GEOGRAPHICAL PROXIMITY AND TRADE IMPACTS IN THE CENTRAL ASIA REGIONAL ECONOMIC COOPERATION PROGRAM REGION

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NO. 60

March 2023

ADB EAST ASIA
WORKING PAPER SERIES

ASIAN DEVELOPMENT BANK

ADB East Asia Working Paper Series

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and Junaid Ahmed

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Publication Stock No.WPS230083-2
DOI: http://dx.doi.org/10.22617/WPS230083-2

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This paper was produced under the Call for Research Proposals: Trade Facilitation in CAREC – A 10-year CPMM Perspective, reviewed by the selection committee, and appreciated the comments provided at the CPMM Conference "Trade Facilitation in CAREC: A 10-year CPMM Perspective" held on 17 August 2022.

The authors acknowledge the contributions of Asian Development Bank staff in the publication of this paper. Kijin Kim provided helpful comments on the paper. Dorothea M. Ramizo facilitated the publication process under the supervision of Akiko Terada-Hagiwara and Zulfia Karimova.

ABSTRACT

High costs and time delays at border crossing points (BCPs) of most Central Asia Regional Economic Cooperation (CAREC) countries additional burdens on trade performance. To explore how trade facilitation measures at BCPs improve trade generation of CAREC countries, this study uses structural and spatial gravity models using the Corridor Performance Measurement and Monitoring (CPMM) dataset for CAREC member countries. The paper reinforces the traditional gravity findings that similarities in languages, colonial history, and large trade volumes are conducive to trade growth. This study also finds that electronic sanitary and phytosanitary (e-SPS) certification can facilitate increased trade. Implementing e-SPS certification expedites clearance times and reduces costs incurred at BCPs. In addition, trade agreements—such as regional and free trade agreements and preferential trade agreements—facilitate trade at the BCPs of participating countries. The study found that subnational trade facilitation measures in neighboring areas also generate additional regional trade. The results suggest that trade analysis could consider spatial association.

Keywords: Trade Facilitation, Central Asia Regional Economic Cooperation (CAREC), electronic certification, trade agreements, and spatial gravity.

ABBREVIATIONS

BCP	–	border crossing point
CAREC	–	Central Asia Regional Economic Cooperation
CEPII	–	Center for Prospective Studies and International Information
COVID-19	–	coronavirus disease
CPMM	–	Corridor Performance Measurement and Monitoring
CV	–	coefficient of variation
e-SPS	–	electronic sanitary and phytosanitary
GDP	–	gross domestic product
PPML	–	Poisson Pseudo Maximum Likelihood
RTA	–	regional trade agreement
SWOD	–	speed without delays
TFI	–	trade facilitation indicator

I. INTRODUCTION

Trade facilitation improves the ease, speed, and cost of moving goods between countries by enhancing infrastructure and simplifying, modernizing, and harmonizing trade procedures at borders. Developing more effective transport corridors and digitalizing border crossing point (BCP) processes can reduce shipping times and costs and integrate rural and suburban peripheries into national and regional economic hubs fostering trade (Kalyuzhnova and Holzhacker 2021). Countries engaged in trade facilitation reduce trade barriers and are more effective players in the competitive regional and global markets.

Together with their concentrated industrial structures, the high trade costs of most Central Asia Regional Economic Cooperation (CAREC) Program countries—i.e., the cost of transporting goods and moving them across borders—constitute a major obstacle to their trade performances (Ahmed and Masood 2021).[1] Underdeveloped infrastructure is estimated to account for 40% of predicted transport costs for coastal countries, and roughly 60% for those that are landlocked (Limao and Venables 2001). Landlocked countries face additional trade costs from fees applied by transit countries and from the costs incurred due to additional border crossing transactions made necessary by their geography. For instance, the value of trade drops by 13%–35% when one of two trading partners is landlocked, and by 10%–51% when both are landlocked (Mazhikeyev et al. 2015).

This makes the development of transit infrastructure and further steps to facilitate trade hard for the CAREC Program landlocked member countries (Grigoriou 2007). Increasing trade facilitation will encourage intraregional CAREC trade and investment, with the region serving as a crossroads of the Eurasian continent. These prospects have made trade facilitation a matter of growing interest and relevance for CAREC member policymakers.

This working paper analyzes fundamental trade facilitation indicators to explore three key related research questions: (i) How much do time delays and the costs incurred at BCPs impact trade facilitation in the CAREC region? (ii) How much do trade facilitation measures—for example, the adoption of electronic sanitary and phytosanitary (e-SPS) certification and new trade agreements—facilitate trade in the CAREC region? (iii) How much does the application of the spatial gravity technique improve efficiency and decrease bias in the coefficient of estimation?

It is evident from the literature that greater trade facilitation has resulted in increased benefits from cross-border trade. For example, the World Bank *Doing Business Survey* (Oberhofer, Pfaffermayr, and Sellner 2021) indicates that longer times required for border procedures have a significant adverse effect on trade. Djankov, Freund, and Pham (2010) conclude that each additional day of border processing reduces trade by 1%. In a similar study, Persson (2008) found that one extra day needed for exports decreased exports by 1.0%, and imports by 0.5%.

Other studies show that the time to import impacts more on trade than the time to export (Zaki 2015 and Yadav 2014). Perishable, seasonal, and high value-added products appear to be more sensitive to transaction time than others (Zaki 2015; and Djankov, Freund, and Pham 2010). In addition to reducing border crossing delays, Martinez-Zarzoso and Márquez-Ramos (2008) suggest that reducing transport costs increases trade flows.

[1] This report was prepared based on information available for Afghanistan as of 31 July 2021. The CAREC Program aims to promote economic cooperation among 11 member countries: Afghanistan, Azerbaijan, Georgia, Kazakhstan, the Kyrgyz Republic, Mongolia, Pakistan, the People's Republic of China (PRC), Tajikistan, Turkmenistan, and Uzbekistan.

Exploiting the World Bank Logistic Performance Index, Hertel and Mirza (2009) show that trade facilitation reforms in South Asia increased intraregional trade in 2001 by 75%; and interregional trade grew by 22%. Further, Felipe and Kumar (2012) show that facilitation reforms significantly benefit trade in Central Asia. Considering the income levels, low-income economies experienced a greater gain in exports than in imports from improvements in their logistics performance (Çelebi 2019).

A pioneering attempt by Kim, Mariano, and Abesamis (2022) to analyze the trade impact of border costs and time using a novel CAREC Program Corridor Performance Measurement and Monitoring (CPMM) dataset, showed that reducing the time by 10% at the importer's border increases intra-CAREC trade by 1%–2%. Kim, Mariano, and Abesamis (2022) also noted that the time spent at the importer's border affects trade flows more than that spent at the exporter's border.

Geographic proximity is also considered by a wide range of studies to be a vital trade impact determinant. Tobler (1979) makes a strong argument for this view, "… everything is related to everything else, but adjacent things are more related than distant things." The Tobler theory shows the importance of spatial relationships between trading regions. Therefore, ignoring spatial dependence in econometrics analysis leads to estimation bias (Anselin 1988). Kim, Mariano, and Abesamis (2022) did not explicitly explore spatial considerations in estimating trade impacts. Therefore, measuring the intensity of the geographical relationships in their observations would contribute to Kim, Mariano, and Abesamis (2022).

