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Aggregating an economic model and GIS to explore trade potentials of India-Caspian countries and a way forward for INSTC

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ABSTRACT

The Caspian countries have a crucial role in new trade scenarios for India as it constantly steers towards its trade diversification and expansion. With the establishment and expansion of INSTC (International North South Transport Corridor), the importance of Caspian countries (Azerbaijan, Iran, Turkmenistan, Kazakhstan, and Russia) has increased. INSTC is also seen as a gateway to Central Asia. It is, therefore, of utmost significance to estimate the trade potential of the aforesaid with India adopting novel methods and techniques with giving due attention to the role of INSTC. The objective of the present study is to examine the role of INSTC in the light of geographical background and in promoting Indian trade. The study also attempts to analyze past trends of Indo-Caspian trade potential. A profound gravity model is developed to estimate India-Caspian countries' recent pattern of trade potential. Population, GDP, trade, and service area of the countries' ports are taken as influencing variables in modelling the trade potential and their statistical significance is estimated using ordinary least square method. The integration of GIS based network analysis and service area modelling is performed first time for estimating trade potential as it represents the port's connectivity to the hinterland. The findings of the gravity model postulate that recent years have been full of changes where Iran has lost its dominance, and Azerbaijan has risen to capture the top position from 2015 to 2020. Steady growth has been observed in Russia and sudden growth in Azerbaijan. The present study is a standalone in which the service area of ports has been used and has a positive relation with trade.

Introduction

Rapidly growing international trade, structural changes in the centers of the global economic development, abrupt breaks in traditional trade flows due to the geopolitical conflicts (e.g., trade embargoes as a consequences of Russian-Ukrainian war) and the increasing importance of considerations on sustainability highlight the necessity of further sophistication of transportation systems reflecting the changing demands.

A striking example of this changing demand for logistical system development is the growing trade between the Southern part of Russia, the states of Central Asia and India. This can be considered as an innovation process, satisfying all conditions of innovation, defined by classic works of Schumpeter (Sweezy, 1943), because these include the transportation of new goods (e.g. innovative products with high value-added content), new methods of logistics (e.g. wide range of application of

operations research and geoinformatics); new markets (the bilateral trade between India and countries of Central Asia formerly was rather marginal), new source of supply of raw materials (e.g. the trade of energy resources from Russia to India is a relatively new phenomenon) and the emergence of new organizational structure's (e.g. new international agreements). The long-range logistic system development needs an in-depth understanding of forces, shaping the trade between the countries in the region and to determine the potential economic effects of logistical infrastructure development in the upgrading of supply channels.

India's trade with Caspian countries, which include Azerbaijan, Iran, Kazakhstan, Russia, and Turkmenistan, has been growing steadily over the years (Bilgin, 2009; Aydin & Azhgaliyeva, 2019). The region is rich in natural resources, including oil, gas, and minerals, and India has been seeking to diversify its sources of energy and raw materials (Bahgat, 2005, Wajid et al, 2020). According to the latest available data from the

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Ministry of Commerce and Industry, India's total trade with the Caspian countries was valued at \$2.9 billion in 2020–21, with exports from India totaling \$1.3 billion and imports from the region totaling \$1.6 billion (Ministry of Commerce and Industries, 2022). India has been diversifying its trade and investment ties with all the Caspian countries and is exploring new opportunities for economic cooperation. However, the challenge before India was direct access to the Caspian region; most of the trade was done through Suez Canal, which made trade very costly and challenging to access central Asia. As a result, trade with Central Asian countries is also very minimal. Considering this, India is initiating to build INSTC (International North South Transport Corridor) - an economic corridor with efficient multimodal transport networks with the help of quality infrastructure, logistics, and distribution networks that link production centres, urban clusters, and international gateways.

Our paper is based on two methodological pillars: the gravity model (GM) and the application of Geographical Information Systems (GIS). GM is a popular economic model used to estimate the trade potential between countries (Shahriar et al., 2019; Jadhav & Ghosh, 2023). GIS can help visualize the distance between two countries, identify geographic barriers, and map the location of critical infrastructure such as ports, railways, and highways (Black et al., 2004; Jones et al., 2010). By combining GM with GIS, analysts can create visual representations of trade potential considering economic and geographic factors. For example, the GM can identify potential trade flows between India and the Caspian countries based on their economic size and geographic proximity (Stanojević & Jovancai, 2015; Onifade et al., 2021; Jama-gidze, 2022). The results can then be visualized using GIS to create maps highlighting potential trade routes, transportation infrastructure, and barriers such as mountain ranges or political boundaries.

This concept is entirely novel, with minimal studies conducted so far; for instance, Amidi and Majidi (2020) and Lawal and Onuchuku (2020) have discussed the probability of GIS in modelling trade. The project's geopolitical viewpoint is examined in the sparse literature on INSTC (See, for instance, Mohapatra, 2022; Kavalski, 2019; Gogna, 2019; Meena, 2020). The authors of the paper claim that further objective research is needed to determine how INSTC affects India's export. In order to close this gap, we examine if distance is a hindrance to India's export as well as whether INSTC has been successful in doing so. Service area of the ports has also been calculated and adopted for modelling trade potential which is never been done in studied of international trade.

GM and GIS can provide valuable insights for policymakers and businesses looking to expand trade relationships with other countries (Zhang et al., 2021). By understanding the economic and geographic factors that influence trade, countries can develop targeted strategies to increase trade flows and identify potential new markets for their goods and services (Caner & Aydin, 2021). However, studies -that assess the trade potential of the India-Caspian region despite the vast capacity of trade relations - have yet to be conducted.

Changing patterns of international trade in the Caspian region have been intensively studied (e.g. Bilgin, 2009; Abtin & Lashari, 2016; Karatayev & Hall, 2020; Khan & Omid, 2023) applying a wide array of methods (Stanojević & Jovancai, 2015; Li et al., 2020), but -to the best of our knowledge -the current paper is the first attempt to analyze the possibilities of development under conditions of the current geopolitical situation, combining the latest methods of international trade analysis and the modern geoinformatic systems.

In the present paper, population, GDP, trade and service area have been adopted as indicators of GM from 2015 to 2020 to examine the trends and patterns of trade potential between India-Caspian countries. The integration of GIS for the assessment of the connectivity of roads is performed for the first time in modelling trade potential.

Re-configuration of trade alliances in the Caspian region: The INSTC

Until recently, Iran was one of the largest trade partners among the Caspian countries. In 2020–21, India's trade with Iran was valued at \$2.2 billion, accounting for over 75% of India's total trade with the Caspian region (Felipe and Kumar, 2012; Hassan Khayat, 2019). However, the Ukraine war has replaced Iran with Russia as India began buying oil from Russia. Among the other Caspian countries, Kazakhstan is also a significant trade partner for India, with bilateral trade valued at \$1.1 billion in 2020–21. India primarily imports crude oil, uranium, and metals from Kazakhstan, while exporting pharmaceuticals, machinery, and vehicles. Azerbaijan is another potential market for India, with bilateral trade valued at \$354 million in 2020–21. India mainly imports crude oil and petroleum products from Azerbaijan while exporting pharmaceuticals, vehicles, and machinery (Sarma, 2010; Alati & Kaur, 2023).

Each Caspian country brings unique opportunities and challenges as far as trade with India is concerned. However, it heavily depends on two significant factors: firstly, the specific products and industries that India is looking to trade with; secondly, the amount of success in operating the new economic corridor INSTC, which is an extended multimodal transport network of 7200 km that connects rail, road, and sea. It connects the Indian Ocean with the Caspian Sea and via the Persian Gulf to Russia and Europe (Fig. 1). INSTC was established in 2000 by its founding members India, Russia and Iran, but officially started in 2002. Presently, 13 countries have joined it, and Bulgaria has been included as an observer. It is expected to reduce the transportation time and cost for goods between India and the Caspian region, thereby boosting trade and economic cooperation (Vinokurov et al., 2022). Per test runs completed in 2014, the INSTC course was 30 per cent cheaper and 40 per cent shorter than current shipping methods (Shepard, 2017; Purushothaman & Unnikrishnan, 2019). Additionally, an Indian agreement with Iran in May 2016 established Chabahar port in Iran, thus providing a vital potential conduit for India's exchange and commerce with West Central Asia (The Indian Express, 2016) (Fig. 2).

The recent Suez Canal blockage (Khan & Rahman, 2021), which cost the global economy a hefty US\$9 billion, has raised the profile of the International North-South Transport Corridor (INSTC) as a cheaper and faster alternative multimodal transit corridor (Cyril et al., 2022). It can answer logistics headaches, future blockage scenarios, and mitigation against the worst impacts. Goods from India can be transported along this corridor. They can be transported through the Suez Canal, which significantly increases the time and cost of transportation, and by rail through Azerbaijan. The latter route is faster and more profitable (Russia Briefing, 2022). The energy demand and environmental burden of various routes do not differ considerably. E.g. in case of a tack transport of 100, twenty-foot equivalent container (TEU) from the harbor of Mumbai to the harbor of Minsk, the total energy demand is 8.24 million MJ, (including the transportation of fuels), the direct energy demand of transportation is just 6.21 million MJ. If we calculate with the total energy demand of train transport (electrified trains, double container wagons, with 25 t empty weight, 49.8% load factor, 20% empty trip factor) is 4744 million MJ, in case of sea ship (CC Suez Trade class, 4.7–7 k TEU container capacity) this indicator is 3568 million MJ. If we take into consideration just the direct energy consumption, the highest value remains in case of truck transport, but the energy consumption will be lower in case of train transport (2135 million MJ), than in case of ship transport (2472 million MJ). In case of greenhouse gas emission, the direct environmental burden of train transport is lower by 32%, then the emission, caused by the sea transport (<https://www.econtransit.org>).

