify a holistic set of opportunities for improving regional freight connectivity. For example, ITF (2019) observed a significant connectivity gap between Central Asian countries and more logistically advanced countries, with Central Asian countries accessing 50% fewer economic opportunities than a country like Germany. Following the conceptual framework, enhancing freight connectivity in Central Asia could benefit from more effective transport planning, governance, and regulations, as well as more transparent, consistent, and data-driven processes to connect the individual dimensions. Similarly, the Master Plan on ASEAN Connectivity 2025 identifies a significant gap in infrastructure investment and notes the importance of coordination across ASEAN Member States and sectors to address the interdependencies between dimensions of connectivity. Together, additional public and private investment by ASEAN member states and regional coordination are expected to contribute to a connected, competitive, inclusive, and cohesive ASEAN community by 2025.

Infrastructure connectivity

Infrastructure connectivity focuses on the physical infrastructure that facilitates the movement of goods across countries. Infrastructure is the backbone or the “hardware” of the freight system. High regional infrastructure connectivity can reduce transport costs, congestion and transit time, support access to markets and promote regional development.

Recent cross-border transport infrastructure projects, such as the Lao-China Railway (LCR), highlight the strategic benefits of regional infrastructure connectivity. In 2023, the railway transported over 3.1 million tons of goods, marking a substantial year-on-year increase of 138% (Veren, 2023). The passenger travel time by rail between Kunming (China) and Vientiane (Lao PDR) has been reduced to 11.3 hours from an overland journey by road of 3 days (Meadly, 2023). One recent study (Xiao et al., 2024) observed that the construction of the LCR has transformed land use along the corridor, increasing development and economic growth. The project has also led to greater geo-economic co-operation between these neighbouring countries and the opening of a new Special Economic Zone at the border to facilitate cross-border trade. Yuan and Yang (2022) also observe that transport infrastructure is critical for boosting and supporting the coordinated development of major regional cities in their study of the impacts of the Hong Kong–Zhuhai–Macao Bridge project.

Bhattacharyay (2010) argues that infrastructure connectivity is essential for ASEAN's aspirations towards economic integration, competitive enhancement, and equitable development across its member nations. The study notes that robust infrastructure, from transportation to energy to information and communication technology (ICT), is vital for stimulating trade, attracting investment, and enabling the free flow of goods and people across the region. Addressing the infrastructure gap through significant investment and fostering regional co-operation and partnerships between the public and private sectors are deemed crucial for realising the ASEAN Economic Community's objectives of becoming a single market and single production base while ensuring the region's sustainable and inclusive growth.

Similarly, Bespalyy (2023) highlighted the role of transport infrastructure in connecting Central Asia, focusing on international development projects and transport corridors, notably the Belt and Road Initiative (Schulhof, van Vuuren and Kirchherr, 2022). Infrastructure connectivity is not merely a physical requirement for economic activity but a strategic asset that can significantly elevate Central Asia's economic stature on the global stage. Central Asia's strategic location as a land bridge between China and Europe positions the region as a critical juncture for the Belt and Road Initiative (BRI).

Through concerted efforts in infrastructure development and regional co-operation, Central Asia can leverage its geographic and economic assets more effectively, fostering sustainable growth and development across the region (Gould, Kenett and Panterov, 2018). Enhanced connectivity will attract more freight and transit demand across Central Asia, increasing revenue for local railway operators and the logistics sector. Infrastructure connectivity is also portrayed as a catalyst for trade facilitation, competitiveness enhancement, and attraction of foreign direct investment (FDI). Regional collaboration and substantial investments in infrastructure projects are critical to surmount existing infrastructure connectivity challenges.

Like Central Asia, Mongolia currently suffers from limited physical infrastructure connectivity as only three border crossing points have rail connectivity, while other border crossing points tend to have inadequate road connectivity (ADB, 2018). Another key issue is the variation in railway gauge between Mongolia and

China, which necessitates the transfer of freight between wagons of different gauges, adding time and cost to freight operations.

Improved infrastructure connectivity can disproportionately benefit regions with better access to the new infrastructure; however, it can also lead to uneven economic development. Subnational regions with strategic positions along the transport corridors might experience higher growth compared to those that are more peripheral. The environmental degradation resulting from transport infrastructure projects may also be unevenly distributed. Environments adjacent to new infrastructure might suffer from pollution and habitat destruction while the broader benefits of improved transport, such as economic growth, are distributed more widely.

Finally, infrastructure connectivity is not limited to long-distance freight transport networks. The infrastructure developed for first and last-mile distribution is also critical for the physical movements and storage of shipments. Similarly, communications infrastructure is necessary for the efficiency of these movements, particularly across borders and at modal interface areas where customs procedures can involve many different stakeholders. The need for a seamless transition between transport modes is also important and requires efficient and effective intermodal facilities.

Institutional framework

Many aspects of the regulatory and institutional environment affect the operations of shippers, traders, exporters and logistics service providers. These include rules and regulations related to imports and exports, financial regulations (e.g. letter of credit rules and the ability to exchange currency), registration and licensing of service providers and customs brokers, border crossing procedures, and even limits on the logistics services that can be legally offered. Overly complex and restrictive rules and regulations can impede the movement and storage of goods, services and information within a freight system. This institutional framework is the "software" of connectivity that authorises, facilitates, impedes or forbids the movement and storage of freight across physical infrastructure networks (Banomyong, Cook and Kent, 2008).

Trade, transit and transport facilitation, part of the institutional framework, plays a key role in supporting the efficiency and effectiveness of an international freight system. Trade facilitation, in its broadest terms, can be defined as a measure or set of measures that aim to reduce the cost and time of domestic and international trade transactions (Sakyi and Afesorgbor, 2019). There are many possible elements of a trade facilitation initiative. Often, these initiatives include the simplification, modernisation, and harmonisation of export and import processes. Transit facilitation is a subset of trade facilitation actions that specifically focuses on policies and measures to ease the passage of goods through one or more countries en route to another country. Transport facilitation refers to the set of measures, policies and practices aimed at improving the efficiency and efficacy of transport systems. As an example of how trade facilitation agreements and institutional frameworks can impact regional freight connectivity, consider the three categories of border-crossing restrictions defined by UNESCAP (2019):

1. <u>No permission for cross-border transport by road</u>. Traffic rights are not granted to foreign vehicles that cross borders for commercial transport. Transloading of cargo must take place at border areas for goods to travel across the border.
2. <u>Cross-border transport by road permitted subject to quota</u>. Traffic rights are granted to foreign vehicles through the issuance of a road permit system. Specific quantities of road permits are granted to road transport operators depending on the bilateral or multilateral arrangements between countries. Road permits are often issued with conditions; for example, foreign trucks

may be required to use designated border crossing points and follow specific routes upon entering foreign countries. Cabotage (i.e. the transport of goods between two places in the same country) by foreign vehicles is typically prohibited.

3. Cross-border transport by road permitted and not subject to a quota. There are no quota restrictions on foreign road freight vehicles. This is usually the case when a number of countries enter into a "customs union", such as the Eurasian Economic Union.

Clearly, the more permissive border crossing agreements promote better freight connectivity between countries by limiting transport delays and reducing administrative compliance costs.

The design of institutional frameworks related to information sharing can also impede or enhance connectivity. Strong institutional connectivity requires the streamlining of information flow on three levels:

1. Simplification: Reducing the amount of information required by relevant public authorities to an absolute minimum. This is a work in progress in Central Asia and the ASEAN region with dedicated support from the private sector. The simplification processes underway involve both streamlining procedures and reducing the type and number of necessary documents.
2. Normalisation: The reduction of variations in the formalities, procedures, and documents required at both the national and international levels. Documentation requirements should be consistent across all freight terminals (e.g. sea ports, airports and transhipment facilities) within a single country and, ideally, aligned with documentation requirements in nearby countries and major trade partners. Normalisation is likely to concern transport documents, International Commerce Terms (or INCOTERMS), payment conditions and trade documents.
3. Harmonisation: The harmonisation of information format and standards for electronic data transmission. Changing from paper documents to electronically transmitted information is a complex undertaking but greatly enhances freight connectivity by allowing rapid document sharing and verification across multiple stakeholder groups. This harmonisation should include the alignment of information-sharing regulations and system designs between countries in the same region. However, due to the many different systems currently in use, harmonisation remains a major challenge. The ASEAN Single Window is an example of one harmonisation effort (UNESCAP, 2015), while the UNECE (2020) has advocated for the establishment of Nationals Single Windows in Central Asian Countries.

Strong institutions and co-operation between governments, local authorities, businesses, and other stakeholders are essential to improve freight connectivity. A horizontal governance approach can help to connect different parts of the public sector in an effort to facilitate the movement of goods both within and across borders (ITF, 2019).

The ASEAN region currently has three main transport facilitation agreements that are intended to enable freight connectivity between member countries (ASEAN, 2016). The objectives and key provisions of each of the three ASEAN agreements are described in Annex A:

1. ASEAN Framework Agreement on the Facilitation of Goods in Transit (AFAFGIT).
2. ASEAN Framework on Multimodal Transport (AFAMT).
3. ASEAN Framework Agreement on the Facilitation of Inter-State Transport (AFAFIST).

In 2015, the CAREC[1] Developing Member Countries (DMCs) agreed to adopt principles for freedom of transit within the CAREC geographical area by concluding and fully implementing bilateral and regional cross-border transport agreements (CAREC, 2019). This includes joining key UN Cross-Border Transport Facilitation Agreements and Conventions such as the TIR Convention (1975), the Convention on Harmonization of Frontier Control of Goods (1982), and the CMR Agreement (1956). These agreements and conventions are designed to enhance transport and logistics facilitation across the CAREC region, focusing on improving customs and border control procedures, implementing modern risk management principles, and improving border crossing infrastructure and equipment. This holistic approach aims to facilitate cross-border and transit traffic, support the establishment of multimodal logistics centres, and streamline the movement of goods and people across the CAREC transport corridors. It is interesting to note that the ASEAN member states have decided to develop and implement new regional transport facilitation agreements, while the CAREC region has opted to pursue accession to UN international conventions.