Sanitary and phytosanitary (SPS) processing times and costs are important factors in two CPMM indicators: (i) trade facilitation indicator (TFI)1: time taken to clear a border crossing point; and (ii) TFI2: cost incurred at border crossing clearance. ADB and the CAREC Institute (2021) concluded an e-SPS certification study in the CAREC region where two countries—the People's Republic of China (PRC) and Uzbekistan—have transitioned to e-SPS certification.[2] The study found that the hard copy SPS certification processing still in use by the other CAREC Program members causes significant time delays, such as up to 15 days for Pakistan. This study analyzed the impact on trade of e-SPS certification for a more complete understanding of the potential presented by further trade facilitation.

Against this backdrop, this study makes two important contributions. First, a departure from the recent literature based on the structural gravity models to apply spatial consideration to data during 2010–2020. Kim, Mariano, and Abesamis (2022) did not explicitly explore spatial consideration in their trade impact estimations. This study adds to their observations by measuring the intensity of the effects of the physical geographical relationships between countries. Secondly, in measuring the effects of trade facilitation actions in the CAREC region, the study included the impacts of e-SPS certification and free trade agreements.

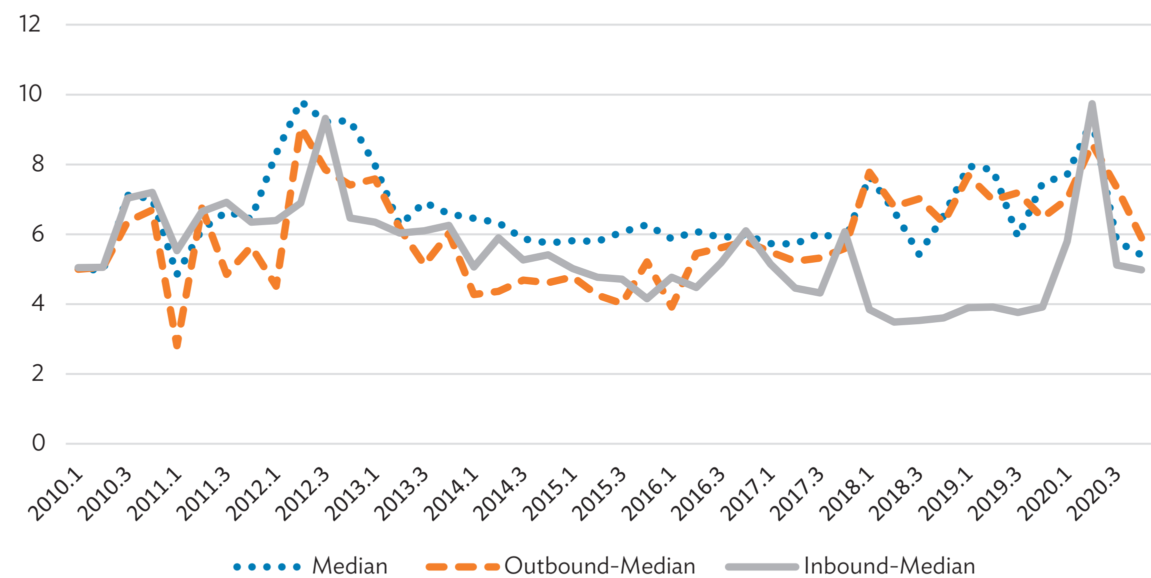
The findings of this paper reinforce those of previous traditional gravity analysis papers. Similarities in language and colonial history—as well as comparatively large trade volumes as of 2022—are conducive to further growth in trade.[3] This study also finds that e-SPS certification can facilitate increased trade. Implementing e-SPS certification expedites clearance times and reduces the costs incurred at BCPs. In addition, trade agreements—such as regional trade, free trade, and preferential trade agreements—facilitate trade at the BCPs of the participating countries. Finally, the study has found that subnational trade facilitation measures in neighboring areas also generate additional trade in the region and that trade analysis could consider spatial association.

[2] ADB. 2021. Expanding Agri-Trade in Central Asia through the Use of Electronic Certificates. *ADB Briefs*. No. 184. Manila.
[3] Colonial history pertains to colonial relationship variable used in standard gravity model.

II. DESCRIPTIVE ANALYSIS

This study formulated CPMM TFIs to track the time, costs, and speeds of shipments crossing through six commonly used BCPs and traveling along sections of the six CAREC road and rail transport corridors (Appendix 1) and to analyze the related impacts on trade facilitation in the region. CPMM data—reported quarterly and annually—are more relevant to the region than the other trade facilitation indicators available (Appendix Table A1).

Figure 1: Trade Facilitation Indicator 1: Time Taken to Clear a Border Crossing Point: Road Transport, 2010–2020
(hours)



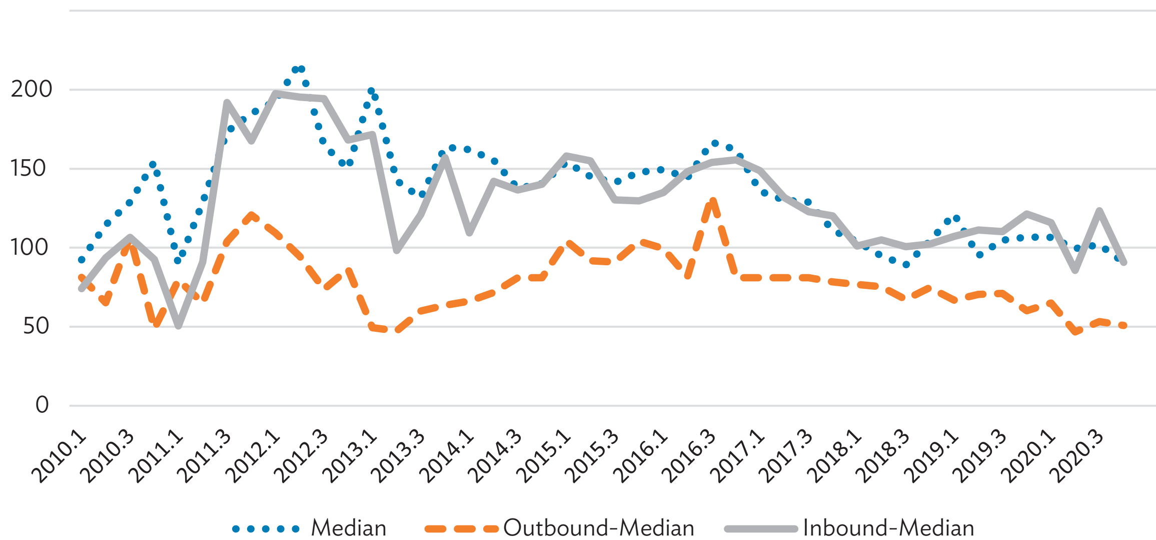
Source: Author's calculation from the CPMM dataset (accessed July 2022).

Figures 1 and 2 show no consistent trend for either TFI1 (time) or TFI2 (cost). The median border crossing time (TFI1) dipped and then showed a notable upturn during 2010–2012 before peaking in the third quarter of 2012. It declined gradually and with less volatility over the subsequent years before another peak in 2020 due to disruptions, primarily the result of "temporary border closures and longer inspection times due to more stringent measures" during the coronavirus disease (COVID-19) pandemic (ADB 2021).

The TFI2 BCP crossing costs trend was generally more stable than TFI1 from 2011 onward. BCP fees do not frequently change. Inbound costs were significantly higher than those for outbound shipments over the period except for two quarters in 2011.