Recently, INSTC has come into the limelight due to the Russia-Ukraine war - which led to a spike in Russia-India trade -and Iran (due to sanctions from the USA both went off SWIFT and are under pressure to find new ways for their economies to run smoothly. Since

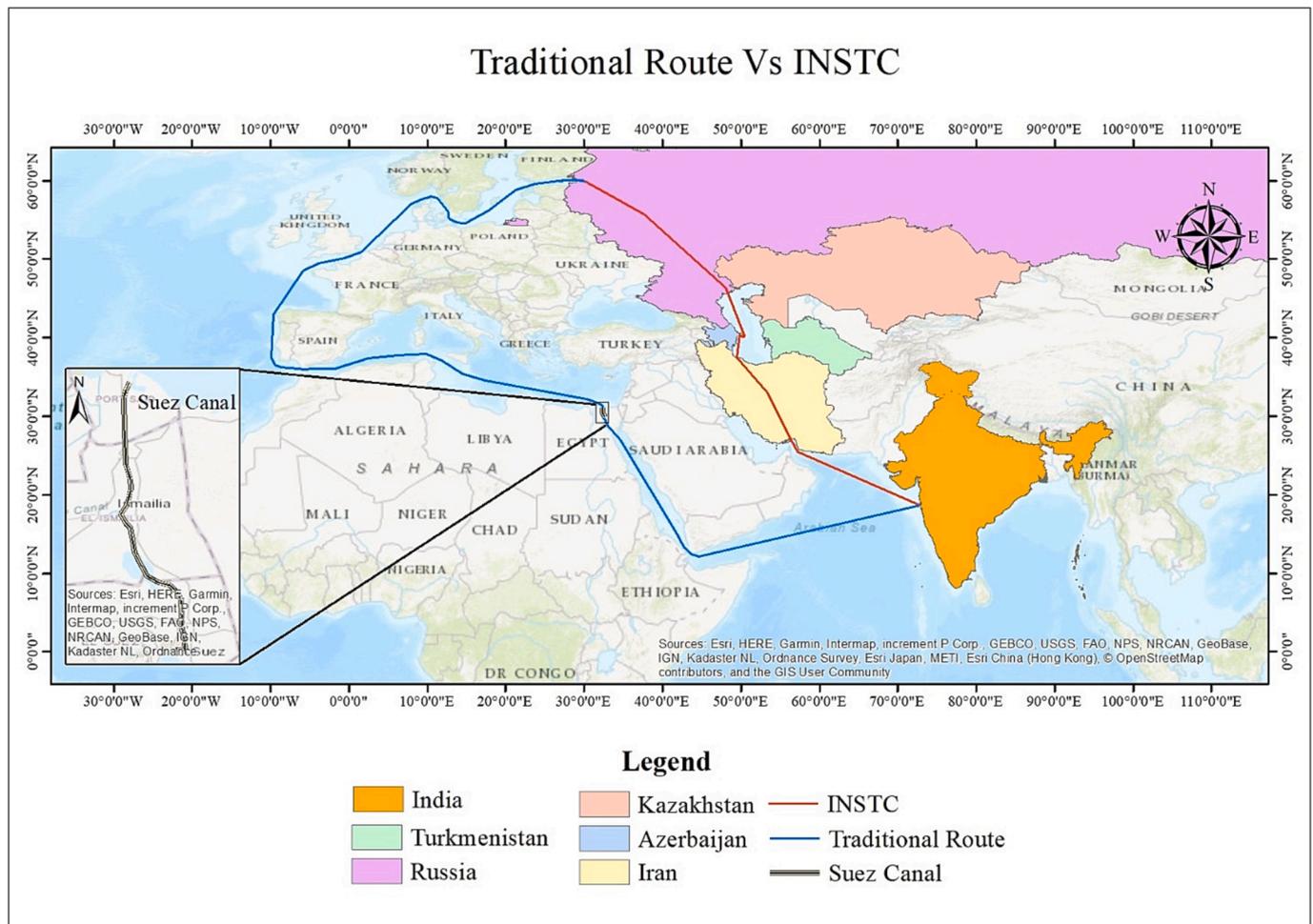


Fig. 1. Traditional Sea Route (Via Suez Canal) Vs INSTC Route (Via Chabahar Port in Iran) Source: Prepared by authors.

INSTC is a cheaper and faster route than the conventional Suez Canal (Fig. 1), it is argued that the former could be an alternative (Passi, 2017). The objective of the present study is to highlight the significance of INSTC for trade relations of Indo-Caspian countries by developing a GM from 2015 to 2020. We also seek to propose the adoption of service area as one of the influencing factor for GM that is calculated through network analysis tool of GIS so that the transportation facilities and geographic connectivity should be given due weightage in future GMs.

Data and methods

Data

The GM is based on the idea that the amount of trade between two countries is proportional to the size of their economies (as measured by Gross Domestic Product or GDP) and inversely proportional to the distance between them. Other factors, such as common language, shared borders, and trade agreements, can also influence trade flows Christerson (1994). Anderson (2011) used the GM to assess the patterns of gross shipments, while Hua and Porell (1979) critically examined the validity of the GM way back in the late 20th century. GIS (Geographic Information System) is a powerful tool that can be used with the GM to analyze trade potential (Delgado et al., 2010). The model assumes that the size of two locations and the distance between them are the main determinants of the intensity of interaction between them (Shepard, 2013). Specifically, the GM predicts that the larger the population and economic activity of two locations, the greater the exchange volume between them. At the same time, the further apart they are, the lower the

level of exchange (Jung et al., 2008). GM is a conceptual framework rather than a specific equation with fixed parameters, so there is no “latest formula” per se (Benedictis & Taglioni, 2011). The model, however, has been applied in a wide range of fields except international trade, such as migration (Karemera et al., 2000) and transportation planning (Tsekeris & Stathopoulos, 2006) and can provide insights into the factors driving regional economic growth and development. The basic structure of the GM, as described in Eq. (1), remains widely used and accepted.

The formula for the GM is:

$$T_{ij} = (M_i * M_j) / D_{ij}^\alpha \tag{1}$$

where:

- T_{ij} represents the volume of interaction or flow between two locations, i and j
- M_i and M_j represent the relevant indicators of the respective locations (e.g. population, GDP)
- D_{ij} represents the distance between the two locations
- α represents a parameter that determines the degree to which distance affects the level of interaction. It is usually set to a value between 1 and 2.

In logarithmic form, the formula can be expressed as follows:

$$\log(\text{trade}_{ij}) = \alpha + \beta_1 \log(GDP_i) + \beta_2 \log(GDP_j) + \beta_3 \log(\text{Distance}_{ij}) + \epsilon \tag{2}$$

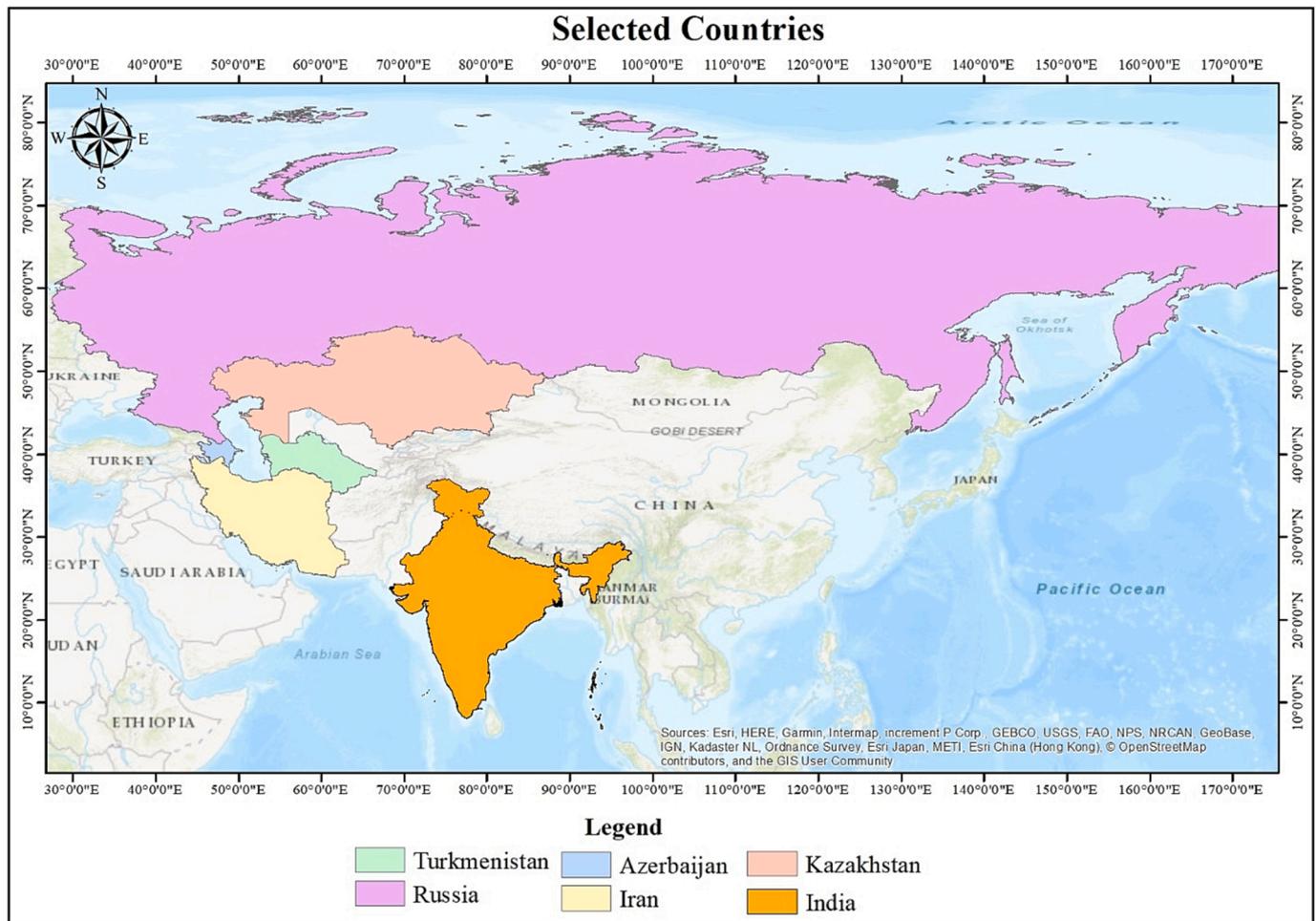


Fig. 2. Geographical location of Indo-Caspian Countries Source: Prepared by authors.

Table 1
Factors influencing trade potential.