UNESCAP (2022) has several recommendations for facilitating transport across sub-regions. The recommendations are intended to enhance institutional connectivity by providing a structured approach to harmonise and simplify transport, customs, and administrative procedures across regions. In adopting a modular, step-by-step approach to agreement implementation, countries can address specific challenges in a tailored manner, leading to more efficient cross-border transport. The agreement aims to reduce barriers and legal conflicts between nations, enabling smoother and faster movement of goods and people, thereby fostering economic integration and development within subregions. This approach might further be explored by CAREC DMCs as under this proposal, UNESCAP recommends the use of a modular approach for designing subregional agreements, allowing countries to select specific modules based on the feasibility and importance of implementing provisions with a step-by-step approach to implementation. Simpler measures will be introduced first, followed by more complex arrangements. The UNESCAP proposal also advises reviewing existing bilateral agreements on international road transport to avoid legal conflicts and ensure compatibility between different legal instruments.

Service providers

Public and private logistics service providers (LSPs) collectively make up the logistics industry. The logistics industry plays a crucial role in enabling international trade, facilitating supply chain operations, and connecting markets worldwide (Skender et al., 2016). Changing consumer expectations for faster, more flexible, and transparent delivery services in recent years have pushed the logistics industry to innovate and improve. LSPs have also begun to appear in many emerging economies where they were previously scarce. However, there is still confusion about the terminology used to describe the logistics industry. Traditional logistics services such as transport, storage, and warehousing are easily defined, whereas other logistics activities such as “sourcing” or “inventory management” might encompass a range of different services. To add to the confusion, a number of longstanding transport and warehouse operators have re-cast themselves as logistics service providers, although they have not changed or increased the type of services they provide.

According to Banomyong, Cook and Kent (2008), the size and capability of logistics-related enterprises will depend on the barriers to entry, the extent of regulation, and the level of demand for services. It is usual in many countries for trucking firms, warehousing operators, freight forwarders, and customs brokers to

[1] The CAREC (Central Asia Regional Economic Cooperation) member countries are Afghanistan, Azerbaijan, China, Georgia, Kazakhstan, Kyrgyz Republic, Mongolia, Pakistan, Tajikistan, Turkmenistan and Uzbekistan.

be small, flexible, and hesitant to invest in high-capital assets. Rail, ocean, and air service providers tend to be larger and more formal, with higher capital investment costs. A mix of large and small service providers in a logistics market creates competition and limits costs for shippers and consignees. For small businesses and individual consumers, there is no benefit to having exceptional transport infrastructure unless there is a competitive marketplace of logistics providers that can deliver their goods effectively.

LSPs play a critical role in enabling freight connectivity and serving the needs of shippers and consignees (Tongzon and Cheong, 2014). They must maintain an international network of service providers combined with local knowledge of specific markets. This combination allows LSPs to anticipate and resolve regulatory, cultural, and geographical challenges to ensure the smooth movement of goods across regional borders. LSPs will also ensure compliance with all relevant laws and regulations.

As an example of the importance of service providers in regional connectivity, Coulibaly and Thomsen (2016) observed that Central Asia's region's landlocked geography inherently complicates access to international markets even with the help of local LSPs. The paper also highlights the specific challenge of navigating through Uzbekistan, which introduces uncertainties regarding delivery times and costs due to strict transit regulations and informal payments. Furthermore, the lack of cold chain options impacts the food-processing industry by limiting their ability to maintain product quality during transit, thereby affecting their competitiveness in international markets.

Shippers and consignees

Firms buying or selling goods that require shipment constitute the shippers and consignees. They are the principal users or the "customers" of the freight system. They require that their goods move through the freight system effectively and efficiently, both as inputs to and outputs from their businesses. Different shippers and consignees have various levels of knowledge and understanding of their logistics system. They will have different sensitivities in terms of price, time, and reliability. As an example, high fashion garment makers will be more sensitive to time and reliability than shippers of bulk commodities, who may be more sensitive to price than anything else. Frozen food shippers will be concerned with the availability of refrigerated freight service, as well as time and reliability, with price playing a secondary role.

A connection between the requirements of shippers and consignees and the other dimensions of connectivity is crucial for effective freight transport. For example, high-quality maritime transport infrastructure might be crucial for connectivity in a coastal country whose primary export is bulk mineral goods. Yet air freight connectivity might be more important for a country that exports high-value technological products or fresh fish. Strong connectivity also requires the distribution of freight infrastructure to be aligned with major sources of production and consumption of goods. At the same time, major shippers and consignees may adjust the location of their facilities to areas with abundant freight infrastructure.

Recent studies underscore the interdependence between shippers and consignees and the rest of the freight system. Enhancements in national logistics performance, facilitated by both the government and the private sector, positively influence export values across ASEAN countries (Ardine et al., 2023). This suggests that effective logistics services not only support intra-regional trade growth but also benefit exporters and importers through more efficient and reliable trade operations. Rastogi and Arvis (2014) highlighted the significant impact of logistics performance on exporters and importers in Central Asia, emphasising the challenges and opportunities presented by the region's unique geography and political environment.

Freight connectivity challenges

The ability of a country or region to achieve high levels of freight connectivity depends on the aggregation of the four dimensions described above. Investing in physical infrastructure without addressing policy and technological gaps can lead to inefficient and costly freight movements. Similarly, focusing solely on policy reforms and technological advancements without adequate infrastructure can constrain the overall efficiency of regional freight networks due to a lack of capacity to handle demand.

Achieving and maintaining robust freight connectivity can be challenging, especially when faced with inadequate physical infrastructure. Poor maintenance, missing links, or low capacity can significantly hinder efficient freight movement, leading to delays and increased costs. Moreover, the negative impact of insufficient infrastructure is often compounded by complex customs procedures and trade rules that lack simplification or harmonisation. This combination of factors can severely restrict the smooth and cost-effective flow of goods, underscoring the importance of a comprehensive approach to enhancing freight connectivity that addresses infrastructure, regulatory, and procedural barriers (Banomyong, 2008).

Another potential challenge is related to digital connectivity. Digital connectivity facilitates the flow of information within the national, regional, and international freight systems (Chan et al., 2018). Having limited access to real-time information on transportation conditions, disruptions, and professional logistics services can lead to inefficient routing, network congestion, and underutilisation of assets.

Table 1 summarises common connectivity challenges that reduce the performance of the overall freight transport system.

Table 1. Summary of freight connectivity challenges

Challenge	Examples
Infrastructure gaps	Inadequate, inferior quality, and unevenly distributed transport infrastructure.
Regulatory barriers	Diverse or conflicting national regulations or procedures.
Border crossing inefficiencies	Cumbersome customs processes and lack of harmonisation.
Limited multimodal options	Insufficient development and integration of multimodal transport systems.
Technological disparities	Varying levels of technology adoption among countries, affecting logistics and tracking systems.
Financial constraints	Limited investment in infrastructure development and maintenance.
Geopolitical issues	Political tensions and lack of co-operation between neighbouring countries.

The biggest challenge for freight connectivity in Southeast Asia and Central Asia remains financial constraints. Infrastructure is one of the keys to economic growth in a country. However, the positive impact of infrastructure construction does not guarantee available funding. For the ASEAN region, infrastructure investment was approximately USD 109 billion (excluding Brunei and Lao PDR) in 2022, despite investment needs of USD 124 billion. If this condition continues until 2040, ASEAN is predicted to experience an infrastructure funding gap of USD 20 billion per year (Aziz, 2023). The Asian Development Bank (ADB) estimated CAREC countries' current infrastructure gap at USD 1.15 trillion or USD 77 billion per year for the period 2016–2030 for 10 CAREC countries (excluding China) at 2015 prices (ADB, 2017).

Even if funding for infrastructure is made available for Southeast and Central Asia, gaps in freight connectivity are likely to remain, especially if regulatory regimes are not harmonised or fully developed. Without coordinated regulatory frameworks and institutional connectivity, there will be delays due to inconsistent border procedures, inspections, and documentation requirements. Such a scenario would undermine the potential benefits of the physical infrastructure and ultimately limit the regional economic integration and growth that new infrastructure would otherwise produce.

Assessing connectivity

This section aims to provide a foundational understanding of the diverse methodologies employed to measure freight connectivity, as well as the indices developed to quantify it. The literature on freight connectivity encompasses a wide range of perspectives, each focusing on distinct aspects of connectivity, such as infrastructure quality, regulatory environments, market linkages, and the integration of transport modes. In the literature, two separate categories of connectivity indices can be observed. The first category of indicators and methodologies measures connectivity from a macro-level perspective, combining several indicators to evaluate how well national economies are connected to and integrated with global markets. The second category of indices focuses on operational connectivity, such as the quality of specific dimensions or elements of a freight system. This might include the capacity for national ports to accommodate container ships or the performance of a given border crossing.

A detailed list of indices and methodologies to assess macro-level and operational connectivity are presented in Annexes B and C, respectively. Each index has its strengths and weaknesses, which are derived from its scope, methodology, and focus areas. These lists are not intended to be exhaustive but rather to offer a review of the most widely used indicators and assessment methods for freight connectivity.

The macro-level indices assess various aspects of international freight connectivity and globalisation. There are eight macro-level indices described in detail in Annex B:

1. The Globalization Index.
2. The Global Connectedness Index.
3. The KOF Index of Globalization.
4. The Global Connectivity Index.
5. The Connectedness Index.
6. The Liner Shipping Connectivity Index.
7. The Logistics Performance Index.
8. The Air Connectivity Index.

These indices collectively provide a comprehensive assessment of international freight systems. However, they share common limitations, such as a tendency to overlook qualitative factors, interpretation challenges due to complex and opaque methodologies, and potential biases. Additionally, most indices focus on the economic dimensions of connectivity, with less emphasis on political, cultural, or technological integration factors. This highlights the need for a holistic approach to understanding and enhancing global connectivity that considers both quantitative and qualitative elements.

In addition to the macro-level indices, there is also a selection of methodologies and indices that can be used to evaluate operational connectivity. Eleven operational methodologies and indices are described in detail in Annex C, each designed to measure the performance of individual dimensions of transport and logistics efficiency from different perspectives:

1. ASEM Sustainable Connectivity.
2. Multimodal Transport Connectivity Index.
3. Intermodal Connectivity Index.
4. Sustainable Inland Connectivity Indicator (SITCIN).
5. The Maritime Trade Connectivity Indicator.
6. Foreland Port Connectivity Index.
7. Container Performance Index.
8. Corridor Performance Measurement and Monitoring (CPMM) methodology.
9. Border Performance Index.
10. Cost/Time and Distance model.
11. Time Release Study.