Table 1 shows hardly any improvement in the trade facilitation indicators during 2010–2020. It indicates that the border crossing time by road averaged 15.1 hours in 2020, a 23.7% increase from 12.2 hours in 2019. The average road border crossing cost also rose approximately 23.2% year-on-year. Both increases were driven by delays imposed by strict pandemic-related controls and additional health and quarantine payments for such procedures including mandatory COVID-19 testing, disinfecting spray, and temperature scanning. By comparison, speed without delays (SWOD) and TFI4 (speed to travel along CAREC corridors) changed little during 2019 and 2020. Trucks registered an average SWOD of 42.9 kilometers per hour (km/h) in 2020, down 1.6% from 2019, and TF14 rise slightly to 22.7 km/h.

Figure 2: Trade Facilitation Indicator 2: Costs Incurred at Border Crossing Points: Road Transport, 2010–2020
($)



Source: Author's calculation from the CPMM dataset (accessed July 2022).

Table 1: Trade Facilitation Indicator Trends, 2010–2020

Indicator	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Road											
TFI1	6.3	6.2	8.8	5.6	9.9	9.3	11.3	16.9	12.0	12.2	15.1
TFI2	192.3	150.1	145.1	236.3	177.0	149.3	160.5	158.6	155.5	161.8	199.4
TFI3	758.4	1092.6	1067.6	1596.4	1359.2	1341.2	1173.7	946.9	952.8	900.9	917.9
TFI4	24.4	24.2	25.9	22.3	22.9	23.2	22.3	22.2	23.4	22.6	22.7
SWOD	41.0	43.0	39.4	37.8	42.0	40.2	41.7	45.0	46.3	43.6	42.9
TFI3b	650.2	906.8	874.2	1369.4	1128.8	1118.7	884.2	677.9	810.2	840.2	911.0
Rail											
TFI1	22.1	26.1	25.3	29.9	32.6	27.4	25.9	26.2	23.2	20.6	23.0
TFI2	160.1	265.1	279.9	228.6	147.7	208.1	214.8	201.6	196.0	198.3	193.1
TFI3	464.5	343.8	468.2	911.4	1364.0	1250.1	965.5	975.6	969.9	820.0	836.3
TFI4	22.3	14.6	14.8	13.3	11.4	14.0	14.3	14.8	15.9	19.0	16.8
SWOD	27.2	30.1	34.4	31.7	32.2	38.3	38.6	37.6	35.4	45.0	42.2

SWOD = speed without delays, TFI = trade facilitation indicator.

Notes:

1. The TFI1 indicator is the time taken to clear a border crossing point (hours).
2. TFI2 is the cost incurred at border crossing clearance ($).
3. TFI3 is the cost incurred to travel a corridor section (per 500 kilometer [km] per 20-ton cargo).
4. TFI4 is speed to travel with delay on CAREC corridors (kilometers/hour [km/h]).
5. TFI5 is the speed to travel without delay on CAREC corridors (km/h).
6. TFI3b is the transit cost (per 500 km per 20-ton cargo).

Source: CPMM dataset (accessed July 2022).

The CPMM rail indicator trends during 2010–2020 were like those for road transport except for a slight reduction in border crossing costs (Table 1). The average rail border crossing time rose to 23.0 hours in 2020 from 20.6 hours in 2019. The average border crossing cost (TFI2) for rail slipped from $198.30 in 2019 to $193.10 in 2020 despite the pandemic. TFI4 dropped from 19.0 km/h to 16.8 km/h, and SWOD from 45 km/h to 42.2 km/h.

Table 2 and Table 3 summarize the overall road and rail TFI1 and TFI2 statistical results for 2010–2020, including the mean, median, and coefficient of variation (CV).

Table 2: Road and Rail Trade Facilitation Indicator 1: Time Taken to Clear a Border Crossing Point, Corridors 1–6
(hours)

	Overall			**Road**			**Rail**		
	Mean	Median	CV	Mean	Median	CV	Mean	Median	CV
TF1	13.7	14.1	27.3	10.3	9.9	35.2	25.7	25.9	13.6
Corridors									
1	-	-	-	6.5	6.2	59.9	31.5	31.0	20.4
2	-	-	-	7.8	7.2	24.2	14.2	4.5	163.9
3	-	-	-	5.5	5.2	25.0	4.5	5.1	57.6
4	-	-	-	4.4	4.0	39.0	20.8	21.0	25.6
5	-	-	-	22.7	28.0	69.9	-	-	-
6	-	-	-	39.0	69.6	35.8	5.7	4.5	90.1

CV = coefficient of variation, TF1 = trade facilitation indicator 1.

Source: Author’s calculation from the CPMM dataset (accessed July 2022).

Table 3: Road and Rail Trade Facilitation Indicator 2: Cost Incurred at a Border Crossing Point, Corridors 1–6
($)

	Overall			**Road**			**Rail**		
	Mean	Median	CV	Mean	Median	CV	Mean	Median	CV
TFI2	178	171	12.8	171	160	16.2	208	202	18.8
Corridors									
1	-	-	-	193	150	78.0	265	256	32.28
2	-	-	-	164	173	18.9	214	214	-
3	-	-	-	99	97	27.9	72	85	73.4
4	-	-	-	177	143	56.0	130	134	41.1
5	-	-	-	212	202	29.63	-	-	-
6	-	-	-	151	138	38.6	133	147	36.4

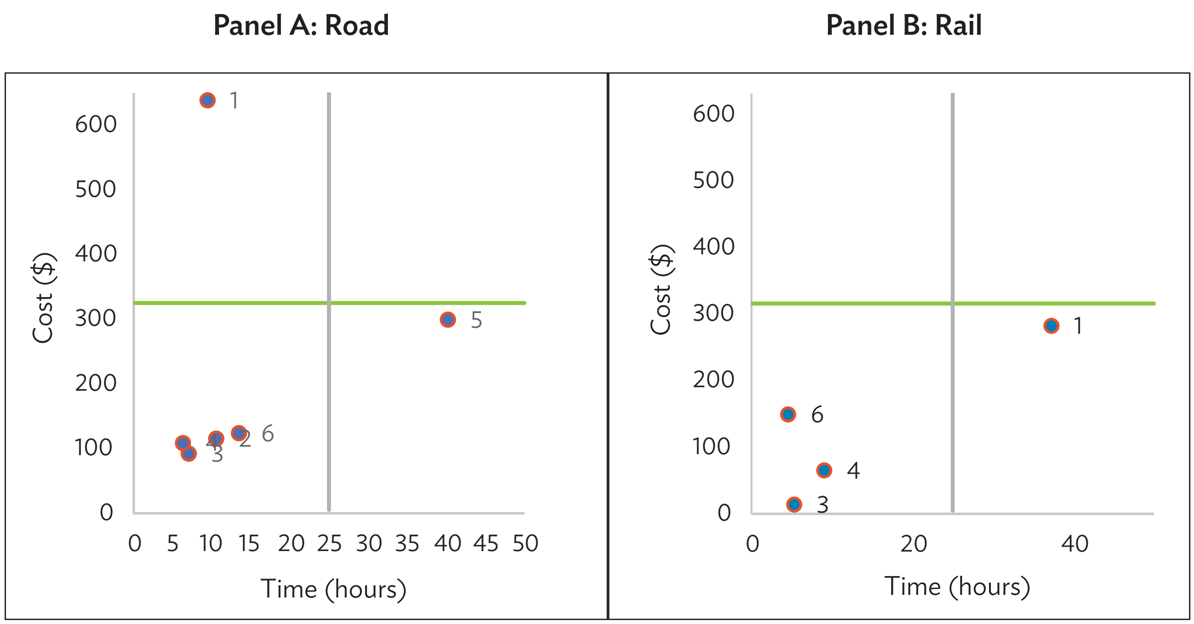
CV = coefficient of variation, TFI = trade facilitation indicator.