Selected factors	Factor description	Source	Previous literature-base
Total population	Natural log of the population is obtained	Population data is obtained from data bank portal of World Bank (https://data.worldbank.org/)	Vanderkamp et al., 1977; Karemera et al., 2000; Poot et al., 2016; Hassan Khayat, 2019
Total trade	Natural log of the trade is obtained	Trade data is obtained from UN Comtrade portal (https://comtrade.un.org/data)	Anderson, 1979; Egger, 2000; Lewer and Van den Berg, 2008; Flipe and Kumar, 2012
Total GDP	Natural log of the GDP is obtained	GDP data is obtained from data bank portal of World Bank (https://data.worldbank.org/)	Bergeijk et al., 2010
Service area	Service area is prepared in km ² in GIS platform using shapefiles of the countries and combined road and railway network	Road network: data is taken from open street map (https://www.openstreetmap.org/); Countries' shapefile: data taken from Dive-GIS (https://www.diva-gis.org/)	N.A.
Distance between capitals	Linear distance calculated in km in GIS platform	Location of the country's capital taken from google earth, the kml files then converted to shapefile and linear distance is calculated in GIS platform	Porojan, 2001; Poprawe, 2015

Source: Calculated by authors

where:

Trade_{ij} represents the volume of trade between importing and exporting countries.

GDP_i represents the GDP of importing countries
GDP_j represents the GDP of exporting countries
Distance is the distance between the capitals of the importing and exporting countries

α represents the intercept of a regression
 β represents the coefficients of the regression
 ϵ denotes the error of the regression model.

The formula indicates that the greater the size of the two locations and the shorter the distance between them, the higher the volume of interaction or flow (Lui et al., 2022). There is no fixed proposed number of factors for estimating GM as it is a general model of spatial interaction (Thompson et al., 2019), the Eq. (2) can have any number of factors. Hence, it is open to the assimilation of additional influencing or attracting factors (Sen and Smith, 2012).

The present study adopts four variables, i.e., trade, population, GDP, and service area, where trade is a dependent variable and GDP, population, and service area are explanatory variables. As a result, the new equation is as follows:

$$\log(\text{trade}_{ij}) = \alpha + \beta_1 \log(\text{GDP}_i) + \beta_2 \log(\text{GDP}_j) + \beta_3 \log(\text{Population}_i) + \beta_4 \log(\text{Population}_j) + \beta_5 \log(\text{service_area}_i) + \beta_6 \log(\text{service_area}_j) + \beta_7 \log(\text{Distance}_{ij}) + \epsilon \quad (3)$$

In the present study, Eq. (3) was used to model the trade potential of the India-Caspian region. where,

α denotes the intercept of Eq. (4)
 \log is the natural log of the values
 i and j denote India and a selected Caspian country, respectively
 GDP is the gross domestic product of the given country
 Population is the total number of persons inhabiting the country
 Service area represents the area served by the ports of the country
 ϵ denotes the R2
 $\beta_1 \dots \beta_7$ is the coefficient calculated using the following Eq. (4) of ordinary least squares (OLS).

$$Y = \alpha + \beta X \quad (4)$$

ϵ generally represented a random error term or residual in most studies; however, recent studies have also used the R2 as ϵ . Hsu et al. (2021), Cai (2021) and Shohan (2022) used the R2 in GM estimation.

Different variables employ the forces of attraction in GM of international trade. The distance between the two business centres plays the role of a repulsive force. In the present study, population size, total trade, GDP, and Service area of the ports have been adopted as the forces of attraction in the GM. The linear distance between the capitals of the selected countries is taken as the counter-repulsive force in developing

Table 2
 Distance of Different Sea-routes.

Sea Route	Distance (in km)
Mumbai-Chabahar	1555.76
Mumbai-Bandar Abbas	2150.19
Anzali-Baku	422.121
Anzali-Awaza	517.69
Anzali-Bekdash	679.732
Anzali-Kuryk	892.346
Anzali-Aktau	953.767
Anzali-Bautino	1100
Anzali-Astrakhan	1407.08

Source: Appendix 1, Appendix 2.

$\text{GDP}_{\text{India}}$ = log of GDP of India, Ln_GDP_partner = log of GDP of partner Country, Ln_Pop_partner = log of population of the partner country, $\text{Pop}_{\text{India}}$ = log of population of India, Ln_service_area = log of service area of the country, Ln_Distance = log of distance between trading countries; $\beta_1 \dots \beta_n$ = Coefficients of the respective factors, ϵ = error.

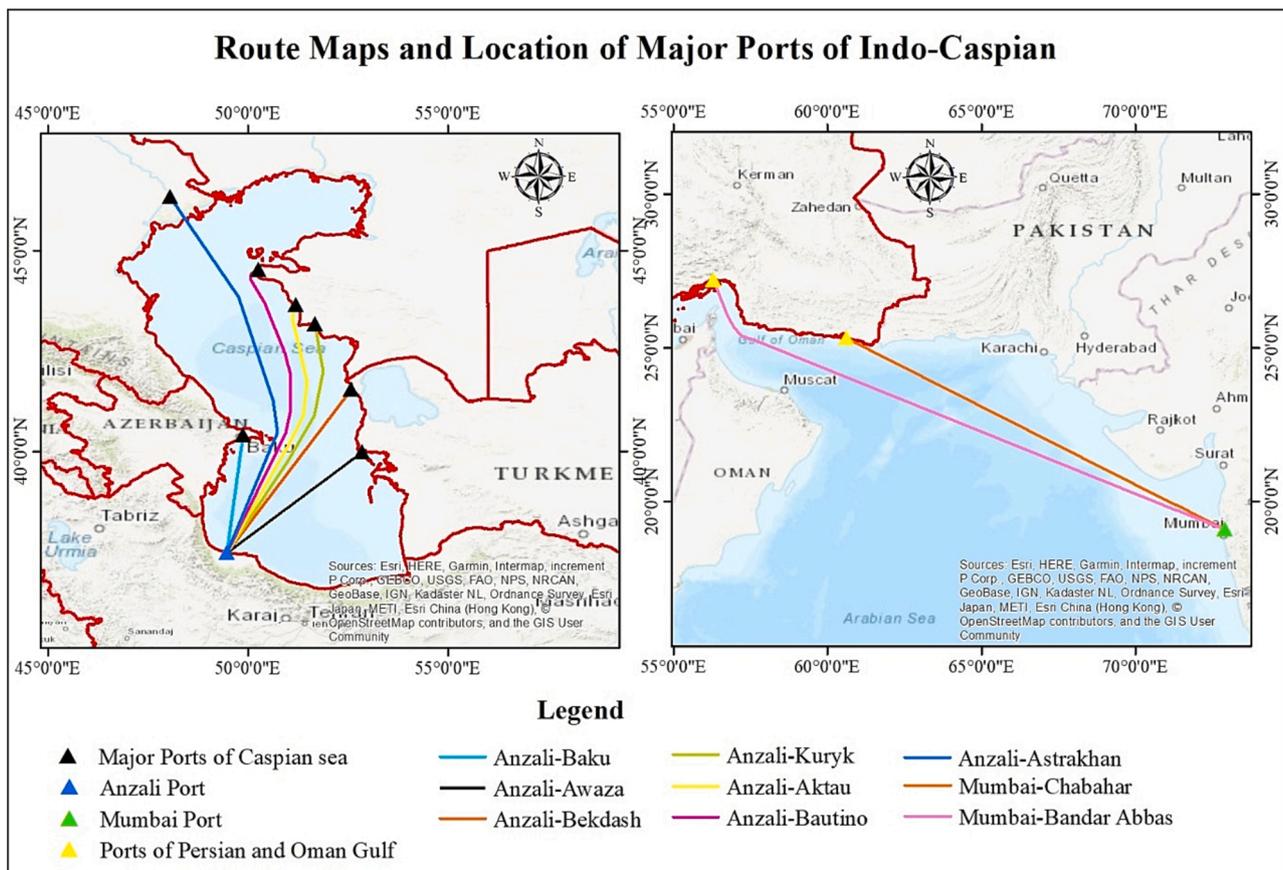


Fig. 3. Route Map and Locations of Indo-Caspian countries. Source: Prepared by authors.

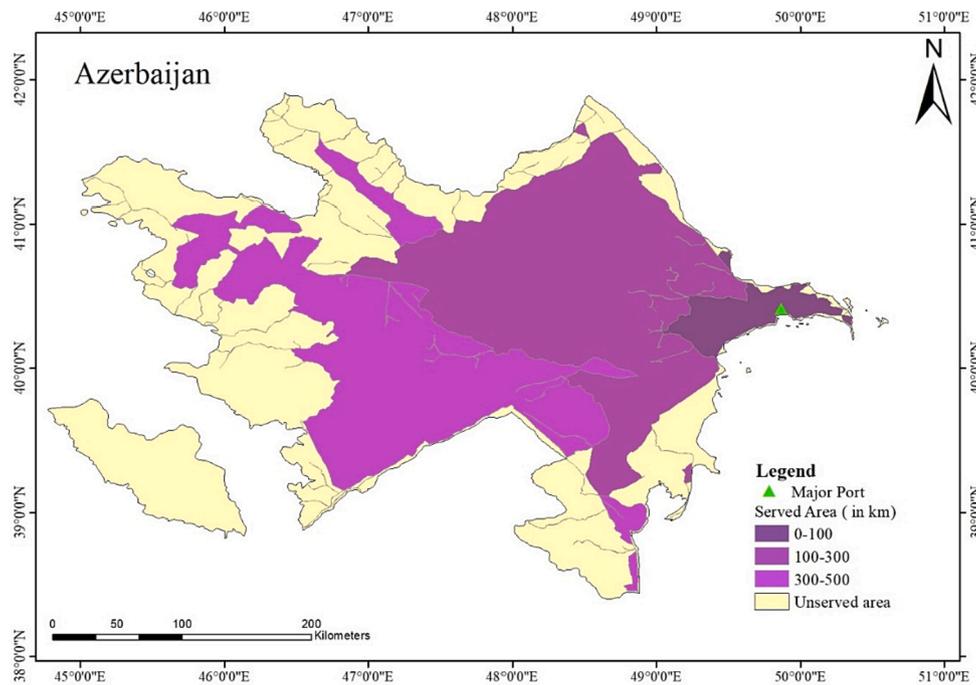


Fig. 4. Service area of Azerbaijan Source: Prepared by authors.