These operational connectivity indices are quite diverse, with focuses ranging from infrastructure and regulatory frameworks to specific operational efficiencies and customs processes. However, their overall effectiveness may be limited by their specific focus areas, measurement approaches, and the extent to which they integrate multiple dimensions of connectivity. To obtain a comprehensive view of connectivity, stakeholders may need to consider the assessment of multiple indices and methodologies.

What are connectivity gaps?

Connectivity gaps in the context of freight transport refer to disparities or inadequacies in the seamless flow of goods or information between different regions, modes of transport, or transportation networks. Connectivity gaps can be observed in various forms, each impacting the overall efficiency of freight systems. Some connectivity gaps can result from the quality, capacity and design of physical freight transport infrastructure. These connectivity gaps often have impacts that are quite visible to users and operators, such as deteriorated infrastructure or transport network congestion. Other connectivity gaps result from a lack of stakeholder coordination, operational inefficiencies, or latent demand that is not met by existing services. These impacts are typically less visible to external stakeholders and much more difficult to assess. Table 2 presents a list of potential connectivity gaps and the factors that contribute to them.

Identifying and addressing these connectivity gaps is crucial for enhancing regional freight connectivity. Solutions often require a blend of improving physical infrastructure (hard measures) and optimising administrative, regulatory, and operational aspects (soft measures). Examples of these measures and their potential for addressing connectivity gaps in Central and Southeast Asia are provided in the following section.

Table 2. List of factors contributing to various freight connectivity gaps

Connectivity gap	Contributing factors
Infrastructure deficiencies	Low-quality or inadequately maintained transport infrastructure can lead to increased transport times, higher transport costs, and reduced reliability.
Inadequate capacity	Infrastructure and services that are not sufficient to meet demand can result in congestion, delays, and potentially higher freight costs.
Technological shortcomings	A lack of modern technological platforms for tracking and optimising the movement of goods hinders the flow of real-time information, leading to delays and increased operational costs.
Regulatory and policy barriers	Difficulties in cross-border transport due to varying standards and procedures often create delays and lead to increased costs.
Operational inefficiencies	Suboptimal transport routing and underutilised resources may result in inconsistent service delivery, higher shipping prices, and reduced ability to respond to market demands.
Lack of coordination among stakeholders	Leads to disjointed and suboptimal supply chains, affecting the overall performance of the freight system.
Limited accessibility	Certain regions may be underserved by infrastructure or service providers, impacting their economic development and integration into broader supply chains.

Measuring connectivity gaps at three different levels

Given that there are many factors that contribute to gaps in regional freight connectivity, identifying such gaps requires a systematic approach. A three-level methodology is proposed to identify regional freight connectivity gaps:

- Macro-level: identifies relative gaps in national freight connectivity between different countries in a region.
- Meso-level: identifies gaps in connectivity for a given international or domestic origin-destination pair or along a specified freight route or corridor.
- Micro-level: identifies gaps in connectivity for specific links or nodes in the freight network (e.g. border crossing points or intermodal terminals).

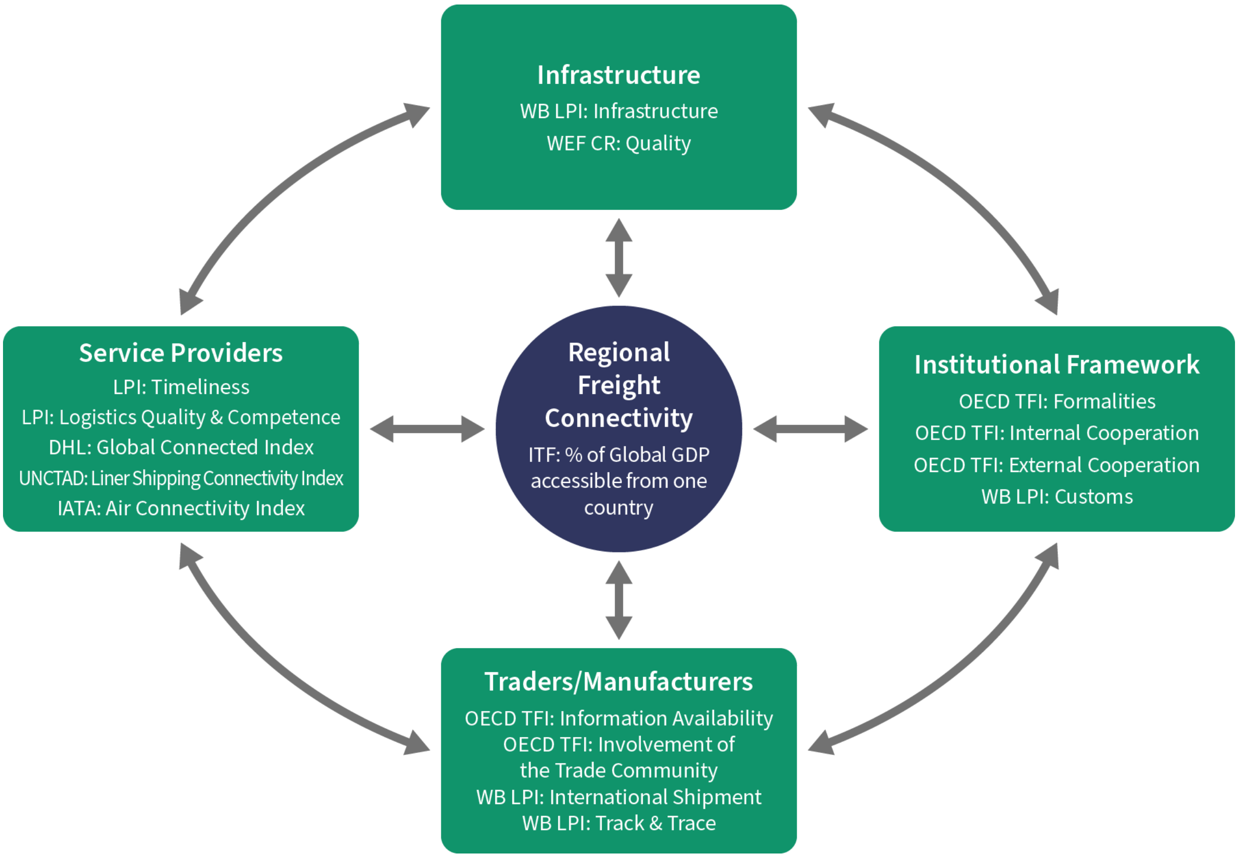
Examples for each type of connectivity gap assessment are provided below. These can be selected or adapted depending on the application and availability of information.

Macro-level connectivity assessment

The freight connectivity scorecard

The freight connectivity conceptual model presented earlier in this report (see Figure 1) provides a foundation for assessing freight connectivity at the macro level. This model can be transformed into a scorecard with scores reflecting each of the four dimensions of connectivity. This scorecard uses widely available indicators such as the World Bank's Logistics Performance Index (WB LPI), the OECD's Trade Facilitation Indicators (OECD TFI), the World Economic Forum Competitiveness Report (WEF CR), DHL's Global Connectedness Report, UNCTAD's Liner Shipping Connectivity Index, and IATA's Air Connectivity Index. Figure 2 illustrates how these indicators can be combined to create a freight connectivity scorecard.

Figure 2. The freight connectivity scorecard



The indicators used for this scorecard are extracted from a variety of sources. This freight connectivity scorecard can be applied broadly around the world and adapted by regional development organisations, providing that regional data related to freight connectivity are available. Other indicators may be substituted for those below if they are not available for a given country. In certain applications, like the practical example given at the end of this subsection, some of these indicators might not apply.

The World Bank's Logistics Performance Index (LPI) assesses logistics performance through a worldwide survey that gathers feedback from global freight forwarders and express carriers, providing an informed assessment of countries' logistics environments. The LPI evaluates countries across six key dimensions of logistics performance, which reflect the main aspects of the logistics process. These dimensions are customs, infrastructure, international shipments, logistics quality and competence, tracking, and timeliness. The scoring in the WB LPI is based on a 5-point scale, where 5 is the highest score. The LPI infrastructure score is used in this evaluation (World Bank, 2023).

The World Economic Forum Competitiveness Report (WEF CR) offers an innovative and comprehensive framework for assessing the quality of economic growth, including a score for infrastructure quality. While it brings significant strengths in providing a holistic view of growth and facilitating policy guidance, the methodology also faces challenges related to complexity, data quality, and potential subjectivity in interpretation. A scoring system from 1 to 7 is used for infrastructure quality, where 7 indicates the best possible performance (WEF, 2024).

The OECD’s TFI methodology organises trade facilitation measures into several indicators, such as information availability, involvement of the trade community, advance rulings, appeal procedures, fees and charges, document formalities, automation, internal and external co-operation, and governance and impartiality. Each measure is assessed based on precise, fact-based variables that reflect both the regulatory framework and the practical implementation of trade facilitation measures in the country. A scoring system from 0 to 2 is used, where 2 indicates the best possible performance. Only measures relevant to regional freight connectivity are included in the scorecard (OECD, n.d.).

The DHL Global Connectedness Index (GCI) offers a comprehensive analysis of globalisation by measuring international flows of trade, capital, information, and people across countries. Its scope encompasses evaluating these flows in both depth (the extent to which a country’s domestic activity is internationalised) and breadth (the distribution of a country’s international activities across different countries). A scoring system of 1 to 100 is used, where 100 indicates maximum connectivity (Altman and Bastian, 2024).

The Liner Shipping Connectivity Index (LSCI) indicates an economy’s position within global liner shipping networks. It is calculated from the number of ship calls, the container handling capacity of ports, the number of services and companies, the size of the largest ship, and the number of countries connected through direct liner shipping services (UNCTAD, 2023). Port container traffic is measured in twenty-foot equivalent units (TEUs). The number of port calls and the time spent in ports are derived from automatic identification systems and port mapping intelligence. This indicator is not applicable if the assessed region or countries are landlocked.

The IATA Air Connectivity Index measures the degree to which air transport connections support a country's economic development and productivity levels (IATA, 2020). It is designed for policymakers to evaluate air connectivity's role in their country's economy, capturing aspects such as the economic importance of destination cities and onward connections to the global air transport network. The index is based on the number of available annual seats to each destination from the point of interest (a city or country's major airports). This data is typically gathered from airline schedules. The limitation of this index for freight connectivity assessment is that it uses passenger connectivity as a proxy measure but remains the best available global indicator for air connectivity.