Source: Author’s calculation from the CPMM dataset (accessed July 2022).

Corridors 6 and 5 recorded the longest times to clear BCPs, and the average overall time masks a large variation in the length of the crossing times between the six corridors. These ranged from 4.4 hours on Corridor 4 to about 39.0 hours on Corridor 6. ADB (2021) identified the causes of long delays as being manual and serial customs procedures, time spent waiting in line due to BCP constraints, and loading and unloading due to the need to change trucks. The slow average crossing times on Corridor 6 were due to sudden *ad hoc* closures at the Pakistan–Afghanistan border.[4] Rail transport BCP clearance on Corridor 6 was much faster, while on Corridor 1 it was far slower. The CV for Corridor 5 road crossing was high, indicating a high degree of variability in the time delays at its BCPs relative to the average for them all.

Costs incurred by road and rail at BCPs averaged $178 across the six corridors, with averages from $99 on Corridor 3 to $212 on Corridor 5. The average overall BCP cost for rail was $208. TFI2 cost averages varied less across the corridors than did those for TFI1.

Figure 3: Time and Cost Comparison: CAREC Corridors 1–6, 2020



CAREC = Central Asia Regional Economic Cooperation.

Source: CPMM dataset (accessed July 2022).

Figure 3 illustrates the relative performance of CAREC Corridors 1–6 based on the average time spent and costs incurred in road crossings at their BCPs. Panel A shows that road transport in Corridor 5 has the highest average border crossing time: 40 hours. The study estimated border crossing costs for Corridor 1 at $639, making it the most expensive of the six CAREC corridors. Panel B for rail transport shows Corridor 1 to be the most inefficient in terms of time and costs.

[4] ADB placed on hold its assistance in Afghanistan effective 15 August 2021. *ADB Statement on Afghanistan Asian Development Bank* (published on 10 November 2021). Manila.

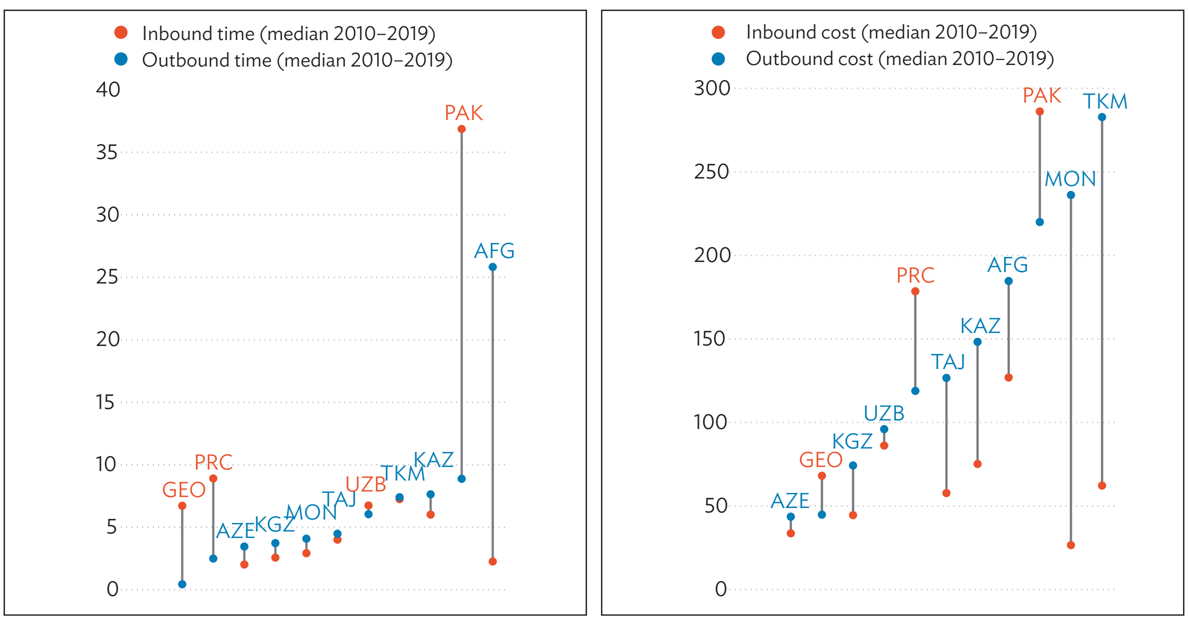
Corridors 3 and 4 are the best performers for road and rail transport. A second group—Corridors 2 and 6—also does quite well. The third group—Corridors 5 and 1—is markedly behind on both the TFI1 time and TFI2 cost indicators. Corridor 1 data shows a mixed performance. It does well in terms of time for road transport BCP crossing but poorly in terms of both time and cost for rail. Some reasons attributed to the highest road transport time delays and costs incurred are border security and controls, customs clearance, loading and unloading, phytosanitation, transport, and traffic inspections. Similarly, delays and costs incurred for rail transport include loading and unloading cargo, fixing cargo shifts, fixing document errors, reissuing transit documents, customs inspection, and technical and commercial inspection, among others.

III. BORDER CLEARANCE: A COUNTRY COMPARISON

Figure 4 shows gaps between inbound and outbound border clearance costs and times. To avoid time-specific effects, the study took a median value for the 2010–2019 sample period and excluded potentially pandemic-skewed 2020 data. Inbound costs were higher than outbound costs in Georgia, Pakistan, and the PRC, with the differences particularly large in Mongolia and Turkmenistan.

Border clearance is also longer inbound than outbound in Georgia, Pakistan, and the PRC. It is the other way around for Afghanistan, and the two clearance times are comparable for the other CAREC countries.

Figure 4: Inbound and Outbound Border Clearance Cost and Time, 2010–2019
($ / hours)



AFG = Afghanistan, AZE = Azerbaijan, GEO = Georgia, KAZ = Kazakhstan, KGZ = Kyrgyz Republic, MON = Mongolia, PAK = Pakistan, PRC = People's Republic of China, TAJ = Tajikistan, TKM = Turkmenistan, UZB = Uzbekistan.

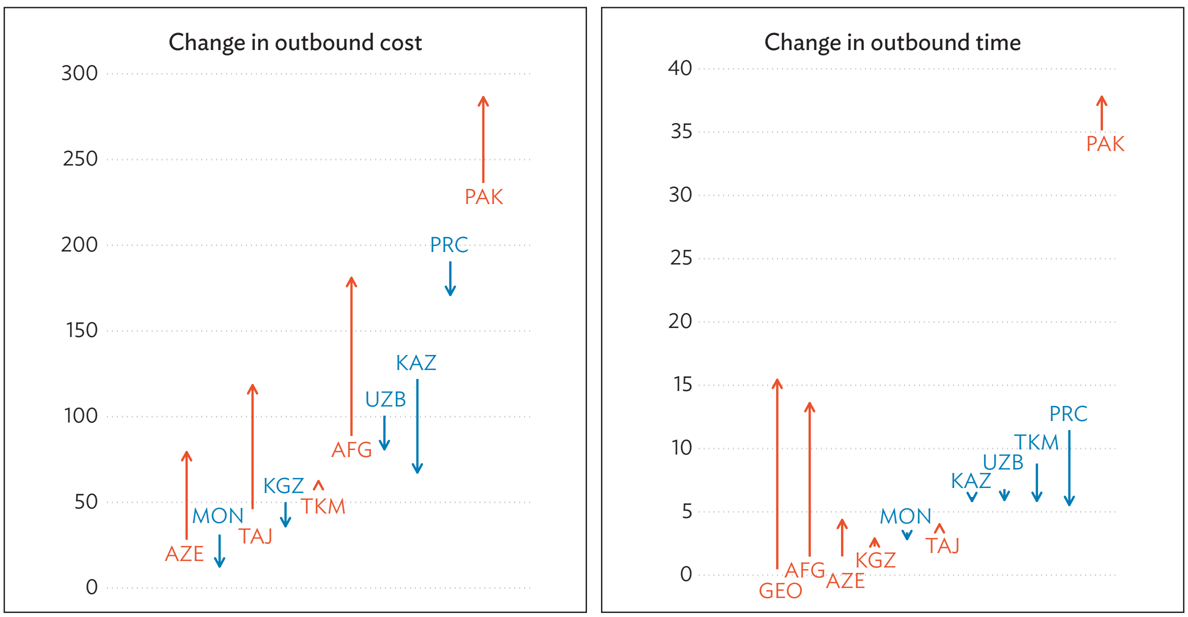
Source: Author's calculation from the CPMM dataset (accessed July 2022).