Source: Prepared by authors

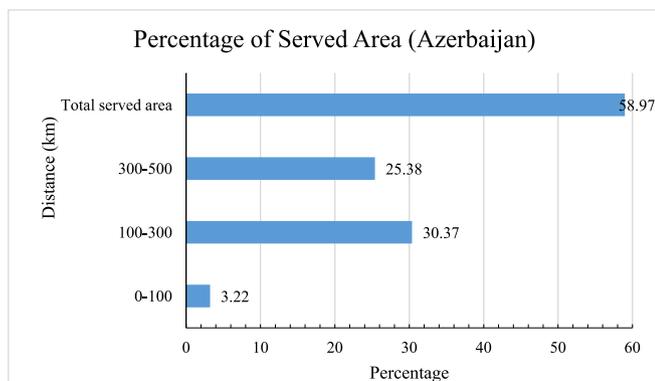


Fig. 5. Service area of Azerbaijan. Source: Calculated by authors.

the GM (Table 1).

The rationale behind the selection of influencing factors

No fixed factors influence the trade between two countries; instead, a set of factors play mutually to determine the trade. Therefore, GM should be estimated dynamically by incorporating different factors potentially affecting the trade (Kahouli, 2016). Adopting the factors depends on how strongly they affect the trade flows in a given set of countries.

GDP: GDP is an essential gauge of the overall health of an economy. It measures the total value of goods and services in a country. It is a significant component of the GM used to determine the volume of trade as it is directly proportionate to the production of goods and services within a country’s territory. It is a widespread phenomenon that a country’s economic importance is measured in terms of the GDP (along with other factors); the more significant the GDP, the bigger the economy of the country, but of course, it must be taken into consideration, that the GDP is a flow-type indicator and does not necessarily reflect the wealth of a given nation because the later is a result of formerly

accumulated goods. GDP represents the masses of the two economies (Shepherd et al., 2019). Therefore, it is rational to adopt the GDP in modelling the trade potential of the two countries. Apart from GDP, GDP per capita, income also represents the masses of the economy (Khan & Khan, 2013).

Population: One of the fundamental postulates of macroeconomics is that there is a positive, significant relationship between economic growth and the increase in the labour force (Subasat & Bellos, 2011; Hirway, 2012). It has long been part of GM development and has strong scientific foundation as a strong influencing factor (Vanderkamp, 1977; Schultz, 1982). Big business clearly benefits from high population growth and technological development that can outpace the population growth. Therefore, the population is another factor influencing the attraction force between the two countries. The population has been adopted as an attractive factor in trade potential modelling (Grosche et al., 2007; Lewer and Van den Berg, 2008; Mishra, 2020).

Trade: Aggregate demand (AD) influences trade (Bowles & Boyer, 1995). All capital goods, consumer products, exports, imports, and government spending make up a country’s aggregate demand. If there is an increase in AD, it positively affects a country’s trade volume and determines the trade potential of the two countries. If the trade volume increases, trade potential is also higher between the two countries as trade attracts forces (Bagwell & Staiger, 1988; Bekele & Mersha, 2019). Trade volume attracts the two trade partners just like a Newton’s law (Christie, 2002). There is an absolute consensus among the scholars about the importance of trade in developing GM.

Service area: The service area plays a huge role in developing trade centres (Li & Oh, 2010). Likewise, in an international trade service area the ports is a determining factor for estimating the flow of commodities (Wilson et al., 2005; Notteboom & Rodrigue, 2017). It is useful to incorporate the extent or proportion of service area of ports or other business hubs in the economic studies. However, there have been limited studies focusing on integrating such parameters in economics, especially the studies based on the application of GIS for quantifying the service area of ports as a factor influencing trade are nearly absent. Hawash et al. (2021) used a change detection method to assess the service area of the Sudan ports in the Red Sea, but it needed network analysis. It is very significant that service area is added in the GM of

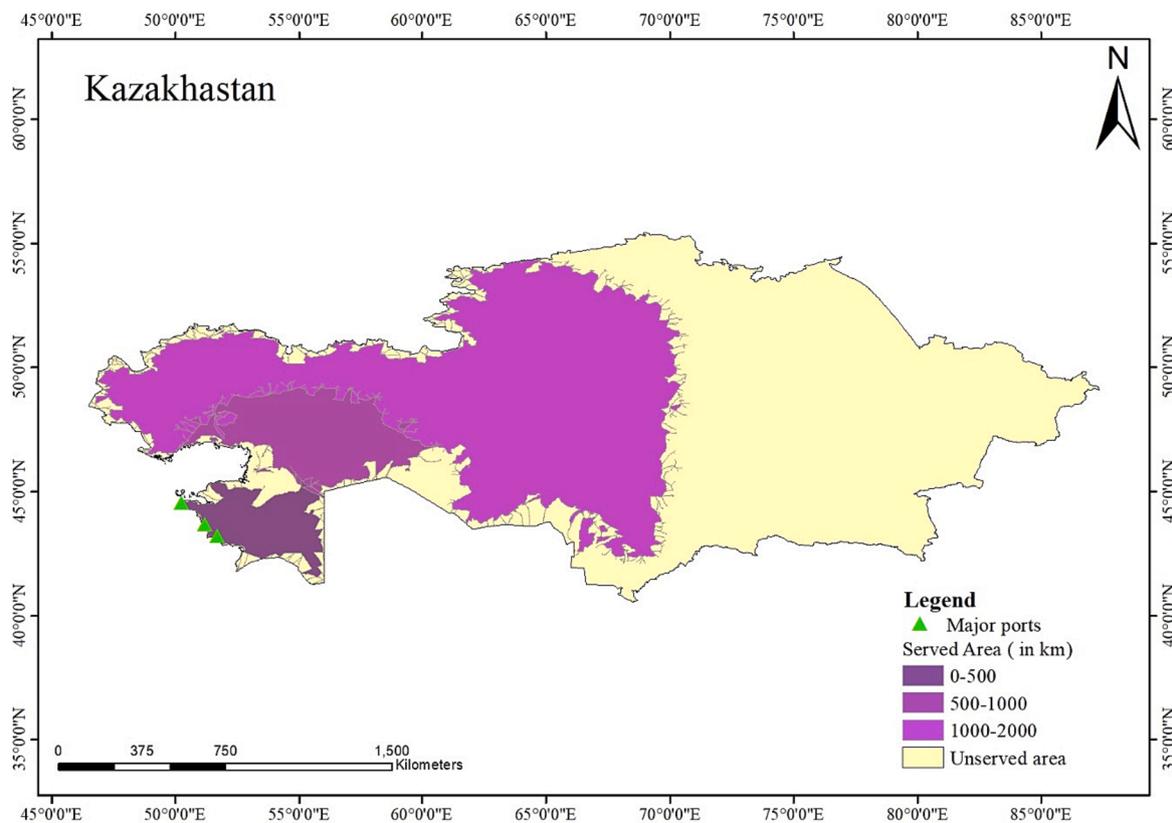


Fig. 6. Service area of Kazakhstan. Source: Prepared by authors.

Source: Prepared by authors

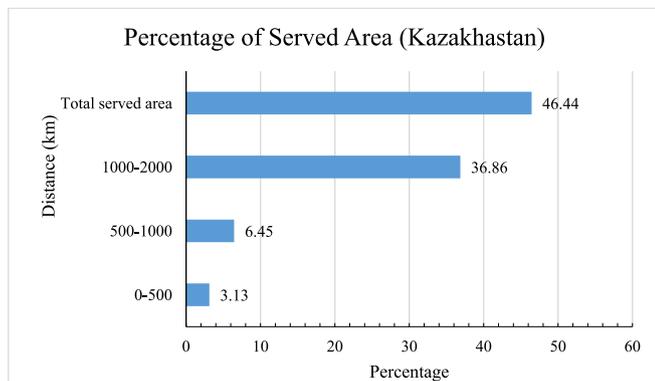


Fig. 7. Service area of Kazakhstan. Source: Calculated by authors.

trade potential for developing intuition about its significance. In the present study, network analysis is utilized to model and quantify the service area for the first time.

Methods

Service Area: In GIS (Geographic Information Systems), a service area is a type of spatial analysis that calculates the extent or coverage of a particular service or facility from a given location within a specified travel time or distance. This type of analysis is often used in urban planning, transportation, and healthcare to determine a facility or service’s reach and identify underserved areas. To create a service area in GIS, users define a starting location, the mode of travel (e.g. walking, driving), and a range of time or distance thresholds. The GIS software then uses spatial algorithms to calculate the reachable area based on a

network dataset that includes road, rail, or other transportation infrastructure. The resulting service area can be displayed on a map, allowing users to visualise the extent of coverage and to identify areas that fall within or outside the service area. This information can be used to optimise the placement of facilities, allocate resources more effectively, and improve accessibility for residents or customers. GIS-based service area analysis can provide valuable insights for businesses, governments, and other organisations that need to make informed decisions about where to locate facilities or invest in infrastructure. With the capabilities of GIS software, users can perform sophisticated service area analyses with a high degree of accuracy and customisation.

Gravity Model: It is based on the idea that the amount of trade between two countries is proportional to the size of their economies (as measured by Gross Domestic Product or GDP) and inversely proportional to the distance between them. Other factors, such as common language, shared borders, and trade agreements, can also influence trade flows Christerson (1994). Anderson (2011) used GM to assess the patterns of gross shipments, while Hua and Porell (1979) critically examined the validity of GM way back in the late 20th century. GIS (Geographic Information System) is a powerful tool that can be used with the GM to analyse trade potential (Delgado et al., 2010). The model is based on the assumption that the size of two locations and the distance between them are the main determinants of the intensity of interaction between them (Shepard, 2013). Specifically, the GM predicts that the larger the population and economic activity of two locations, the greater the exchange volume between them. At the same time, the further apart they are the lower the exchange level (Jung et al., 2008). GM is a conceptual framework rather than a specific equation with fixed parameters, so there is no “latest formula” per se (Benedictis & Taglioni, 2011). The model, however, has been applied in a wide range of fields except international trade, such as migration (Karemera et al., 2000) and transportation planning (Tsekeris & Stathopoulos, 2006) and can provide insights into the factors driving regional economic growth and