To assess freight connectivity, the OECD TFI, the WB LPI, the WEF CR, the UNCTAD LSCI, and the IATA ACI scores for each dimension are tabulated against each other within a region to highlight relative connectivity gaps between countries. The idea is to obtain an overview of areas where challenges might occur due to differences in the scores of each connectivity dimension.

In addition to the dimension-specific indicators, the ITF’s Global Connectivity Score is used as an overall reference for overall freight connectivity. The ITF connectivity score quantifies a country's ability to access global markets based on the percentage of global GDP accessible through its transport networks. Box 1 describes the calculation methodology in detail. The score is influenced by factors like the quality and capacity of transport infrastructure, efficiency of border crossing procedures, transport costs, and travel times. Higher scores indicate better connectivity, suggesting a country is well-positioned to participate in global trade as it is capable of accessing a larger share of the global market with relative ease. Conversely, low scores point to potential barriers that might hinder a country's access to global markets, such as inefficient infrastructure or lengthy border crossing times (ITF, 2019).

The ITF connectivity score for Central Asian countries is around 50% of that of Germany, which is one of the best performers (ITF, 2019). This affects the region’s ability to integrate into global value chains. Since the indicator also considers the location of domestic production and consumption centres, travel distance can be a major obstacle to connectivity. Countries in Central Asia must overcome their large land area, geographic position and low population density to reach global economic centres. A manufacturer in

Germany or the United States can reach 20% of the global GDP within 2 000 kilometres of travel. For a Kazakh manufacturer, the average distance needed to reach the same 20% threshold is over 4 000 kilometres. In terms of cost, the gap is even larger between developed economies and Central Asian countries. The cost of reaching 20% of world GDP is nearly USD 300 per tonne for Kazakhstan, whereas, for Germany and the United States, the cost is around USD 50 per tonne.

Box 1. Understanding the ITF connectivity score

The following hypothetical scenario is used to illustrate the results of a connectivity score analysis.

Assume that Country A has a baseline connectivity score indicating it can access 40% of global GDP within a certain cost and distance threshold through its existing transport networks. This score reflects the country's existing infrastructure capacity, average transport costs, and border crossing efficiencies.

If Country A invests in upgrading its transport infrastructure, reducing travel times and increasing capacity, the connectivity score might improve to 50%. This indicates an increased ability to access global markets, potentially leading to higher trade volumes and economic growth.

If Country A also streamlines its border crossing procedures, further reducing time and costs associated with cross-border trade, its connectivity score could rise to 60%. This improvement highlights the significant impact of reducing non-physical barriers on trade connectivity.

Country A's score can be compared with Country B's score, which is assumed to have a connectivity score of 70%. The score of Country B can be used to identify gaps and opportunities for improvement. Country B's higher score might result from more advanced infrastructure, better logistics services, or more efficient border management practices. The analysis indicates specific areas where Country A can focus its efforts to enhance connectivity. Investments in infrastructure, policy reforms to speed up border crossings, and improvements in logistics services are potential measures to boost its connectivity score.

To illustrate how the freight connectivity scorecard can be applied in practice, the example of transporting goods from Malaysia to Vietnam via Thailand and Lao PDR is presented in Table 3. In this table, the score of UNCTAD's Liner Shipping Connectivity Index and IATA's Air Connectivity Index are not included as the focus is on land connectivity between Malaysia, Thailand, Lao PDR, and Vietnam. The ITF's global connectivity score is not currently available for Southeast Asia and is therefore omitted in this example.

The final scores for each dimension were normalised by converting the original scores into a percentage of the maximum possible score. It is clear from the results that there are few freight connectivity issues between Malaysia and Thailand, as the scores across all dimensions are remarkably similar. Freight connectivity will be challenging with Lao PDR, however, as the country has the lowest score in all connectivity dimensions when compared to neighbouring countries. Lao PDR's lower scores across all categories highlight significant regional freight connectivity gaps, particularly in infrastructure and institutional frameworks. This suggests Lao PDR faces more substantial challenges in facilitating efficient regional connectivity, and any regional trade that originates from, terminates in or transits through Lao PDR may encounter delays due to infrastructure and institutional procedures. Future investments in regional connectivity could, therefore, focus on improving the score of Lao PDR's infrastructure and institutional frameworks to the level of its neighbours.

Table 3. Assessment of freight connectivity from Malaysia to Vietnam via Thailand and Lao PDR

Freight Connectivity Measure	Malaysia	Thailand	Lao PDR	Vietnam
Infrastructure				
WB LPI Infrastructure Score	72%	74%	46%	64%
WEF CR Infrastructure Quality	74%	70%	62%	64%
Institutional Framework				
OECD TFI: Formalities	76%	90%	25%	70%
OECD TFI: Internal Co-operation	60%	40%	55%	65%
OECD TFI: External Co-operation	50%	50%	50%	50%
WB LPI Customs Score	66%	66%	46%	62%
Service Providers				
WB LPI Timeliness Score	74%	70%	56%	66%
WB LPI Logistics Quality & Competence	74%	70%	48%	66%
DHL Global Connected Index Score	60%	58%	44%	57%
Shippers and Consignees				
OECD TFI: Information Availability	80%	75%	70%	80%
OECD TFI: Involvement of the Trade Community	85%	85%	25%	70%
WB LPI: International Shipment Score	70%	70%	46%	66%
WB LPI: Track and Trace Score	74%	72%	48%	68%

Meso-level connectivity assessment

The Banomyong and Beresford multimodal transport cost model

Like other macro-level assessments, the use of the freight connectivity scorecard is subject to limited granularity in terms of the specific causes of connectivity gaps within a given freight corridor. Therefore, there is a need to explore further connectivity. One approach is the Banomyong and Beresford multimodal transport cost model (Banomyong and Beresford, 2001). This model has previously been applied to many different geographical locations with a variety of freight types. It should be utilised together with the freight connectivity scorecard to provide an indication of specific regional logistics system performance, especially when assessing the performance of a domestic or international freight corridor.

In order to use this model, each step in the freight transport process within the corridor must be decomposed into a detailed logistical activity map. Table 4 presents a template for the logistical activity map with each of the inputs required for the multimodal freight transport cost model. Data utilised when creating this graphical model can be based on quotes or transit time components that are obtained during interviews with transit and transport service providers, traders, governmental officials, or other available sources. Data on transit times offered for each transit route and the variation in delays at critical nodal links must also be obtained. Note that both cost and travel time data can be difficult to obtain from public sources. The complete information needed to build the graphical model is as follows:

- The origin and destination of the cargo.
- The full route from origin to destination, with an indication of the activities where the cargo is essentially stationary (such as border crossings and points of intermodal transfer).
- Mode of transport for each leg of the journey.
- Distance for each leg of the journey.
- Transit time for each leg of the journey.
- Cost or quotes for each leg of the journey.

Table 4. Logistical activities template for the multimodal transport cost model

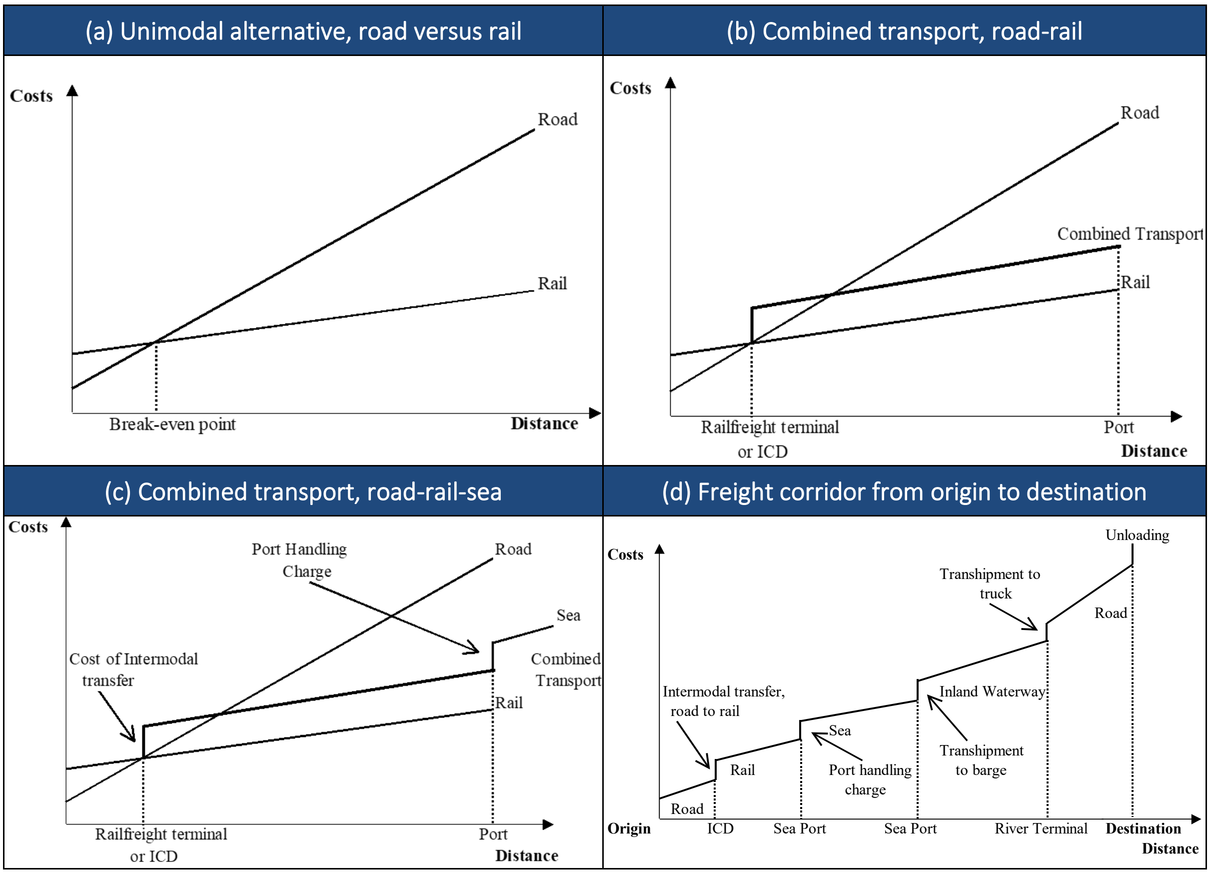
Activity	Average time	Time variability	Average cost	Cost variability	Actors involved	Documents or operations	Cumulative distance
1							
2							
3							

Once the logistical activity data has been collected for a given product along the corridor of interest, the data can then be graphically illustrated by plotting cost and time against the distance from the origin to the destination for alternative multimodal routes. The model thus visually represents the cost and time components of the movement of goods from origin to destination illustrates the delays at borders or other checkpoints, and indicates the approximate proportion of non-transport costs in relation to transport costs. The multimodal freight transport cost model can incorporate costs or travel times associated with any freight transport mode (e.g. road, rail, inland waterways or maritime transport) and with transfers between modes (e.g. at ports, rail terminals or inland clearance depots).