The study examined the change in border clearance costs over time using median values for 2010–2014 and 2015–2019. The study excluded 2020 values due to potentially distortionary effects created by the pandemic.

Figure 5 shows that the inbound costs and times in Afghanistan and Georgia were higher during 2015–2019. Inbound costs increased in 2015–2019 in Azerbaijan, the PRC, Tajikistan, and Turkmenistan. The inbound costs and time for remaining CAREC countries were lower to varying degrees during 2010–2014 compared with 2015–2019. Some of the measures CAREC countries adopted to lower costs incurred and time delays at BCPs are modernizing transport infrastructure and mutual acceptability of trade facilitation rules and regulations.

Figure 5: Change in Inbound Costs and Time During 2010–2014 and 2015–2019

($ / hours)

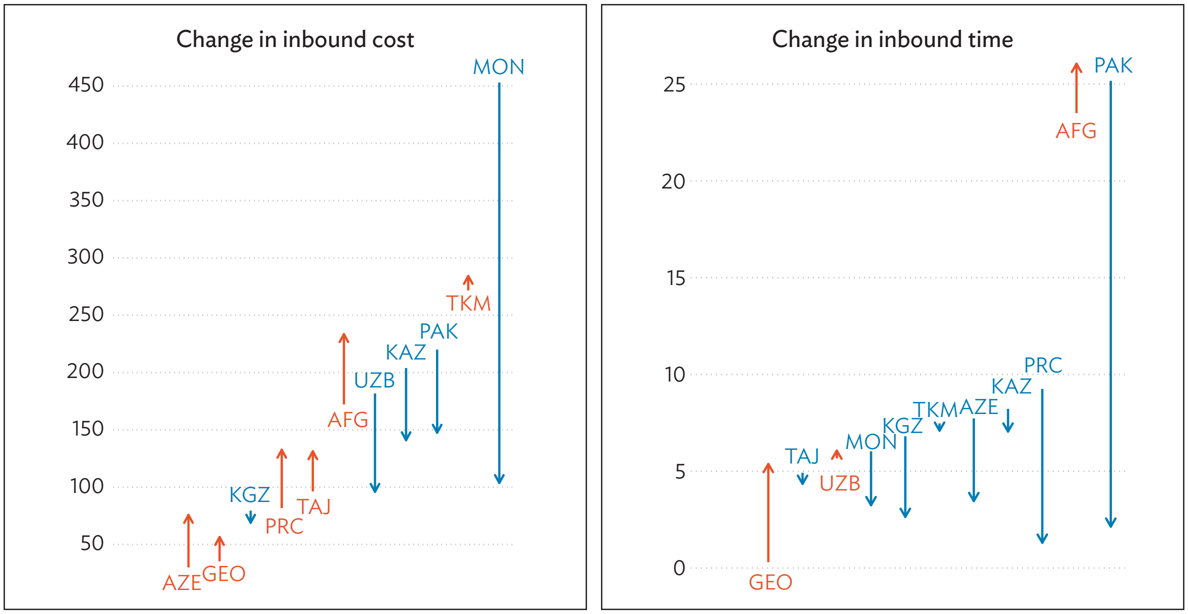


AFG = Afghanistan, AZE = Azerbaijan, GEO = Georgia, KAZ = Kazakhstan, KGZ = Kyrgyz Republic, MON = Mongolia, PAK = Pakistan, PRC = People's Republic of China, TAJ = Tajikistan, TKM = Turkmenistan, UZB = Uzbekistan.

Source: Author's calculation from the CPMM dataset (accessed July 2022).

In Figure 6, the study looked at the median value of outbound time and costs during 2010–2014 and 2015–2019. Both the time and costs associated with the outbound border clearance procedures increased during 2015–2019 in Afghanistan, Azerbaijan, and Pakistan.

Figure 6: Change in Outbound Costs and Time During 2010–2014 and 2015–2019
($ / hours)



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Source: Author's calculation from the CPMM dataset (accessed July 2022).

IV. METHODOLOGY AND DATA SOURCES

This study considered both the gravity and the spatial models.[5] The gravity model has become an effective tool for applied trade policy. However, this analysis has extended this approach to include spatial interaction in the observations, because spatial interaction is ignored by the main gravity models.

Annual bilateral exports—measured in current US dollars—are taken from BACI data.[6] Annual values of gross domestic product (GDP) are taken from the World Development Indicators database of the World Bank. The Center for Prospective Studies and International Information (CEPII) is the source for traditional gravity variables, including bilateral geographical distance, language commonality, colonial relationship, and contiguity (Conte, Cotterlaz, and Mayer 2022). The bilateral distance is measured in kilometers while the other three variables are binary. The CAREC country border clearance data are from the CPMM and complemented by the border cost (and time) data from the World Bank's World

5 The statistical estimation of the gravity equation—Poisson Pseudo Maximum Likelihood High Dimensional Fixed Effects—is the state-of-the-art approach to estimating gravity because of its ability to deal with zero trade flows heteroscedasticity and fast convergence.

6 BACI provides data on bilateral trade flows for 200 countries at the product level (5,000 products). Products correspond to the "Harmonized System" nomenclature (6-digit code). http://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele_item.asp?id=37.

Development Indicators database.[7] The information on e-SPS is sourced from the International Plant Protection Convention of the Food and Agriculture Organization.[8]

Data from 2010–2014 on border costs and time are missing for Azerbaijan (2010, 2013, 2014); Georgia (2010, 2013, 2014); and Pakistan (2010). The study also does not include year data for 2020 because trade flows between country pairs could have been affected by the COVID-19 pandemic. In the spirit of panel estimation, the study ensured that every country pair appears in the sample at least twice and dropped the country pairs with only a single entry. As a result, the sample comprised the bilateral trade of the 11 CAREC members with 132 trading partners during 2015–2019. Appendix B provides a complete list of the countries.

V. GRAVITY AND SPATIAL GRAVITY ANALYSES

Gravity models lacked a theoretical foundation until Anderson (1979) formulated a model based on the elasticity of substitution by origin and constant elasticity of substitution expenditures. Later, the approach of Anderson and van Wincoop (2003) became and remained the benchmark for gravity trade analysis. The model is essentially based on two multilateral resistance terms: the outward multilateral resistance captures the relative resistance of exporting to different destination markets; the inward multilateral resistance implies the relative resistance of importing from different source markets. Bilateral trade cost between a country pair is attributed to various geographic and trade policy variables. Among them are contiguity, bilateral distance, presence of regional trade agreements, language commonality, and past colonial ties.