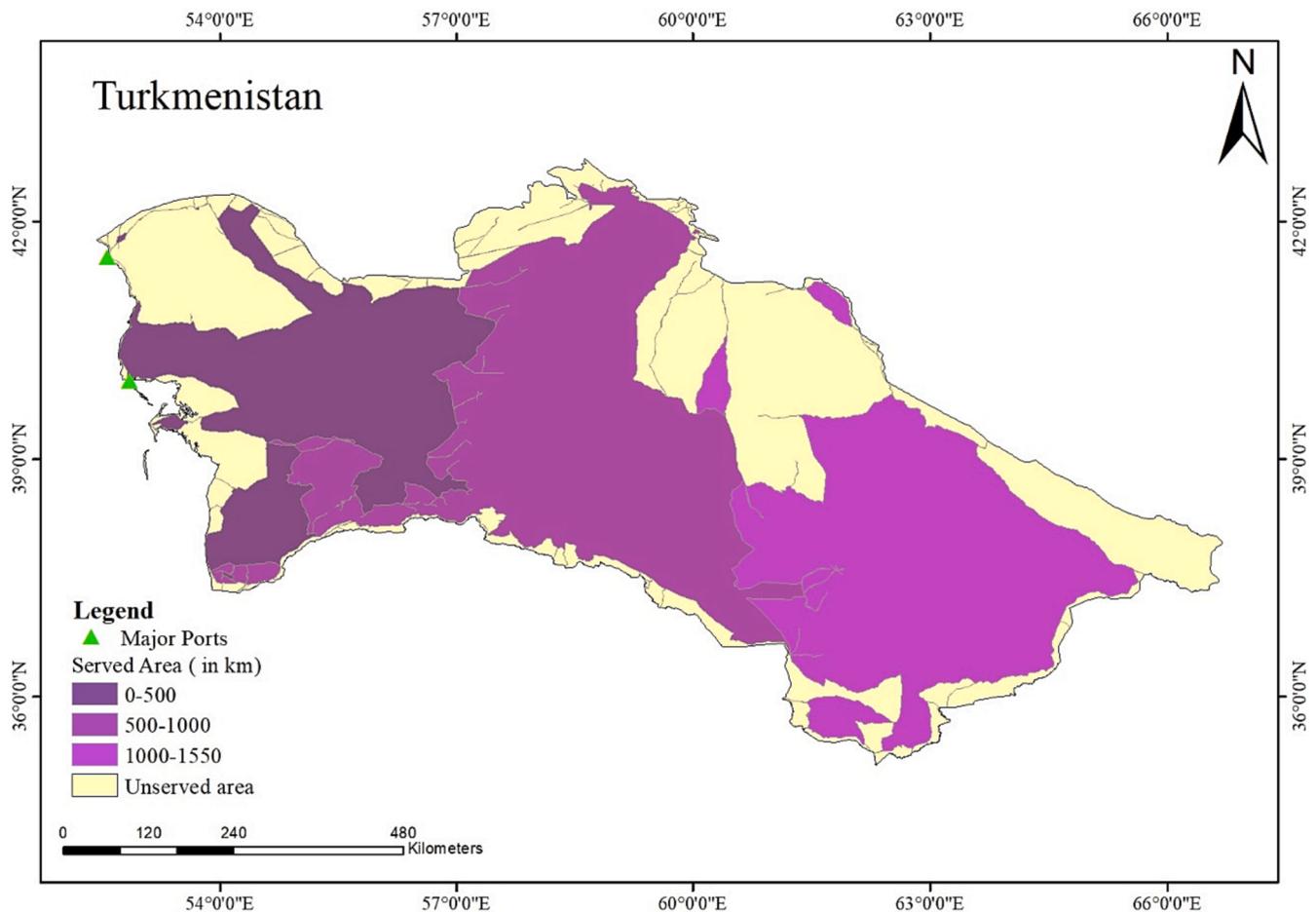


Fig. 8. Service area of Turkmenistan. Source: Prepared by authors.

Source: Prepared by authors

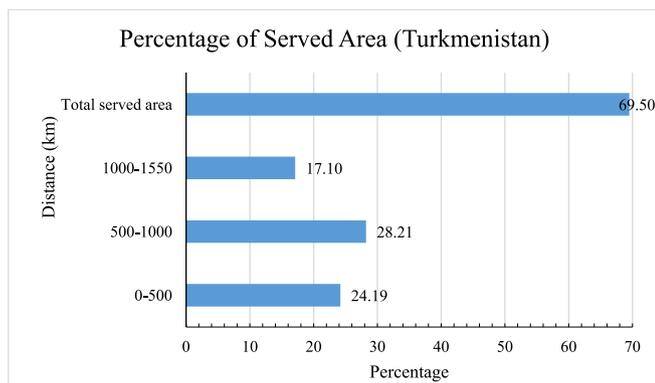


Fig. 9. Service area of Turkmenistan. Source: Calculated by authors.

development. The basic structure of the GM, as described in Eq. (1), remains widely used and accepted.

Selection of countries

Azerbaijan, Kazakhstan, Iran, Turkmenistan, and Russia have been selected based on the criteria of having a coast in the Caspian Sea. These five countries have seven ports in the Caspian Sea. Iran, Azerbaijan, and Russia have one port each however, Turkmenistan and Kazakhstan have two ports and three ports each. Russia is the largest country among the selected countries, while the smallest is Azerbaijan.

Results

All the selected countries have well-developed routes in the Caspian Sea and well-served areas in the hinterlands except Russia. The Iranian ports are crucial for India-Caspian trade due to their geographic location. Port Anzali and Bandar Abbas are intermediaries between Caspian countries (Fig. 3). The geographical distance is directly proportional to the cost of transportation; hence, it is crucial to consider distance. Astrakhan is the farthest from Port Anzali, and Baku is the closest (Table 2).

The service area of ports in selected countries could be more consistent throughout. When, for instance, the total served area of Azerbaijan under 500 km of road lengths is more than 58% (Fig. 4), it accounts for roughly 25.58% of the country's area. Area that is served by 100 km of road length is only 3.22%, while from 100 km to 300 km falls 30.37% area of the country (Fig. 5). For Kazakhstan, the maximum threshold for road length is 2000 km (Fig. 6), yet only 46.44% of the country's area is served by its three ports, 36.86% area is served by through road with length between 1000 km and 2000 km and only 3.13% area is served by the road with 500 km length (Fig. 7). Western part of the country is not served by the Caspian ports at large (Fig. 6). Turkmenistan holds a very advantageous position where roughly 24.19.5 % of the country's area is served by roads having 500 km length, 28.21% area falls between road length range of 500 to 1000 km. 17.10% area of the country is served by road length of 1000–1550 km. A total 69.50% area is served in total in Turkmenistan (Fig. 8). Mostly, northern corridor of the Country is not served and falls beyond road range of 1550 km. Obviously, numerous important towns of the country can be accessed within 500 km action radius. Iran has 43.61% of country's total

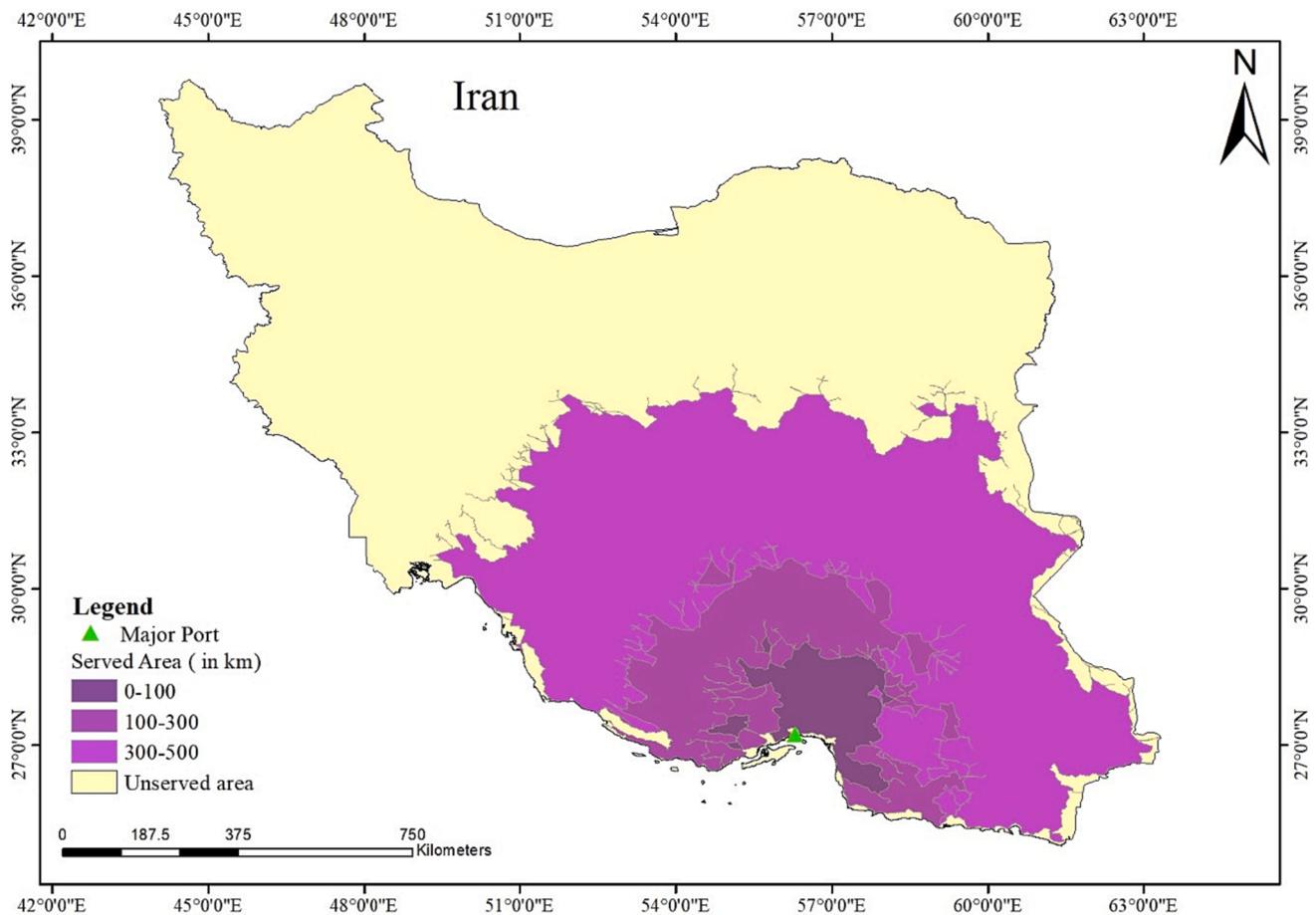


Fig. 10. Service area of Iran. Source: Prepared by authors.