Points of transhipment, at border crossings or between modes, are incorporated into the cost and time curves as vertical steps as they do not involve any physical progress being made along the logistics corridor. For example, at ports and inland terminals, a freight handling charge is levied; therefore, the costs incurred here are represented by a shift upwards in the cost curve, but no change in distance travelled. The height of the step is proportionate to the amount of the charge. Any delays incurred are similarly reflected in the travel time representation of the model. These vertical steps can reflect different charges or processes involving a time delay, such as document fees, transit charges and cargo clearance costs. As a rule of thumb, the higher the vertical step, the more likely it is that the border crossing or the nodal link is a bottleneck in the freight corridor. Using the graphical model, the impact of these infrastructural or procedural bottlenecks on the overall logistics corridor can be assessed relative to other costs and delays. Further information, such as the breakdown of individual fees at border crossings or ports, can be added to highlight areas for action by policymakers.

Figure 3 shows illustrative examples of the model's graphical output with the distance and cost of transport plotted on the x-axis and y-axis, respectively. There are four versions of the model for different transport distances. The first model in Figure 3(a) shows two unimodal alternative routes for overland transport, where road transport is cheaper than rail transport over a short distance due to the initial costs required for transporting the goods to the railway station. However, as the distance increases, the two lines cross and beyond the crossing point, rail transport has a lower transport cost than road transport. Figure 3(b) introduces the option of a multimodal trip using both road and rail. In Figure 3(c), a maritime transport leg is added to the multimodal trip with additional costs for intermodal transhipment at a seaport. Finally, Figure 3(d) illustrates the full multimodal trip from origin to destination, with several transhipment costs and varying transport cost slopes depending on the mode. The model inputs could also be used to plot travel time curves for the same routes.

Figure 3. An example of the multimodal corridor cost model



Source: Adapted from Banomyong and Beresford (2001).

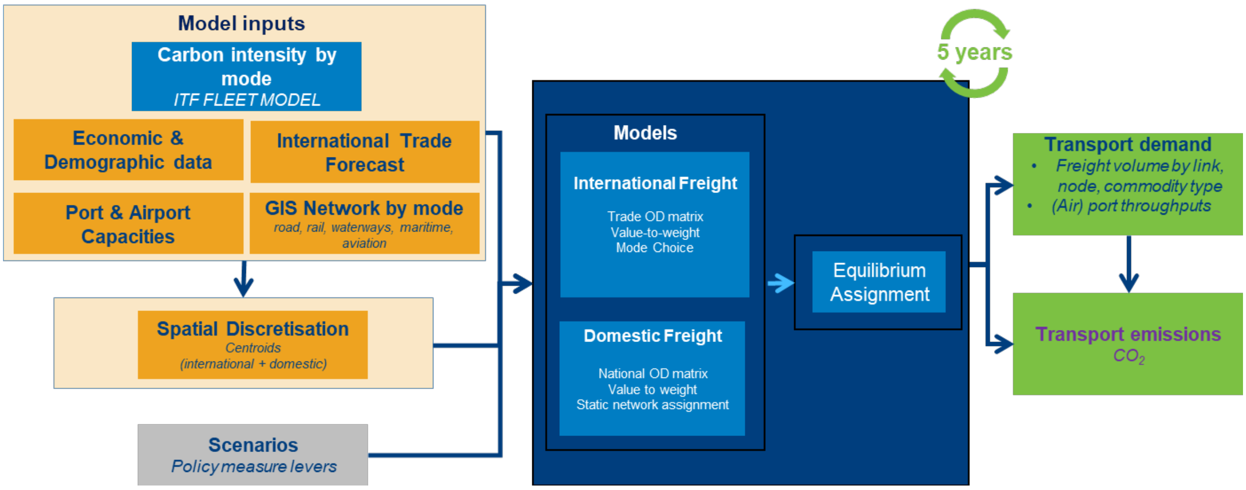
The graphical output can be a useful tool in the debate over the value of time in freight transport operations by analysing transit times by mode and route. The longer the time required for freight to reach its destination, the greater the implicit costs of working capital. Total implicit costs may, however, be even greater, as some goods are required on an urgent basis, and future business may be lost if goods arrive too late. The value of time will therefore depend on the nature of the commodities being transported. The cost of delay must also be considered when appraising the risks attached to specific multimodal routes. As part of a freight corridor analysis, it is important to examine the trade-off between the monetary costs for transporting the goods and the implicit costs associated with the travel time and risk of delay.

In summary, this model provides a framework for reviewing door-to-door supply chain costs. It identifies the critical components of multimodal transport, including origin-to-destination transport, consignment loading and unloading, intermodal transfers, and performance variability. Its strengths include its ability to identify theoretical alternative locations for facilities like inland terminals and understand the cost structure of multimodal transport services along economic corridors.

The ITF Non-urban Freight Model

The ITF Non-urban Freight Model (NUFM) is another tool for meso-level analysis. The NUFM is a multimodal network model designed to forecast the impacts of policy measures on global freight transport under various scenarios. This model estimates global freight flows, assigning these flows to specific routes, modes, and network links across all major transport modes, including air, inland waterways, maritime, rail, and road. It integrates international and domestic freight models, using data on trade and transportation from ITF member countries to calibrate and validate the model. The objective of the model is to understand and plan for the future of global freight transport, offering insights for policymakers, industry stakeholders, and researchers interested in the complex dynamics of international and domestic freight movements. The diverse model outputs can also be used to evaluate the connectivity of freight transport for a country or region of interest. The inputs and outputs of the NUFM are shown in Figure 4.

Figure 4. Overview of the ITF Non-urban Freight Model



The current version of the model estimates freight transport activity for 19 commodities across all major transport modes. The underlying network contains more than 8 000 centroids, or locations where goods are consumed and produced, and more than 150 000 transport links. Link information includes capacity, travel time (including border crossing times), and travel costs per tonne-kilometre (OECD, 2024). The modelling approach accommodates congestion and capacity constraints, especially at ports, to determine the most efficient routes for freight movement. It emphasises multimodal transport networks and includes elements such as consignment loading and unloading, intermodal transfer, and performance variability, with the flexibility to incorporate additional activities like storage and customs clearance. The model's flexibility allows for scenario analyses, including the implementation of policy measures aimed at reducing CO2 emissions and enhancing transport connectivity through different combinations of infrastructure developments, economic instruments, and technological innovations.

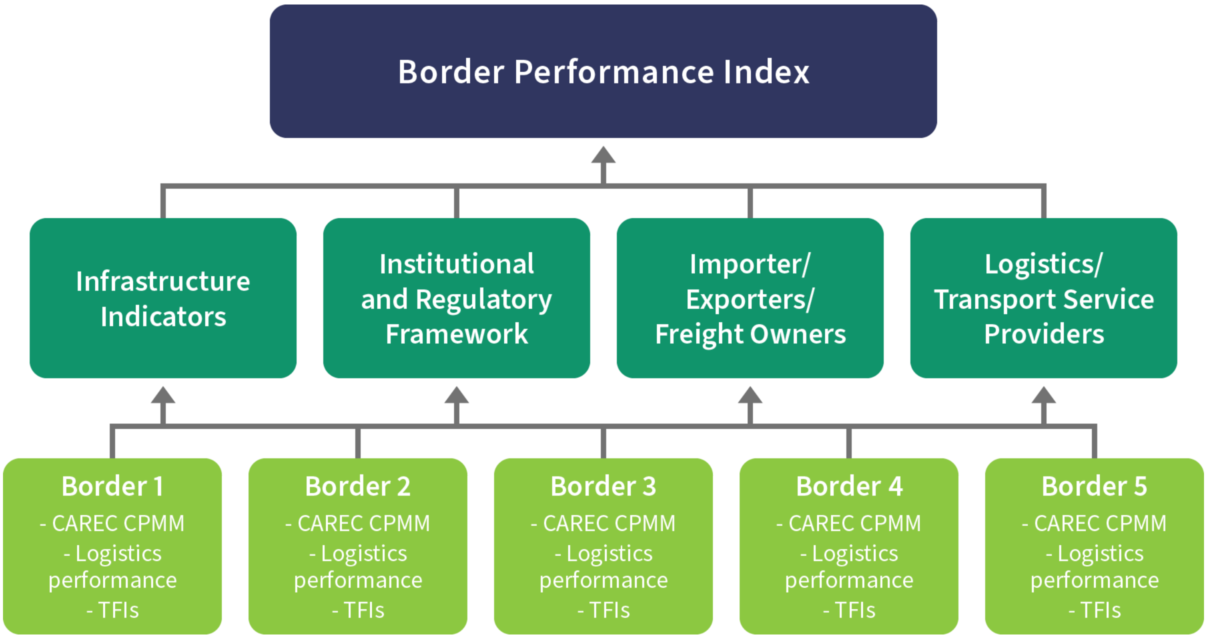
While both meso-level models described herein can be used independently, they can also be combined for greater insights. Integrating the NUFM with the multimodal cost model described earlier involves aligning the comprehensive, scenario-based forecasting abilities of the former with the detailed, operational focus of the latter. The NUFM's broad perspective on policy measures, infrastructure development, and trade barriers can provide a strategic framework for applying the multimodal cost model's detailed analysis of door-to-door supply chain costs and multimodal transport efficiencies. Integrating models produces a more nuanced understanding of freight transport's cost, time, and performance variability across different modes and routes, enhancing strategic decision-making for infrastructure development and policy formulation. By leveraging both the NUFM's forecasting capabilities and the multimodal cost model's operational insights, policymakers and planners can gain a holistic view of multimodal transport's future needs and challenges. This integrated approach can facilitate more informed decisions on infrastructure investments, policy measures, and supply chain strategies, ultimately contributing to the development of efficient, cost-effective, and sustainable freight transport systems.