Despite its numerous applications, the traditional log-transformed model yields biased and inconsistent estimates (Yotov et al. 2016, p. 17). This is due to major challenges related to the difficulty of measuring multilateral resistance terms, dealing with zero trade flows, the existence of heteroscedasticity, as well as to the lack of proper treatment of the endogeneity of trade policy. The multilateral resistance terms are theoretical constructs, not directly observable, and yet treated as empirical by the inclusion of exporter-time fixed effects and importer-time fixed effects (Novy 2013; Olivero and Yotov 2012). The traditional ordinary least square estimator estimation excludes zero trade flows during the log transformation and does not reflect the presence of heteroscedasticity in trade data. This challenge is resolved through the Poisson Pseudo Maximum Likelihood (PPML) estimation.

As a starting point, the study specifies a gravity model (Equation 1) to explain bilateral trade flows based on several factors including contiguity, bilateral distance, language commonality, past colonial relationships, and the GDPs of the exporting and importing countries. These factors act primarily as controls to identify the effect of border clearance cost, the main variable of interest for this study.

7 For reference, see https://data.adb.org/dataset/central-asia-regional-economic-cooperation-carec-program-corridor-performance-measurement.

8 Thanks to Craig Fedchock, ePhyto Programme Director of International Plant Protection Convention for providing the data.

Equation 1

$$y_{ijt} = \exp\left[\alpha_i + \beta_j + \gamma_t + \delta_1 \text{Contiguity}_{it}\right) + \delta_2 \ln\left(\text{Distance}_{ij}\right) + \delta_3 \text{Language}_{ij} + \delta_4 \text{Colony}_{ij} + \delta_5 \text{RTA}_{ijt} + \delta_6 \ln\left(\text{GDP}_{it}\right) + \delta_7 \ln\left(\text{GDP}_{jt}\right) + \delta_8 \ln\left(\text{BorderCost}_{ijt}\right)] \; \varepsilon_{ijt}$$

The dependent variable is trade from origin *i* to destination *j* during year *t*. Note that the variable is taken in levels, which allows the inclusion of the cases of zero trade between the country pairs. On the right-hand side, the binary variable $Contiguity_{ij}$ denotes whether trading partners share a border. Similarly, $Distance_{ij}$ captures the bilateral geographical distance between country pairs. $Language_{ij}$ and $Colony_{ij}$ are dummies to record language commonality and colonial histories. The variable RTA_{ijt} denotes the existence of a regional trade agreement between the country pair. Log-transformed values of the annual GDP of exporters are denoted by GDP_{it} and importers are denoted by GDP_{jt}.

The variable $BorderCost_{ijt}$ denotes the cost in US dollars associated with the border clearance procedures. The variable measures total border clearance costs between a trading pair, i.e., the outbound cost on the exporter side and the inbound cost on the importer side. Alternatively, the study models the effect of border clearance in terms of time measured in hours ($BorderTime_{ijt}$). The study also includes a binary variable to denote the commencement of electrochromic processing of e-SPS. Lastly, α_i and β_j capture fixed effects for exporters and importers, whereas year dummies γ_t account for global trade evolution over time.

This gravity model can be inadequate in explaining origin-to-destination trade flows in terms of how each region might affect its neighbors. Factor endowment on the exporter side and demand preferences on the importer side are thought by regional scientists to exert spatial spillover effects on neighboring regions. Diffusion of production technologies, value chain networks, trade routes, and other infrastructure constitute spatial dependence of origins and destinations on their neighboring regions. To address this, the study proposes a spatial autoregressive model (Equation 2) that considers origin, destination, and origin-to-destination dependence.

Equation 2

$$y_{ijt} = \exp[\alpha_i + \beta_j + \gamma_t + \delta_1 \text{Contiguity}_{it} + \delta_2 \ln\left(\text{Distance}_{ij}\right) + \delta_3 \text{Language}_{ij} + \delta_4 \text{Colony}_{ij} + \delta_5 \text{RTA}_{ijt} + \delta_6 \ln\left(\text{GDP}_{it}\right) + \delta_7 \ln\left(\text{GDP}_{jt}\right) + \delta_2 \ln\left(\text{BorderCost}_{ijt}\right) + \rho W_{it} y + \varphi W_{jt} y + \omega W_{wt} y] \; \varepsilon_{ijt}$$

This spatial gravity model includes three additional variables to deal with spatial dependence. The spatial variables are based on a first-order contiguity weight matrix W, where W_{ij} ($i \neq j$) is coded as 1 if the two members of a pair are contiguous and 0 otherwise; while $i \neq j$ implies that a region is not its neighbor. The study adapts this W matrix to the neighbor relationships unique to origin-destination flows to build the three spatial weight matrices W_j, W_i and W_w to specifically model origin-centric, destination-centric, and origin-to-destination-centric dependence as illustrated by LeSage and Pace (2008). Luo and Choi (2022) mark a recent application of the approach. Through Kronecker product operations, $W_i = I_n \otimes W$ reflects that a country's exporting behavior may stimulate or impede trade flows from its neighboring exporters to the same destination. Reciprocally, $W_j = I_n \otimes W$ reflects how the spatial effect on trade flows from an origin to a destination may induce or dampen similar flows to neighboring destinations.

In addition to the origin-centric and the destination-centric spatial dependence, the study constitutes $W_w = W \otimes W$ to capture a second-order connectivity between an origin's neighborhood and a destination's neighborhood.

This estimation is noteworthy in that all continuous variables (distance, GDPs, border cost, and border time) are log-transformed, whereas the rest of the explanatory variables are binary. The dependent variable, bilateral trade, is taken in levels and includes zero trade flows. To cope with the presence of zero trade and heteroscedasticity in trade data, the study applied PPML estimation, an alternative approach that has been popularized since the seminal studies of Silva and Tenreyro (2006 and 2011). More recently, Correia et al. (2020) offer PPML with high-dimensional fixed effects for the computation of a gravity equation. This estimator effectively deals with the non-existence problem (Silva and Tenreyro 2022).

VI. RESULTS AND DISCUSSION

Table 4 presents the gravity estimates from the model specified in Equation 1. Border cost related to border clearance is included in the estimations given under columns (1) and (3). Estimates using the alternative measure of the border clearance in terms of time are shown under columns (2) and (4). Columns (3) and (4) include e-SPS as an additional variable.

The coefficient signs for various variables are as expected. First, the study obtained a positive and statistically significant impact of contiguity. This is important in the case of the CAREC region, where most of the member countries are landlocked and thus trade more intensively with one another. Second, the coefficient for distance is around –1.3, implying restricted trade flows stemming from higher trade costs over longer distances. In this regard, Head and Mayer (2014) found –1.1 to be the mean value for the coefficient on distance based on their metanalysis covering 2,508 estimates from 159 studies. Similarly, the effect of GDP on bilateral trade remains about 0.5–0.7 (Head and Mayer 2014), and estimates corroborate this. Furthermore, the effects of language commonality, past colonial relationships, and regional trade agreements are positive on bilateral trade flows.

The study obtained negative and statistically significant coefficients for the cost and time associated with border clearance procedures. The explanation is intuitive: higher costs incurred or greater time spent clearing borders results in more restrictive trade flows. Precisely, a 1.0% increase in the border clearance cost decreases trade by 0.5%. The effect of an increase in the time required for border clearance procedures is similarly negative and statistically significant, although smaller than that of cost. The estimates show that a 1.00% increase in border clearance time decreases trade by roughly 0.27%.