Source: Prepared by authors

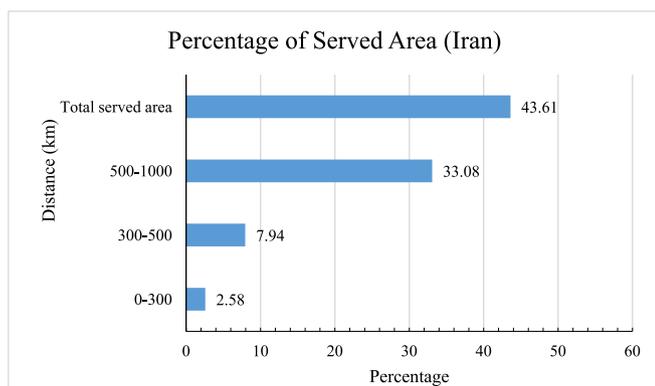


Fig. 11. Service area of Iran. Source: Calculated by authors.

area that is served by Bandar Abbas. Small 2.58% area of the of country is served by roads with length 0 to 300 km. 7.94% area is served by roads with length 300 km to 500 km. 33.08% area is served by road having length of 500 to 1000 km (Fig. 11). The northern part of Iran is not served by Bandar Abbas (Fig. 10). The Establishment of Chabahar increases 0.11% of the total served area while there is an approximate 2% increase in the area served by roads lengths of 0–300 km and 300–500 km (Fig. 13). The northern parts of Iran remain unserved by the afore-said ports. Russia has only 5.93% of its area that is served by the Astrakhan port. Negligible 0.71% area of the country is served by the road with length ranging from 0 to 1000 km. 60% area of the country is

served by 1000 to 2000 km length of the roads. Between the road length of 2000 to 3000 km, there is only 2.62% area. However, it is also need to consider that Russia is the largest country of the world and 440 thousand km of territory can be achieved in the service area of Astrakhan. This is a relatively small part of the country. However, it should be considered that this area is more than five times larger than the territory of Azerbaijan, nearly 90 % of the territory of Turkmenistan. It must be taken into consideration that the territory of Russia, which the modern Caspian ports can achieve, is one of the most densely populated parts of the country, including important logistical (Rostow na Donu), industrial (Volgograd) and agricultural (Kuban) centres (Fig. 14, Fig. 15).

The OLS modelling of GM reveals that the intercepts are highly variable from country to country. Turkmenistan has largest positive intercept i.e., 7369.72 while Kazakhstan has largest negative intercept i. e., –5823.97. The best R^2 is obtained for Turkmenistan while smallest R^2 is observed for Russia (Table 2).

GM of the selected Caspian countries from 2015 to 2020 represents fluctuating trends except for Russia, which denotes a stable increase in trade potential. The trade potential of Iran has considerably declined since 2018, whereas Kazakhstan has shown a declining trend since 2018; before that, there was an increasing trend. Azerbaijan has experienced an increase in the trade potential. The change can be effectively visualized in Fig. 16. The most significant increase in trade potential is observed in Azerbaijan (2.165), while the smallest is observed in Turkmenistan (0.383). Contrary, Iran witnessed a massive dip with a negative value of –2.850 (Table 3).

The trade potential kept varying from 2015 to 2020 for deferent countries. For Azerbaijan, it has shown a positive trend while for Iran, there is observed a declining trend in trade potential. Kazakhstan and Turkmenistan maintained roughly constant trade potential over the

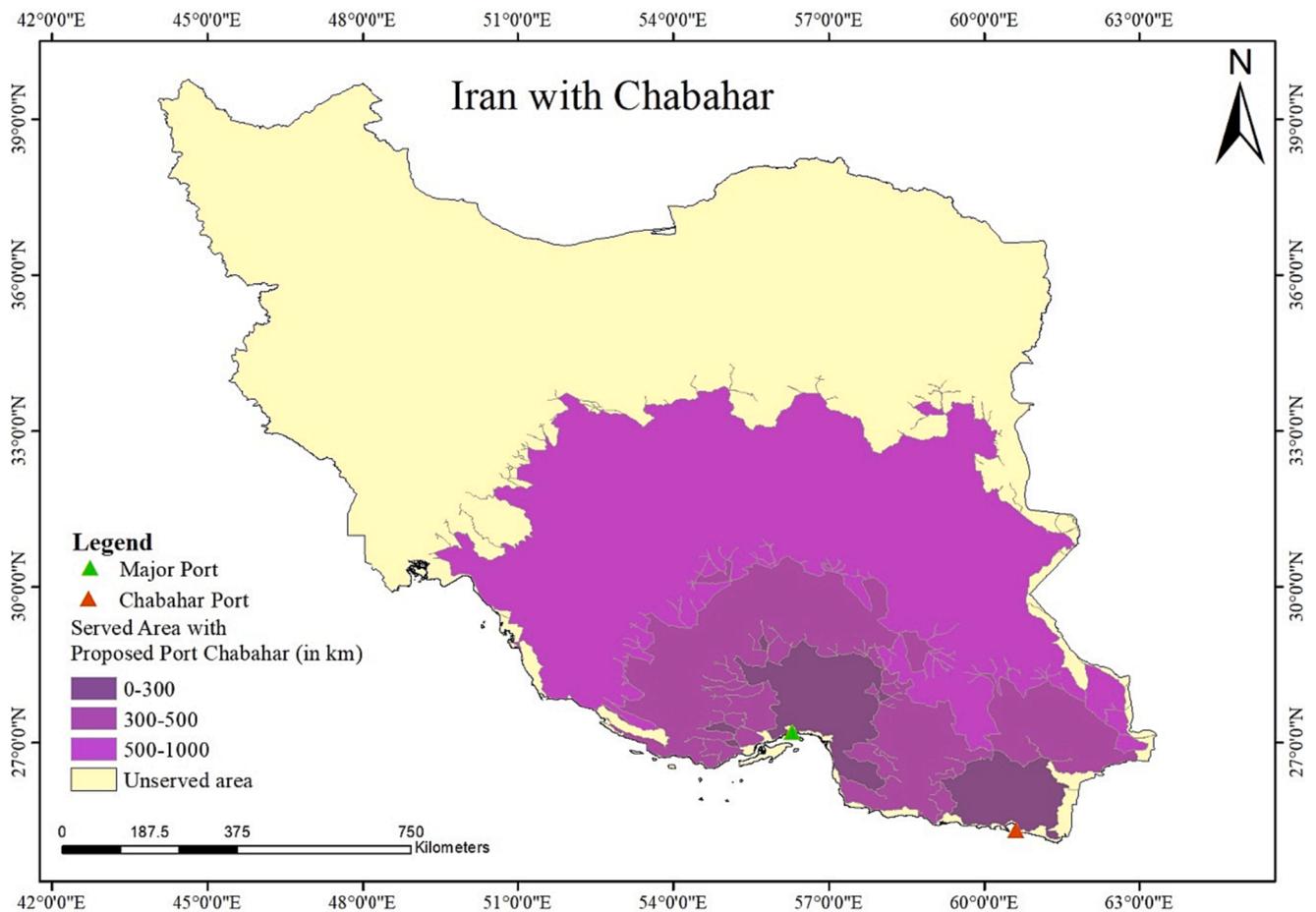


Fig. 12. Increase in service area of Iran after construction of Chabahar port. Source: Prepared by authors.

Source: Prepared by authors

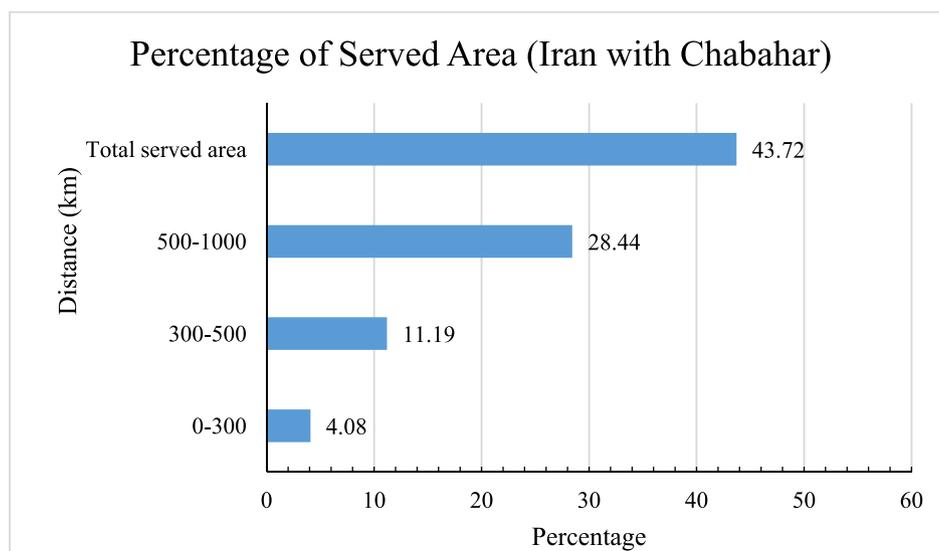


Fig. 13. Increase in service area of Iran after construction of Chabahar port. Source: Calculated by authors.

reference period (Fig. 16). Fig. 17 offers better visual interpretation for change in trade potential in both directions. Except Iran, all the Caspian countries have experienced a positive change in the trade potentials over 2015 to 2020. Maximum increase is witnessed in Azerbaijan followed by Russia (See Table 4).