Micro-level connectivity assessment

The Border Performance Index

The Border Performance Index (BPI) is a metric designed to evaluate the efficiency and effectiveness of border processes in trade, specifically at border crossings. It assesses elements of border performance, such as the speed of customs clearance, the ease of transporting goods across borders, and the overall regulatory environment affecting cross-border trade. The BPI methodology involves distributing a survey questionnaire to border-crossing users to measure perceptions of the performance across the four key dimensions of regional freight connectivity: infrastructure, regulatory framework, logistics service providers, and shippers and consignees, as illustrated in Figure 5. The development of the BPI is influenced by the World Bank's Logistics Performance Index (LPI). The BPI and the LPI differ primarily in their scope and focus. The BPI focuses on the efficiency of border processes related to trade, such as customs, border control, and cross-border transportation. It assesses the ease and speed of moving goods across borders.

Figure 5. Conceptual model of the Border Performance Index



Each dark green box in Figure 5 represents a different dimension in the index, such as customs efficiency, logistics quality, or infrastructure. These dimensions are quantified for each border using established performance metrics, including (1) CAREC CPMM (Corridor Performance Measurement and Monitoring) and (2) the OECD Trade Facilitation Indicators (TFIs), whose details are described below. The interconnections indicate that each element contributes to the overall BPI, reflecting a comprehensive approach to evaluating border performance in a logistics and trade context.

(1) The CAREC CPMM is a methodology that measures and records actual cargo shipments along CAREC corridors and at border-crossing points (ADB, 2020).

(2) The OECD TFIs are a set of measures developed to help governments improve their border procedures, reduce trade costs, and enhance trade flows (OECD, n.d.).

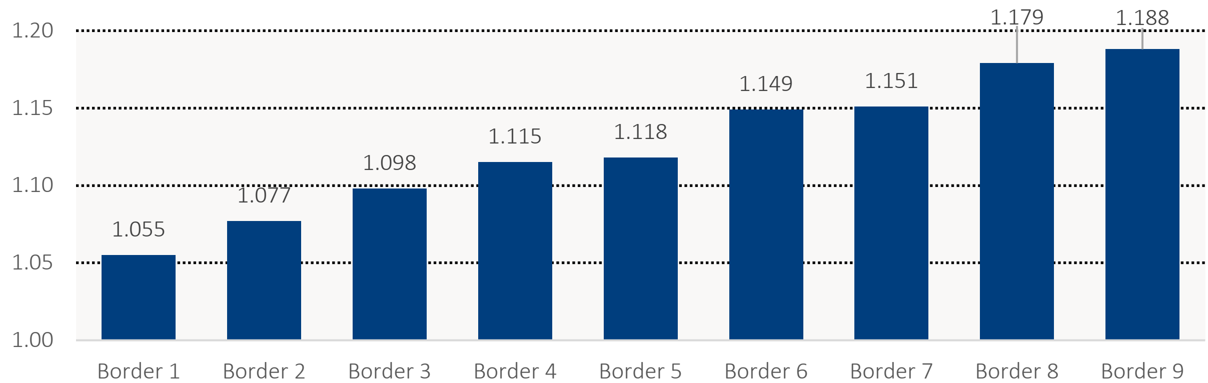
The scales used in the BPI questionnaire are based on the OECD TFIs and measure the extent to which border crossings have implemented trade, transit and transport facilitation measures, as well as their connectivity performance relative to others. A response of 0 represents low connectivity performance, 1 represents adequate connectivity performance, and 2 represents the highest performance.

For each dimension of connectivity, scores ranging between 1 and 2 indicate that border processes are efficient and meet or exceed the standards for trade facilitation and logistics operations. Scores less than 1 are indicative of inefficiencies or challenges in providing border crossing connectivity. Based on the overall BPI, individual border crossings can be categorised as:

- High performer: Crossings with high scores across all or most dimensions, indicating efficient and effective border operations.
- Consistent performer: Crossings with consistent performance across dimensions, though there may be room for improvement.
- Partial performer: Crossings where performance is mixed or below average in several dimensions, indicating significant areas for development.

BPI scores can be used for benchmarking, allowing comparison between different border crossings in the same region or country to identify best practices and areas needing improvement. High-performing areas can serve as models for developing strategies to improve lower-performing areas. Figure 6 offers an example of the output of a BPI result. In this example, the BPI scores of nine different border crossings in Thailand were benchmarked. All borders had an average score of 1 or greater, indicating that, from the perspective of users, the overall connectivity performance is adequate.

Figure 6. Results from a Border Performance Index assessment in Thailand



While the overall scores are remarkably similar, the differences can highlight varying levels of border performance, and the dimension-specific results can pinpoint specific areas where improvements can be targeted to improve border operations. Continuous evaluation using the BPI followed by targeted improvements is essential for raising the performance of border operations.

Policy measures to enhance freight connectivity

Once connectivity gaps are identified through macro-, meso-, or micro-level assessment, policy actions and investments can be taken to address them. Policy measures for enhancing freight connectivity generally fall into one of two categories: hard policy measures that involve physical infrastructure and soft policy measures that involve regulations and international coordination. Both types of measures should be coordinated to maximise the potential connectivity benefits. Coordination between soft and hard measures is analogous to having the right operating system for the available hardware.

Hard policy measures

Hard policy measures in the context of freight transport connectivity refer to physical infrastructure or fleet-based interventions such as the development of a new rail corridor or the purchase of new maritime vessels. These measures are tangible, involving construction, expansion, or refurbishment as opposed to soft policy measures, which typically seek to streamline regulations, modify trade agreements, or produce behaviour change. UNESCAP (2019) highlights the importance of hard measures such as infrastructure investments in enhancing freight connectivity through the development and integration of transport networks across Asia and the Pacific.

In recent years, significant research and investments have targeted hard measures to enhance global connectivity. For example, the Belt and Road Initiative (BRI) undertaken by the Chinese government focuses heavily on infrastructure development across continents. China has invested approximately USD 1 trillion in the BRI, with projections suggesting total expenditures of up to USD 8 trillion. The BRI's objective is to enhance global economic links, particularly through infrastructure development across Asia, Africa, Oceania, and Latin America. For Southeast and Central Asian countries, the BRI has significant implications, including improved infrastructure, increased trade, and potential geopolitical shifts. The initiative's expansive reach underscores its relevance in reshaping regional dynamics, offering both opportunities and challenges for the participating countries (CFR, 2023).

The Asian Highway Network and the Trans-Asian Railway Network are among the hard measures recommended for enhancing freight connectivity in Central and Southeast Asia, as they are intended to aggregate disparate infrastructure systems into a cohesive regional network. These are examples of hard measures that invest in improving transport infrastructure. Hard measures related to transport infrastructure do not necessarily need to involve building new railway tracks or highway lanes. The implementation of safety and efficiency measures like better signalling systems, automated toll booths, and enhanced navigation aids are hard measures that can improve connectivity by limiting the frequency of disruptions and reducing travel time.

Expanding or enhancing logistics-only infrastructure such as dry ports, intermodal terminals, and logistics parks is another important category of hard policy measures (Park, 2020). In the case of port-related infrastructure, capacity expansion, such as expanding docks, terminals, and storage areas to handle larger volumes of cargo, reduces dwell time. Upgrading to more efficient cranes, automated loading systems, and improved logistics software will similarly improve cargo handling. The deepening and widening of channels will allow for larger vessels with lower transport costs per unit of weight or per container.

Table 5 provides a selection of hard policy measures that can improve freight connectivity when implemented effectively.

Table 5. Potential hard measures for enhancing freight connectivity

Measure	Activity
Transport infrastructure capacity enhancements	Building, upgrading and rehabilitating physical transport infrastructure such as roads, railways, ports, and airports.
Transport network expansion	Expanding the network of transport infrastructure by creating new links that reduce transport costs and time.
Establishment of dry ports and intermodal terminals	Creating new or expanded terminals to facilitate the transfer of goods between different freight transport modes.
Logistics parks and hubs	Development of transhipment depots and warehouses to enable a hub and spoke network for freight consolidation.
Border infrastructure improvements	Adding new border facilities or expanding the capacity of existing facilities to reduce waiting times.
Information technology infrastructure	Introducing or improving track and trace capability to enable more efficient information sharing and logistics operations.
Investment in fleet modernisation	Replacing older freight vehicles with modern, more fuel-efficient and reliable vehicles to reduce operating costs per tonne-kilometre.

The hard measures presented in Table 5 often involve substantial capital investments and extensive implementation times. Furthermore, any cross-border infrastructure will require co-operation between governments, which may be facilitated by a regional coordination organisation such as the ASEAN secretariat or the CAREC program. Hard policy measures such as the development of logistics hubs, where logistics service providers are the intended end users, should also be coordinated with the needs of the private sector.

In the context of Central Asia, a specific, quantitative example of hard measures for enhancing freight transport connectivity is the target set by the 2020 CAREC Transport and Trade Facilitation Strategy (TTFS) to build 7 800 km of roads and 1 800 km of rail track by 2020. This expansion and development of road and rail networks was much needed to support trade and transport efficiency across Central Asia. These targets were exceeded by 2017, resulting in considerable progress towards the enhancement of freight connectivity in the region (CAREC, 2019). Similarly, the Master Plan on ASEAN Connectivity 2025 (MPAC) encouraged the completion of the ASEAN Highway Network (AHN) by upgrading key corridors to meet the AHN minimum desirable standard for lane width and pavement surface (see UNESCAP, 2001). This is part of an ambitious effort to establish integrated, safe, and sustainable regional land transport corridors that connect the region (ASEAN, 2016). By 2015, the total length of substandard roads in the AHN was reduced to 2 454 km, 46% lower than the total length of substandard AHN roads in 2010.

Funding is always a challenge when implementing hard measures. The MPAC 2025 mentions the importance of mobilising resources from a variety of sources due to the significant investment requirements for many projects and the constraints on ASEAN Member States' budgets. These sources include multilateral funds, pension funds, bond markets, other governments, and the private sector. However, the MPAC 2025 stated that domestic capital markets in most ASEAN Member States currently provide limited opportunities to source project finance for infrastructure projects, especially outside Singapore, Thailand, and Malaysia. Specific emerging funding vehicles mentioned include:

- Asia Bond Fund (ABF).
- Asian Bond Market Initiative (ABMI).
- ASEAN Infrastructure Fund (AIF).
- Asian Infrastructure Investment Bank (AIIB).
- New Development Bank (NDB).
- Expanded Partnership for Quality Infrastructure (PQI).