Lastly, a positive effect could be expected from e-SPS as electronic processing tends to reduce the cost and time of border clearance. However, the coefficient of the variable e-SPS obtained was not statistically different than zero. The underlying reason is that in most countries where the electronic procedure has been adopted, the introduction has been only recent. Some countries registered for e-SPS or began testing its use in 2017 or earlier, but only the PRC and Uzbekistan began live exchanges of e-SPS certificates before 2020. Other CAREC countries have yet to fully transition to the e-system. The majority of the world's nations have yet to adopt it.

Table 4: Gravity of CAREC Trade (Equation 1)

	(1)	(2)	(3)	(4)
Contiguity	0.267*	0.265*	0.267*	0.265*
	(0.141)	(0.140)	(0.142)	(0.141)
ln(Distance)	–1.320***	–1.326***	–1.319***	–1.326***
	(0.130)	(0.129)	(0.132)	(0.131)
Language	0.788***	0.785***	0.788***	0.785***
	(0.124)	(0.124)	(0.124)	(0.124)
Colonial tie	0.902***	0.902***	0.902***	0.902***
	(0.134)	(0.133)	(0.134)	(0.133)
RTA	0.571***	0.572***	0.571***	0.572***
	(0.086)	(0.086)	(0.086)	(0.086)
ln(Exporter GDP)	0.496***	0.463***	0.497***	0.463***
	(0.166)	(0.169)	(0.167)	(0.170)
ln(Importer GDP)	0.695*	0.664*	0.704*	0.663
	(0.385)	(0.383)	(0.410)	(0.408)
ln(Border Cost)	–0.505***		–0.504***	
	(0.185)		(0.185)	
ln(Border Time)		–0.274***		–0.274***
		(0.088)		(0.088)
e-SPS			–0.005	0.000
			(0.108)	(0.108)
Observations	5,120	5,240	5,120	5,240

e-SPS = electronic sanitary and phytosanitary, GDP = gross domestic product, RTA = regional trade agreement.

Notes:

1. Dependent variable bilateral trade is taken in levels (current US dollars). Zero trade values are included.
2. Fixed effects for exporters, importers, and time are included but not reported for brevity.
3. Robust standard errors are in parentheses. Statistical significance is denoted as *** p<0.01, ** p<0.05, * p<0.

Source: Authors' calculations.

The estimations based on Equation 2 are in Table 5. In addition to gravity model variables, the study included three variables to capture origin-centric, destination-centric, and origin-to-destination spatial dependence of trade flows. The coefficient signs are as expected, and the estimates corroborate the findings reported in Table 4.

The coefficients reported are noticeably smaller than those in Table 4. For example, the coefficient of distance is now –1.160 instead of –1.132, which is closer to the estimates of Head and Mayer (2014). The difference can be explained by the omission of variable bias. In other words, the otherwise inflated estimates have been reduced to more realistic values by the inclusion of spatial dependence. This finding is in line with other studies, e.g., Luo and Choi (2022), LeSage and Thomas-Agnan (2012), Porojan (2001), and Fotheringham and Webber (1980, p. 34).

Table 5: Gravity of CAREC Trade (Equation 2)

	(1)	(2)	(3)	(4)
Contiguity	0.496***	0.492***	0.496***	0.491***
	(0.140)	(0.139)	(0.140)	(0.140)
ln(Distance)	–1.163***	–1.168***	–1.164***	–1.169***
	(0.126)	(0.125)	(0.128)	(0.128)
Language	0.680***	0.677***	0.680***	0.677***
	(0.109)	(0.109)	(0.109)	(0.109)
Colonial tie	0.732***	0.732***	0.732***	0.732***
	(0.143)	(0.141)	(0.143)	(0.141)
RTA	0.524***	0.525***	0.524***	0.525***
	(0.078)	(0.078)	(0.079)	(0.078)
ln(Exporter GDP)	0.430***	0.405**	0.430***	0.405**
	(0.156)	(0.159)	(0.156)	(0.160)
ln(Importer GDP)	0.775**	0.734*	0.766*	0.721*
	(0.391)	(0.391)	(0.423)	(0.424)
ln(Border Cost)	−0.416**		−0.417**	
	(0.181)		(0.180)	
ln(Border Time)		−0.202**		−0.203**
		(0.089)		(0.089)
e-SPS			0.004	0.007
			(0.109)	(0.109)
ρ	0.103***	0.102***	0.103***	0.103***
	(0.015)	(0.015)	(0.015)	(0.015)
ϕ	0.077**	0.075**	0.077**	0.075**
	(0.031)	(0.031)	(0.031)	(0.031)
ω	0.009	0.010	0.009	0.010
	(0.015)	(0.015)	(0.015)	(0.015)
Observations	5,120	5,240	5,120	5,240

ρ = origin-centric spatial dependence, ϕ = destination-centric spatial dependence, ω = origin-to-destination-centric spatial dependence, e-SPS = electronic sanitary and phytosanitary, GDP = gross domestic product, RTA = regional trade agreement.

Notes:
1. Dependent variable bilateral trade is taken in levels (current US dollars). Zero trade values are included.
2. Fixed effects for exporters, importers, and time are included but not reported for brevity.
3. Robust standard errors are in parentheses. Statistical significance is denoted as *** p<0.01, ** p<0.05, * p<0.

Source: Authors' calculations.

The variables related to border clearance in Table 5 show that the coefficient for border cost is decreased using equation 2 to −0.4 from −0.5 using equation 1, and that for border clearance time declines from −0.27 to −0.20. The study prefers the equation 2 estimate presented in Table 5. Precisely, a 1.0% decrease in border clearance cost would result in a 0.4% increase in trade flow. Similarly, a 1.0% decrease in border clearance time encourages trade by a factor of 0.2%. The coefficient highlights that when applying equation 2 the adoption of the e-SPS process remains inconsequential in terms of the effect on bilateral trade flows for the estimate sample.

Looking at the spatial dependence related to origin–destination trade flows, the statistically significant coefficients on the variables measuring spatial effects imply that spatial dependence is affecting the latent trade volumes. There was a positive and statistically significant effect of origin-specific and destination-specific spatial dependence. These findings are in line with literature such as Barbero and Rodriguez-Crespo (2018), Luo and Choi (2022), and LeSage and Pace (2008). On the other hand, the coefficient ω is statistically not different than zero, which "implies that there is no significant competitive relationship across trading pairs when a dual neighboring relationship exists at both origins and destinations," as highlighted by Luo and Choi (2022).

A positive ρ signals that exports from one origin to a given destination are positively related to trade flows from neighboring exporters to the same destination. In other words, geographically proximate exporters tend to mimic one another's exporting behavior. This stems partly from the similar resource endowments of neighboring exporting countries and the specialization in the production of the same or similar goods that results (Luo and Choi 2022). As Griffith and Jones (1980) pointed out, flows from an origin are "enhanced or diminished in accordance with the emissions propensity of its neighboring origin locations."

Similarly, the positive sign of ϕ suggests that an exporting country that exports to a destination market tends to export to the surrounding regions of that destination as well. There are two components of this effect. On the supply side, this is due to the spillover. On the demand side, close countries geographically are predisposed to having similar resource endowments and socioeconomic conditions, which leads to a similar pattern of import demand. In other words, flows associated with a destination are "enhanced or diminished in accordance with the propensity of attractiveness of its neighboring destination locations" (Griffith and Jones 1980).