Discussion

Our results support the main consequences of studies on the possibilities of logistic system development in the Caspian region (Akbulae & Bayramli, 2020). Having selected the factors, i.e., trade, GDP,

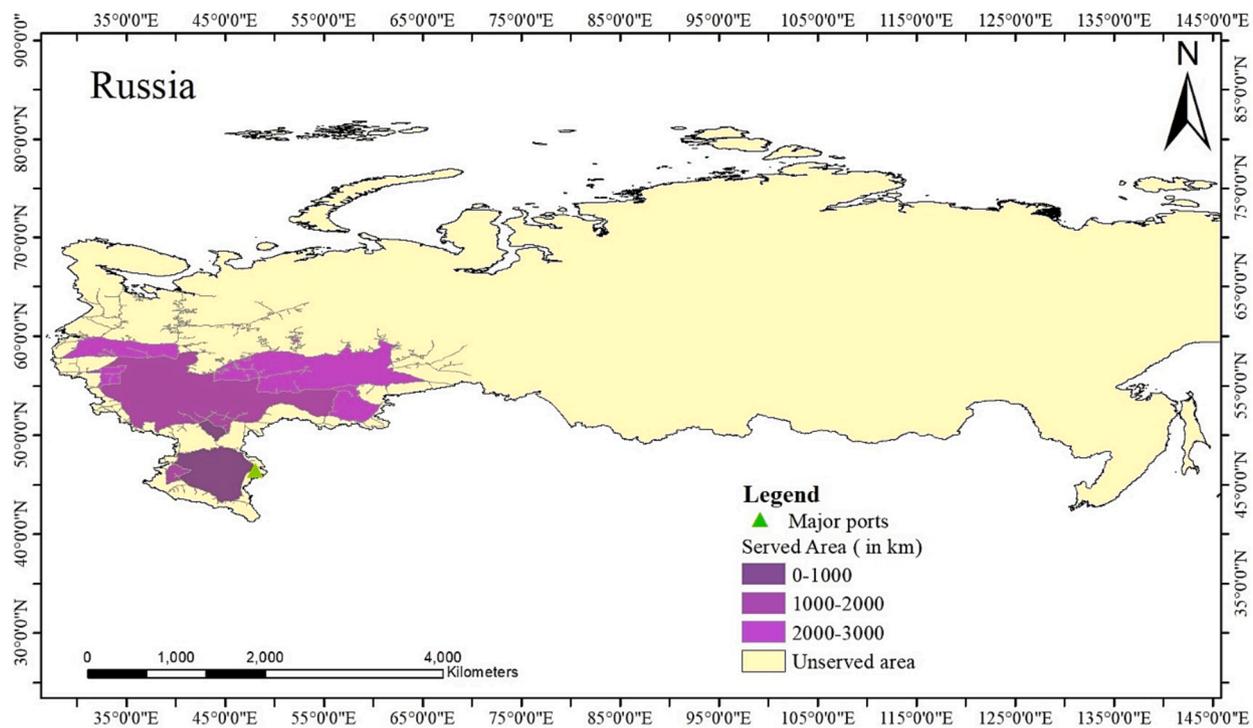


Fig. 14. Service area of Russia. Source: Prepared by authors.

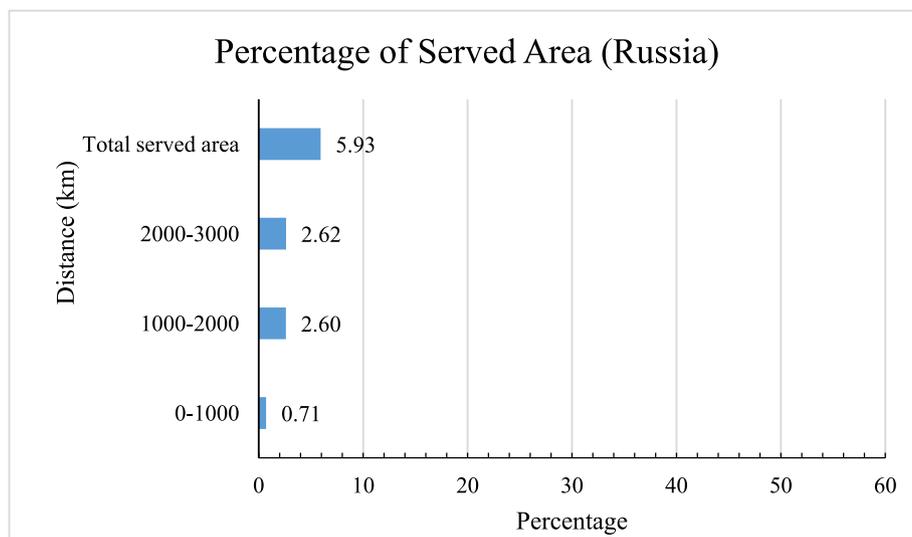


Fig. 15. Service area of Russia. Source: Calculated by authors.

population, service area and distance from the capitals, this study confirmed Russia’s key position and influence India-Caspian trade system, thus verifying a scientific basis for India and Russia to strengthen mutual trade relations with the highest GM values. This is also a reflection of India’s growing interest and its expanding trade potential in Eurasia. Though Russia has a relatively minimal service area to its territory, its trade potential will not be affected due to the small coefficient of the service area (barely 0.2667). Therefore, in the face of economic corridor development of the India-Caspian region, the International North-South Transport Corridor (INSTC) will be a significant boost for all other region countries.

The present study postulates that the construction of the Chabahar Port will also be an essential turning point for India in realizing its goals in Central Asian countries (Kazakhstan and Turkmenistan) connected to the Caspian Sea. Therefore, India also continues to view the port of

Chabahar as a “gateway” to Central Asia. India wants Iran to be vital to its economic/trade expansion. However, Iran’s lack of diplomatic favour towards India is a real hindrance to these ambitions. American hostility towards the Iranian regime and Afghan instability are other factors that limit the possibility of success in the venture (Pant, 2018, p. 18). Due to the regime change in Afghanistan, India is considering several scenarios for the development of Chabahar and the connection with the INSTC - The INSTC envisages the movement of goods from Mumbai (India) to Shahid Beheshti Port – Chabahar (Iran) by sea, from Chabahar to Bandar-e Anzali (an Iranian port on the Caspian Sea) by road, and then from Bandar-e Anzali to Astrakhan (a Caspian port in the Russian Federation) by ship across the Caspian Sea, and after that from Astrakhan to other regions of the Russian Federation and further into Europe by Russian railways (Khan & Mihr, 2023).

Increasing trade potential has already been noticed in this paper. In

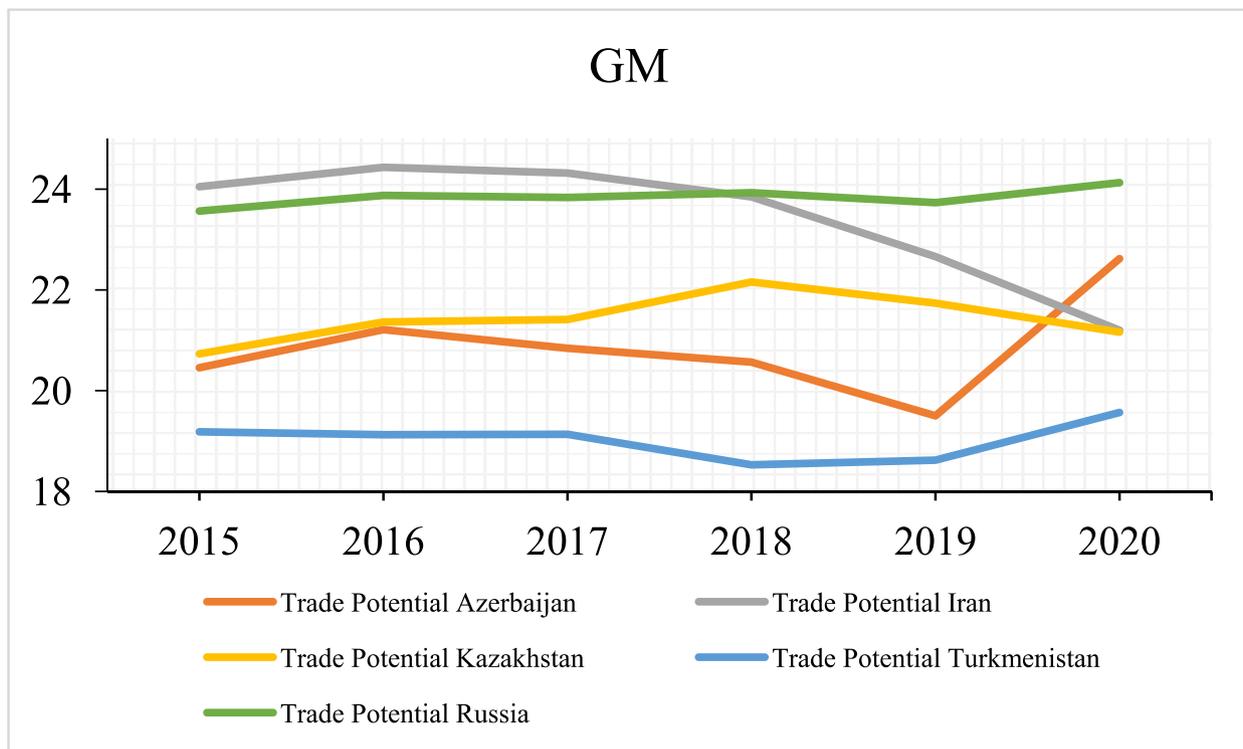


Fig. 16. GM showing trends of trade potential among Caspian countries.

Table 3
Coefficients of multivariate linear regression modelling.

Summary of OLS Azerbaijan							
Intercept (α)	GDP_India (β_1)	Ln_GDP_partner (β_2)	Ln_Pop_partner (β_3)	Pop_India (β_4)	Ln_service_area (β_5)	Ln_Distance (β_6)	R ² (ϵ)
682.0176	12.8602	0.9285	617.2484	422.6785	1.2850	-1.2231	0.9811
Iran							
2393.0358	-0.0694	0.7734	389.9201	-452.0660	2.2617	-0.8142	0.9761
Kazakhstan							
-5823.9700	13.2200	-10.6500	533.4300	696.9300	17.1890	-0.9129	0.9227
Turkmenistan							
7369.7190	-3.3970	-16.5000	601.0280	771.8710	0.7010	-2.6134	1.0000
Russia							
-225.6061	3.9079	0.9671	15.2138	5.7979	0.2667	-0.7913	0.9141

Source: Based on Table 2, calculated by the authors

recent years Azerbaijan has risen to the second strongest trade partner from the region to India with the second highest GM values. In fact, except for Iran and Kazakhstan, Caspian countries' trade potential has shown an increasing trend in recent years. It can be surmised from the changing pattern of trade potential that there is a shift from Iran to other countries which may continue in years to come. However, the Trans-Caspian trade routes have been center of discussion and research for very long time and have received due attention by the scientific community. Previous studies have focused on the trade potential of various Caspian countries, for instance, Palu and Hilmola (2023), have given futuristic perspectives on the trade potential of Trans-Caspian region. Lisovski et al. (2021) highlighted the significance of Indo-European trade routes. Suvankulov and Guc (2012) also examined the key traders of Central Asia using GM. Yet, the scholars missed geographical

analysis, internal transportation networks, role of service area of the Caspian ports. Only conventional factors for developing GM were selected in most of the studies (Raballand, 2003; Weckström, 2013; Ghasemi et al., 2021).