These proposed funding vehicles are part of ASEAN's efforts to encourage more private sector investment in infrastructure across the region. Despite the increase in the availability of funds, the MPAC also emphasises the essential role of enhancing Public Private Partnership (PPP) frameworks in ASEAN to address issues such as risk-sharing arrangements and project development. This is similar to infrastructure funding in CAREC, where private sector participation is encouraged as a strategy to enhance efficiency, broaden the funding base, improve risk management, and promote institutional reforms of state-owned transport operators. These initiatives are planned to be expanded, and other joint public-private initiatives will be implemented as part of the CAREC Transport Strategy 2030 (CAREC, 2019). This approach aims to leverage private sector resources and expertise to develop and manage transport infrastructure, thereby augmenting the capabilities and resources available for such projects within the CAREC region. However, based on the estimated infrastructure funding gap for both ASEAN and CAREC described earlier, infrastructure funding in both regions will remain limited.

Soft policy measures

Soft policy measures for enhancing connectivity focus on policies, regulations, and collaborative efforts rather than on physical infrastructure. These measures are crucial in complementing hard measures to produce effective connectivity. Gould, Kenett and Panterov (2018) describe how the establishment of supportive policies and regulatory frameworks that ease the movement of goods, services, and people across borders is needed to maximise the benefits of physical connectivity enhancements.

There are three typical soft measures that are used to enhance connectivity. (1) Harmonisation of logistics, transport regulations and standards, (2) trade and transport facilitation measures, and (3) collaboration and co-operation among freight transport stakeholders.

One important soft measure is the alignment of national, regional and international logistics and transport regulations to facilitate seamless cross-border logistics and transport. This can be done through the standardisation of vehicle specifications, safety standards, and driver qualifications. Administrative burdens and delays can be avoided when countries agree to recognise each other's certifications and standards through mutual recognition agreements. The implementation of electronic documentation (e-documentation) for logistics and transport to streamline processes and reduce paperwork is another key soft measure. Finally, harmonising safety protocols and environmental regulations will ensure a high standard of logistics and transport operations. A list of potential soft measures for enhancing freight connectivity is shown in Table 6.

Table 6. Potential soft measures for enhancing freight connectivity

Measure	Activity
Regulatory reforms	Enact policies that streamline regulations affecting the transport of goods. This may involve removing bureaucratic obstacles, simplifying licensing procedures, and ensuring transparent regulatory practices.
Harmonisation of standards	Align national standards with international or regional standards for goods, vehicles, and operational procedures to reduce the need for re-inspection at borders and to reduce transit times.
Simplification of customs procedures	Adopt electronic documentation, single-window systems for trade, and mutual recognition agreements to expedite customs clearance processes.
Enhancement of cross-border co-operation	Support collaborative efforts between neighbouring countries, share best practices and resolve common challenges through dialogue and joint initiatives.

The ASEAN Connectivity 2025 Master Plan outlines a comprehensive approach to improve physical, institutional, and people-to-people connectivity (ASEAN, 2016). Specific to freight connectivity, soft measures emphasised the harmonisation of rules, regulations, and standards across ASEAN members to simplify and standardise customs procedures and trade regulations. Efforts include the ASEAN Single Window (ASW), which aims to expedite cargo clearance and promote efficient trade across borders. The efficiency of logistics and supply chain networks across the ASEAN region is also expected to be improved through the adoption of modern technologies, enhanced logistics services, and capacity building. This is combined with further liberalisation of trade in goods and services within the ASEAN member states to reduce barriers and costs associated with cross-border freight movements.

ASEAN has further developed three main transport facilitation agreements, which function as soft measures to support freight connectivity within the region. Annex C provides a summary of each agreement. Together, these three agreements demonstrate the ASEAN member states' commitment to improving regional connectivity and economic integration through soft freight trade measures. While the intentions and principles behind these three framework agreements are laudable, their implementation remains incomplete.

The CAREC Transport Strategy 2030 includes a focused strategic pillar on Cross-border Transport and Logistics Facilitation (CBTLF), aiming to enhance the efficiency of cross-border movement of people and cargo in the region (CAREC, 2019) through soft measures. This strategy emphasises a holistic approach to trade and transport facilitation. Table 7 presents the soft measures targeted by the CAREC region as part of the CAREC Transport Strategy 2030.

These soft measures were designed to address the key issues faced by the CAREC program, including outdated infrastructure and equipment, inefficient and duplicative customs and border procedures, and the absence of effective traffic rights agreements. By implementing these soft connectivity measures, CAREC intends to reduce the average time and cost of clearing borders, thereby enhancing the overall efficiency of cross-border transport and logistics within the CAREC region.

The ASEAN and CAREC strategies both recognise the critical role of soft measures for improved freight connectivity. While ASEAN emphasises intra-regional connectivity, the CAREC initiatives aim primarily at establishing connections between Central Asia and broader global markets. Overall, both organisations take a multi-dimensional approach to connectivity, combining infrastructure development, regulatory harmonisation, and capacity building to achieve their objectives.

Table 7. Soft freight connectivity measures in the CAREC Transport Strategy 2030

Measure	Activity
Improvement of customs and border control procedures	Implement modern risk management principles for cargo vehicles and drivers at border crossing points.
Facilitation of cross-border and transit traffic	Adopt international transport conventions and agreements, as well as regional traffic rights agreements.
Corridor-based approach to CBTLF	Focus on transport facilitation actions along the six CAREC Corridors, monitored by the Corridor Performance Measurement and Monitoring (CPMM) system to assess the impact of CBTLF initiatives.
Regional improvement of border services	Establish integrated management structures, such as Land Port Authorities, and conduct capacity development for border management agencies.
Multimodal operations through regional sea ports	Design operational standards, revise schedules to improve interoperability, and implement advanced shipping notifications with robust risk management systems to expedite cargo clearance. In addition, develop knowledge products for training on the operation of ports, shipping logistics, and logistics centres.
Modern ICT Support	Use modern ICT to support seamless transport operations along CAREC corridors. This includes security and business process streamlining at land border crossing points and seaports, intelligent transport systems for efficient traffic management, and the integration of trade and governance information systems like National Single Windows for Trade.

Source: Adapted from CAREC (2019)

In summary, it is essential to align hard and soft measures for freight connectivity. Misalignment can create unnecessary friction in freight transport networks. Possible misalignments include the building of new cross-border infrastructure without agreeing on the modalities of cross-border goods transport with the neighbouring country or the construction of a new land border crossing without sufficient facilities for goods inspection. Addressing these challenges requires coordination and planning to ensure that the soft measures maximise the potential benefits of new infrastructure.

Conclusions

This paper provides a comprehensive definition of regional freight connectivity and its four key dimensions: physical infrastructure, institutional frameworks, logistics service providers, shippers, and consignees. The individual performance of each dimension and the degree of coordination between them determines the overall level of freight connectivity. Freight connectivity plays a pivotal role in economic development by boosting trade efficiency, contributing to social development by creating jobs, improving access to goods, and fostering a more efficient and resilient regional economy.

Methods are proposed for assessing connectivity at the macro-, meso- and micro-level, depending on the purpose of the analysis. These methods can be used to identify connectivity gaps, which are defined as disparities or inadequacies in the seamless flow of goods or information between regions and transport modes. Connectivity gaps can be caused by deficiencies in infrastructure, technology, regulations, or operational efficiency. Integrating both hard and soft policy measures is the most effective means of addressing connectivity gaps, as they complement each other in facilitating efficient and effective transportation systems. Hard measures, like infrastructure development, provide the necessary physical means for transportation. Soft measures, such as policy harmonisation and regulatory reforms, ensure seamless operations across borders and reduce bureaucratic and logistical barriers.

It is necessary to emphasise the importance of both infrastructure and institutional frameworks in facilitating efficient cross-border trade, creating a balanced approach that combines physical infrastructure upgrades with improvements in regulatory and operational frameworks to effectively boost freight connectivity across the regions. In addition, cross-border collaboration and policy harmonisation between nations are essential for maximising freight connectivity. These measures significantly enhance freight connectivity by creating standardised regulations and procedures, thus reducing delays and costs associated with cross-border trade. They also foster trust and mutual understanding, encouraging more trade and economic integration in the longer term. Additionally, co-operation can lead to shared best practices and innovations, further improving the logistics and transportation infrastructure.

Finally, this paper provides recommendations for enhancing regional transport corridors' connectivity in Central and Southeast Asia. It focuses on identifying and bridging connectivity gaps through both hard and soft measures, drawing on global examples. Key recommendations include defining regional freight connectivity indicators, conceptualising connectivity gaps, and detailing measures to enhance connectivity.

In the future, the assessment methods described in this paper can be used for post hoc evaluation of the impact of specific infrastructure projects, technological innovations in logistics, or the effectiveness of different policy harmonisation strategies. Additionally, longitudinal studies could be conducted to assess the long-term impacts of freight policy measures on regional trade and economy. With regard to the implementation of soft measures, pilot projects could be initiated in specific corridors to test the solutions proposed herein. Collaborative platforms involving all stakeholders, including governments, the private sector, and international organisations, should be established for continuous dialogue and joint problem-solving. Monitoring and evaluation frameworks will need to be developed to assess the effectiveness of these initiatives and guide future improvements.

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Annex A. ASEAN Transport Facilitation Agreements

Table A1. Summary of ASEAN Transport Facilitation Agreements

ASEAN Framework Agreement on the Facilitation of Goods in Transit (AFAFGIT)	
Objective	To simplify and harmonise transport, customs, and transit procedures, making the cross-border movement of goods more efficient. This includes reducing trade barriers and improving the regulatory conditions for goods in transit across ASEAN countries.
Key Soft Measure Provisions	• Simplification of customs procedures for goods in transit. • Mutual recognition of vehicle standards and roadworthiness for transport vehicles crossing borders. • Identification and development of transit transport routes to facilitate the movement of goods. • Implementation of measures to ensure the safety and security of goods in transit, including insurance and escort requirements.
ASEAN Framework Agreement on Multimodal Transport (AFAMT)	
Objective	To establish a legal framework for multimodal transport operations, covering the movement of goods under a single contract but performed with at least two different modes of transport (e.g., road, rail, sea, or air) within the ASEAN region. This framework aims to boost the efficiency of transporting goods by integrating different modes of transport.
Key Soft Measure Provisions	• Recognition and promotion of multimodal transport operators (MTOs) to ensure the seamless transfer of goods across modes. • Standardisation of documentation and procedures for multimodal transport. • Establishment of liability regimes for MTOs to ensure the protection of cargo owners' rights and interests.
ASEAN Framework Agreement on the Facilitation of Inter-State Transport (AFAFIST)	
Objective	To facilitate and promote the cross-border movement of passengers and goods between ASEAN countries. This agreement focuses on reducing non-physical barriers to transport, such as regulatory and procedural obstacles, to enhance economic integration and connectivity.
Key Soft Measure Provisions	• Simplification and harmonisation of transport, customs, and immigration procedures for inter-state transport. • Development and promotion of efficient, secure, and integrated transport operations. • Implementation of measures to ensure the safety, security, and environmental sustainability of inter-state transport.