VII. CONCLUSION AND POLICY IMPLICATIONS

This study investigated how much reductions in the time taken to clear border crossing points and the costs incurred at border crossing points facilitate bilateral trade among CAREC countries and trading partners. The study employed data from the CPMM developed by the CAREC program as a broad empirical tool to measure and track six indicators of trade facilitation performance along the CAREC corridors. Two of these indicators were analyzed in this study: (i) TFI1: time taken to clear a BCP, and (ii) TFI2: cost incurred at a BCP.

The study divided TFI1 and TFI2 into inbound and outbound values and developed four measurements of trade facilitation at a country-pair level: (i) inbound and outbound time delays (hours), (ii) inbound and outbound costs in US dollars ($), (iii) total average cost in duration (hours), and (iv) cost in US dollars ($). These variables were included in both the structural gravity and spatial gravity trade models the study used to examine their importance to trade flows. The study considered the specific effects of the four trade facilitations for countries both as exporters and importers along with the effects of the adoption of e-SPS certification and the existence of regional trade agreements.

The findings are in line with those produced by the traditional structural gravity approach, i.e., that large countries contribute significantly to greater trade, and greater trade is further facilitated if countries have a common language and colonial past. It is, however, noticeable that the effect of geographical distance is greater than average in the case of CAREC countries, possibly because most of them are landlocked.

The study found that an increase in border clearance costs restricts trade, as does a lengthening of the time spent in the clearance procedure. The effect of increased clearance time was statistically significant but smaller than that of higher costs.

The study also found that hard copy exchanges of SPS certificates did not facilitate trade in the CAREC region, but replacing hard copy exchanges of SPS certification with e-SPS certification could. The electronic process is faster than the hard copy procedures at both the issuance stage and in the exchange with the trading partner. However, this analysis considered only the exchange stage. Finally, the analysis found that not having pragmatic trade agreements negatively impacts trade facilitation at the BCPs.

Policy Implications

The following findings suggest important avenues for further improvement. These are all relevant areas to continue fostering trade facilitation in the region that deserve attention and policy actions.

(i) CPMM provides data at the BCPs that are useful for its trade facilitation indicators, but the BCP trade data needed for more robust country-specific trade analysis at the BCP level are missing. The study suggests that CAREC members collect trade data at the BCPs so that holistic trade generation analyses can be carried out at a BCP level. This analysis is country-level only.

(ii) Digitalization of the trade facilitation indicators—for example, e-SPS certification—plays a significant role in trade facilitation at the BCPs, which CAREC members should encourage.

(iii) A pragmatic and implementable approach can be developed by the relevant stakeholders for regional trade, free trade, and preferential trade agreements between CAREC partner countries to facilitate trade through the BCPs.

(iv) Contiguity analyses are missing at the regional level, mainly due to data limitations. For a holistic, robust, country-level spatial analysis, CAREC members should collect data at the regional, national, and subnational levels.

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APPENDIXES

Appendix 1: Road and Rail Corridors across the CAREC Region

Appendix Table A1: Border Crossing Points on CAREC Corridors 1–6

Country	CAREC Corridors	Key BCPs in CPMM
Afghanistan	2, 3, 5, and 6	Hairatan, Shirkhan Bandar, Spin Buldak, Torghondi, Torkham
Azerbaijan	2	Baku (seaport), Boyuk Kesik, Red Bridge
		Kara-Suu, Takeshikent, Torugart, Zuun Khatavch
China, People's Republic of	1, 2, 4, and 5	Alashankou, Erenhot, Irkeshtan, Horgos, Khunjerab
Georgia	2	Gardabani, Sarpi, Tsiteli Khedi
Kazakhstan	1, 2, 3, and 6	Altynkol, Dostyk, Khorgos, Konysbaeva, Tazhen
Kyrgyz Republic	1, 2, 3, and 5	Ak-Tilek, Chaldovar, Gulistan, Irkeshtam, Karamyk, Torugart
Mongolia	4	Altanbulag, Bichigt, Sukhbaatar, Yarant, Zamiin-Uud
Pakistan	5 and 6	Chaman, Peshawar
Tajikistan	2, 3, 5, and 6	Dusti, Gulistan, Karamyk, Kulma, Pakhtaabad, Panji Poyon
Turkmenistan	2, 3, and 6	Farap, Sarahs, Serkhet Abad
Uzbekistan	2, 3, and 6	Alat, Doutata, Hairatan, Dustlik, Oibek, Saryasia, Termez, Yallama

BCP = border crossing point, CAREC = Central Asia Regional Economic Cooperation, CPMM = Corridor Performance Measurement and Monitoring.

Source: ADB (2021).

Appendix 2: List of Economies Entered in the Regression Analysis

CAREC countries: Afghanistan, Azerbaijan, Georgia, Kazakhstan, the Kyrgyz Republic, Mongolia, Pakistan, the People's Republic of China, Tajikistan, Turkmenistan, and Uzbekistan.

Trading partners:

Afghanistan; Albania; Algeria; Angola; Argentina; Armenia; Azerbaijan; Bangladesh; Belarus; Belize; Benin; Bhutan; Bolivia; Bosnia and Herzegovina; Botswana; Brazil; Brunei Darussalam; Bulgaria; Burkina Faso; Burundi; Cambodia; Cameroon; Canada; Central African Republic; Chad; Chile; Colombia; Congo; Congo Democratic Republic; Costa Rica; Croatia; Djibouti; Dominican Republic; Ecuador; Egypt; El Salvador; Equatorial Guinea; Estonia; Ethiopia; Finland; Gabon; Gambia; Georgia; Germany; Ghana; Greece; Guatemala; Guinea; Guinea-Bissau; Guyana; Haiti; Honduras; Hong Kong, China; India; Indonesia; Iran; Iraq; Ireland; Israel; Ivory Coast; Jordan; Kazakhstan; Kenya; Kuwait; the Kyrgyz Republic; the Lao People's Democratic Republic; Latvia; Lebanon; Lesotho; Liberia; Libya; Lithuania; Macedonia; Malawi; Malaysia; Mali; Mauritania; Mexico; Moldova; Mongolia; Montenegro; Morocco; Mozambique; Myanmar; Namibia; Nepal; Nicaragua; Niger; Nigeria; Norway; Oman; Pakistan; Palestine; Panama; Papua New Guinea; Paraguay; the People's Republic of China; Peru; Qatar; the Republic of Korea; Romania; the Russian Federation; Rwanda; San Marino; Saudi Arabia; Senegal; Serbia; Sierra Leone; South Africa; Sudan; Suriname; Swaziland; Sweden; Switzerland; Tajikistan; Tanzania; Thailand; Timor-Leste; Türkiye; Turkmenistan; Uganda; Ukraine; the United Arab Emirates; the United Kingdom; the United States; Uruguay; Uzbekistan; Viet Nam; Zambia; and Zimbabwe.

Geographical Proximity and Trade Impacts in the Central Asia Regional Economic Cooperation Program Region

This study explores to what extent reducing delays and costs at border crossing points (BCPs) can facilitate bilateral trade flows among Central Asia Regional Economic Cooperation (CAREC) countries. The results indicate that delays at BCPs significantly hinder trade flows and that the costs incurred are even more restrictive. However, digitization measures such as electronic sanitary and phytosanitary certification help reduce these delays and costs. The findings also suggest high spatial dependence in the origin–destination trade flows of landlocked CAREC countries.

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