Source: Adapted from the ASEAN Secretariat.

Annex B. Macro-level freight connectivity indices

Table B1. Summary of macro-level freight connectivity indices

Name (Source)	Description	Strengths	Weaknesses
Globalization Index EY / Economist Intelligence Unit	Measures the openness to trade, capital movements, exchange of technology and ideas, labour movement and cultural integration by country.	It provides a measure of globalisation by incorporating trade, capital movements, technology and ideas exchange, labour movement, and cultural integration, making the index a comprehensive tool for understanding the multifaceted nature of globalisation.	The broad scope does overlook specific nuances of globalisation in different sectors or regions. The methodology is also complex, making the interpretation of specific components that might contribute to connectivity rather challenging.
Global Connectedness Index DHL	Measures the flows of trade, capital, information and people by country.	This index offers a detailed look at the practical aspects of global connectedness. It can help to identify specific areas of strength or weakness in a country's international engagements.	It does not fully capture the qualitative aspects of global connectedness, such as cultural exchanges or political collaborations.
KOF Index of Globalization ETH Zurich	Measures economic, social and political globalisation by country.	The index measures economic, social, and political globalisation separately, thus allowing for a nuanced analysis of different dimensions of globalisation. This differentiation can help policymakers address specific areas more effectively.	The complexity of combining several dimensions into a single index can mask the impact of individual components. The reliance on available data can also introduce biases.
Global Competitiveness Index World Economic Forum (WEF)	Assesses the institutions, policies, and factors that determine the level of productivity of each country.	The index offers a comprehensive analysis of factors contributing to competitiveness, including infrastructure, macroeconomic stability, and innovation. This makes it useful for understanding the multifaceted drivers of economic performance.	The index was not developed to assess connectivity directly. However, as connectivity is a component of competitiveness, it can be assumed that highly competitive countries are more connected than others.
Global Connectivity Index International Transport Forum	Measures connectivity as the ease of access to global GDP.	The index measures connectivity in terms of access to global GDP. The index provides a clear, economic-focused metric for assessing how the performance of transport networks can facilitate or hinder access to markets.	The index focuses primarily on economic access but does not consider other elements of connectivity, such as political or economic integration. Assigning equal weight for connections to each dollar of GDP overlooks the true potential for trade between countries based on import and export composition.

Name (Source)	Description	Strengths	Weaknesses
Connectedness Index McKinsey Global Institute	Measures connectedness by flows of goods, services, finance, people and data.	The index offers a comprehensive view of the economic dimensions of connectivity in terms of exchanges between countries.	The index does not fully account for non-economic factors that also contribute to connectivity, such as international coordination.
Liner Shipping Connectivity Index UNCTAD	Measures the connectivity of a country or a port and indicates a country's integration level into global liner shipping networks.	It specifically measures a country's integration into global liner shipping networks, providing valuable insights for trade and logistics. It is particularly useful for countries and ports looking to improve their maritime connections.	It has a narrow focus on liner shipping and, therefore, does not capture trade connectivity by other transport modes.
Logistics Performance Index World Bank	Measures the performance of countries with respect to trade and logistics.	The index offers insights into the efficiency of customs, infrastructure, international shipments, and more. It is a powerful tool for identifying bottlenecks and areas for improvement in trade logistics.	It focuses primarily on the efficiency of trade and logistics within a country and at its borders. Does not explicitly measure the quality of transport connections between a country's production and consumption centres and those of trading partners.
Air Connectivity Index World Bank	Measures connectivity in the global air transport network. Connectivity is defined as the importance of a country as a node within the global air transport system.	The index assesses the importance of a country within the global air transport system. This is crucial for understanding global air trade flows.	It does not address connectivity for other transport modes. Air cargo transport is often a minor component of overall trade flows.
The Future of Growth Report World Economic Forum (WEF)	Introduces a comprehensive framework designed to measure the components of economic growth. The framework focuses on four key pillars: innovativeness, inclusiveness, sustainability, and resilience.	The index includes a range of qualitative dimensions. The framework offers a comprehensive assessment of growth that goes beyond traditional GDP metrics.	Despite efforts to base the assessment on factual data, the interpretation of certain indicators and the classification into growth pathway archetypes introduces a degree of subjectivity.
Trade Facilitation Indicators OECD	Measures the actual extent to which countries have implemented and adopted trade facilitation measures as per the WTO Trade Facilitation Agreement (TFA).	The index helps policymakers assess the state of their trade facilitation efforts, pinpoint challenges, and identify opportunities for progress.	The TFIs do not assess compliance with specific TFA provisions, which means they might not fully reflect a country's adherence to all the requirements of the WTO TFA.

Source: Updated and adapted from UNESCAP (2019).

Annex C. Operational connectivity methods and indices

Table C1. Summary of operational connectivity methods and indices

Name (Source)	Content	Strengths	Weaknesses
Sustainable Connectivity Indicators ASEM (Asia-Europe Meeting)	Captures a country's efforts to improve its transport connectivity through measures such as infrastructure development and national regulatory frameworks.	The index provides insights into transport connectivity and sustainability. It can be used to guide policies for medium- and long-term sustainable development.	Connectivity is measured indirectly; therefore, the index does not capture real-time performance or the immediate impact of connectivity improvements.
Multimodal Transport Connectivity Index APEC	Measures the connectivity provided by different modes of transport. It helps economies understand how multimodal links are vital to the connectivity of modern supply chains.	The index highlights the importance of multimodal links in supply chains by offering a comprehensive view of transport efficiency.	As a network-based measure, it overlooks the quality of the infrastructure and the operational efficiency of each transport mode.
Intermodal Connectivity Index de Langen and Sharypova (2013)	Assesses the level of connectivity of deep-sea ports with inland intermodal terminals via barge and rail connections.	Provides a detailed overview of connectivity between deep-sea ports and inland terminals, which are crucial for efficient cargo movement. It also emphasises the importance of seamless intermodal transfers.	It does not account for broader aspects of transport connectivity.
Sustainable Inland Connectivity Indicator (SITCIN) UNECE	SITCIN measures the effectiveness and efficiency of national transport systems and the degree of interoperability with adjacent countries.	One of the few indices that focus on interoperability of international transport. It is often used to promote regional integration and sustainable transport solutions.	The interoperability focus does not fully capture the quality or sustainability of individual transport modes within a country.
Maritime Trade Connectivity Indicator (MTCI) International Transport Forum	Measures the share of international containerised trade that is carried on direct liner connections with trade partners.	The indicator provides a simple measure of the direct maritime connectivity between a country and its trade partners. The calculation methodology and data requirements are available in ITF (2024).	It has a narrow focus on international containerised trade via liner shipping.

Name (Source)	Content	Strengths	Weaknesses
Foreland Port Connectivity Index Martínez-Moyaa and Feo-Valeroc (2020)	Measures the connectivity differences between ports with two components: a quantity index based on annualised slot capacity and a quality index that captures the quality of maritime connections. Considers multiple dimensions of connectivity, such as the number of shipping services, destination countries, and the quality of connections.	Incorporates both quantitative and qualitative measures of port connectivity to provide a comprehensive view of a port's role in global shipping networks.	The index's focus on maritime connections overlooks other inland transport links.
Container Performance Index World Bank and S&P Global Intelligence	Measures the efficiency and effectiveness of container ports worldwide, focusing on vessel time in port.	Provides a holistic view of container port efficiency, which is a major determinant of international connectivity for coastal countries. It also generates detailed insights into port operations and vessel turnaround times.	The emphasis on container ports may not capture the performance of other types of cargo or the broader transport network.
Corridor Performance Measurement and Monitoring (CPMM) Methodology CAREC	Measures the efficiency of transport and border-crossing points in the CAREC region. The index uses data from real-time road and rail cargo shipments to assess the efficiency of the six CAREC transport corridors. It considers factors such as travel time, costs, and the ease of crossing borders.	The index provides real-time data on transport and border-crossing efficiency, offering actionable insights for improving corridor performance.	The focus on specific corridors does not reflect overall national transport connectivity.
Border Performance Index Banomyong (2023)	Measures the efficiency and performance of individual border crossings.	Border crossing performance has a direct impact on trade facilitation, and the index has been developed to replace the Trading Across Borders indicators in the Ease of Doing Business Report.	It assesses each side of the border individually.
Multimodal cost model Banomyong and Beresford (2001)	Measures the efficiency and performance of unimodal or multimodal freight corridors from a cost and time perspective.	The index offers a straightforward measure of corridor efficiency and identifies connectivity gaps.	It is a simplistic model that does not capture qualitative aspects of freight connectivity.
Time Release Study World Customs Organisation	Measures the average time elapsed between the arrival of goods at a customs-controlled area and release to the importer.	The index measures the efficiency of customs processes, which are essential for trade facilitation and reducing supply chain delays.	The focus is only on customs procedures. It does not reflect the impact of other border agencies that may contribute to border crossing delays.

Source: Updated and adapted from UNESCAP (2019).

Enhancing freight transport connectivity through analytical frameworks

Applications to Central and Southeast Asia

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The ITF leads the transport component of the SIPA programme (SIPA-T). The SIPA-T project helps decision makers in Central and Southeast Asia by identifying policy pathways for enhancing the efficiency and sustainability of regional transport networks. Project outputs include two regional studies that explore opportunities to improve the connectivity, sustainability, and resilience of freight transport systems in Central and Southeast Asia.

This paper is the first in a series of four ITF expert working papers that collectively provide the methodological foundation for the two SIPA-T regional freight transport studies.

Related publications

The full series of SIPA-T expert working papers on regional freight transport includes the following:

1. Enhancing freight transport connectivity through analytical frameworks
2. Enhancing freight transport decarbonisation through analytical frameworks
3. Enhancing freight transport resilience through analytical frameworks
4. Evaluating the relationships between connectivity, decarbonisation and resilience in freight transport

Access these papers, more information, and other SIPA-T project deliverables by scanning the QR code or visiting the link below:

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