Unlike, previous researches, present study further attempts to incorporate novel factor i.e., service area of the Caspian ports in order to determine the role of internal transportation facilities in shaping the trade potential with India. The best possible location of a port is when it is optimally located in space with the shortest possible route and serving maximum hinterland. A depth assessment of this problem has been conducted effectively with the help of GIS by Gutiérrez and García-Palomares (2008) and Joseph et al., (2014). This study furnished firm ground for the significance of the connectivity of the ports and well-developed transportation network. It is also found that addition of

Source: Table 3

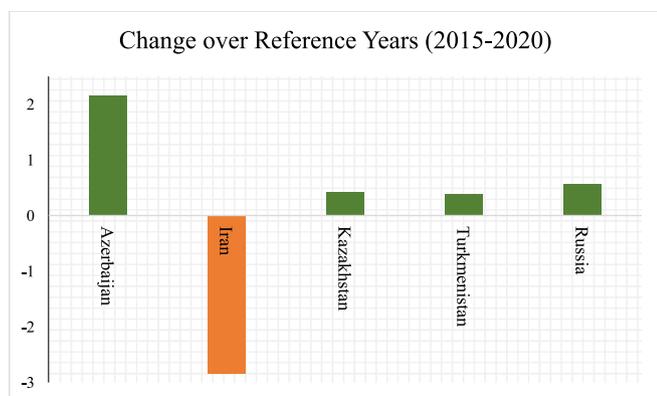


Fig. 17. Change in trade potential (2015–2020). Source: Table 3.

Table 4
Values representing trade potential of India-Caspian Countries.

GM					
Year	Azerbaijan	Iran	Kazakhstan	Turkmenistan	Russia
2015	20.455	24.049	20.731	19.184	23.565
2016	21.212	24.433	21.363	19.128	23.876
2017	20.840	24.319	21.413	19.135	23.837
2018	20.567	23.847	22.157	18.528	23.931
2019	19.501	22.659	21.738	18.622	23.731
2020	22.621	21.199	21.161	19.567	24.129
Change over reference years	2.165	-2.850	0.430	0.383	0.564

service area as one of the factors in GM is statistically significant. The study further sheds light on the prevailing mutual linear distances among ports of Caspian (Sundarakani et al., 2019; Van Bergeijk and Brakman, 2010). It is found in the study that Astrakhan is farthest from Anzali port of Iran which mediates the Caspian region and India. Therefore, it can be suggested that establishing a new port will be beneficial in the wake of new commercial scenarios of India-Caspian trade. It can be hypothesized that the new port closer to Anzali could increase Russia’s service area and trade potential with India and cut off the transportation cost. Although Azerbaijan also has a single major port in Baku, it appears to be sufficient due to its relatively small size and well-connected road network with a proportionately high service area (Yusifov et al., 2019; Ziemnowicz, 1942). Kazakhstan has three ports, but none are evenly distributed along the coast. Turkmenistan has two ports, Bekdash and Awaza, which are well-placed in space and can serve the country evenly, but due to the limited availability of a well-connected transport network Bekdash has limited service area, expansion of road and rail network is highly suggestive around Bekdash.

Conclusion

International trade between nations remains significant for shaping regional and global dynamics. A significant portion of global challenges emerges from maritime politics. The new corridors as a new geographical space create opportunities and challenges for a country like India, which relies heavily on energy resources. The Indian economy has seen significant growth in recent times, and this year foreign reserves alone stood at \$560 billion as of March 2023. Modi government is committed to making the Indian economy from \$3.3 trillion to \$5 trillion by 2025/26, making India 3rd largest economy. The commitment to achieve this goal will depend on several factors, including the relations with countries which can enhance trade with India. The Caspian region (primarily Russia and West Central Asia) is undoubtedly one of those regions.

However, direct access could be more explicit. We have noticed a remarkable trade jump with Russia due to the Ukraine war, but is it still a question to be addressed for the long term? Of course, Indian authorities are diversifying their economic strategies by looking for potential partners and therefore building the corridors as one of the foreign policy priorities. Studying the geographical proximity (as this paper has attempted) through network analysis and service area modelling is helpful to overcome the challenges of transport corridors, and when looking with gravity economic model contributes significantly to boosting hopes of triggering international trade by deepening into comprehending the nature of International trade and variables such as total trade, GDP, population, service area and distance between ports taking into account. In this paper, an attempt has been made to focus on India-Caspian Countries trade – its significance, challenges, opportunities and threats. The network’s fundamental part is growing and uniting India’s nearness to the Caspian region. This implies operationalising INSTC and encouraging fortifying it by growing the capacity of Chabahar port in Iran, early completion of the Chabahar–Zahedan rail connection, and finalising calculated courses of action with all nations along the hallway in Central Asia, Caucasus, Russia and Europe.

Limitations

The selected countries have highly variable surface areas that could be more logical for keeping a constant threshold for the service area modelling. So, different thresholds have been given to each country for dealing with this problem. The enormous threshold is given for Russia, while the smallest is for Azerbaijan. The study assumes that the roads and railway lines are interconnected, which is not a universal fact. The number of selected factors for estimating the GM values is limited to four. Although adopting more factors does not mean better results in GM, exploring and experimenting with more variables is commendable.

Recommendations

In our case, the distances between the countries were approximated by the distance of the capitals. However, in the case of some countries, some alternative distance metrics should be tested, too, e.g., the distance between Moscow and Asthana (an important logistical centre in Russia) is much higher than the distance between Baku and Astrahan. In further phases of research, the role of another country (e.g., Pakistan, Turkey) in the trade development of the region should be analyzed, too.

So far, the spatial analysis of service area is concerned, some countries have good coverage of transportation network while others have less prevalent road network. Therefore, it is highly recommended that countries with limited physical extent of transportation network should focus on the expansion and development of roadways and railway network in order to rip benefits of full trade potential. Russia is one such countries where western part is well served while rest of it is practically devoid of any transportation network. Contrary to that Azerbaijan has very well-developed transportation network, hence, aspects of trade other than transportation should be focused.

CRedit authorship contribution statement

Zainab Khan: Conceptualization, Methodology, Software, Formal analysis, Writing – original draft, Writing – review & editing, Visualization, Project administration. **Kashif Hasan Khan:** Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration. **Hial Koch:** Formal analysis, Investigation, Resources, Data curation, Funding acquisition.

Declaration of Competing Interest

interests or personal relationships that could have appeared to influence the work reported in this paper.

The authors declare that they have no known competing financial

Appendix 1

Country Name	Year	Import	Export	Trade (total) (in USD)	GDP (in USD)	Population	Distance (Mumbai to the Capital in km)	Service_area
Azerbaijan	2016	280718037	31627279	312345316	37867518957	9757812	3242.76	87182.06
Azerbaijan	2017	545025987	41578210	586604197	40865558912.39	9854033	3242.76	87182.06
Azerbaijan	2018	302905166	37744974	340650140	47112941176.47	9939771	3242.76	87182.06
Azerbaijan	2019	341506988	54534297	396041285	48174235294.12	10024283	3242.76	87182.06
Azerbaijan	2020	58406376	45888456	104294832	42693000000.00	10093121	3242.76	87182.06
Azerbaijan	2021	297121764	2243732524	2540854288	54622176470.59	10137750	3242.76	87182.06
Iran	2016	8253714509	2412534962	10666249471	457954614142.54	83306231	2774.44	1001081.7
Iran	2017	11089432705	2596780520	13686213225	486630146443.62	84505076	2774.44	1001081.7
Iran	2018	14730865348	2845297570	17576162918	331682036227.96	85617562	2774.44	1001081.7
Iran	2019	3375419775	3855008082	7230427857	283746685180.34	86564202	2774.44	1001081.7
Iran	2020	297121764	2243732524	2540854288	239735571102.50	87290193	2774.44	1001081.7
Iran	2021	408679185	1284000579	1692679764	359713152725.06	87923432	2774.44	1001081.7
Kazakhstan	2016	320360774	125026101	445386875	137278320084.17	17794055	3547.18	2857861
Kazakhstan	2017	1039035928	118499913	1157535841	166805800595.70	18037776	3547.18	2857861
Kazakhstan	2018	748604918	138585995	887190913	179339994859.38	18276452	3547.18	2857861
Kazakhstan	2019	1597366193	193684391	1791050584	181667190075.54	18513673	3547.18	2857861
Kazakhstan	2020	1283221035	225723705	1508944740	171082379532.99	18755666	3547.18	2857861
Kazakhstan	2021	530008023	207456239	737464262	197112255360.61	19000988	3547.18	2857861
Turkmenistan	2016	21702273	57245478	78947751	36169428571.43	5868561	2504.1	565742
Turkmenistan	2017	14934163	59638048	74572211	37926285714.29	5968383	2504.1	565742
Turkmenistan	2018	33007137	42205837	75212974	40765428571.43	6065066	2504.1	565742
Turkmenistan	2019	3692798	37309163	41001961	45231428571.43	6158420	2504.1	565742
Turkmenistan	2020	686143	44297958	44984101	45241829129.19	6250438	2504.1	565742
Turkmenistan	2021	3847116	111962098	115809214	45242298716.24	6341855	2504.1	565742
Russia	2016	4782004793	1813884254	6595889047	1276786979221.81	144342397	5025.68	4900464
Russia	2017	7980558686	2138971950	10119530636	1574199387070.90	144496739	5025.68	4900464
Russia	2018	6801024922	2334070585	9135095507	1657329646183.62	144477859	5025.68	4900464
Russia	2019	6226189464	2871228560	9097418024	1693113904262.89	144406261	5025.68	4900464
Russia	2020	5937619360	2559257769	8496877129	1489362488439.76	144073139	5025.68	4900464
Russia	2021	8695038077	3334263995	12029302072	1778782625793.74	143449286	5025.68	4900464
India	-	-	-	-	2294797980509.01	1338636340	-	-
India	-	-	-	-	2651472946375.05	1354195680	-	-
India	-	-	-	-	2702929718960.46	1369003306	-	-
India	-	-	-	-	2831552222519.99	1383112050	-	-
India	-	-	-	-	2667687951796.50	1396387127	-	-
India	-	-	-	-	3176295065497.24	1407563842	-	-

Appendix 2

Country Name	Ln_trade	Ln_GDP_India	Ln_Pop_India	Ln_GDP_partner	Ln_Pop_partner	Ln_Distance	Ln_served_area
Azerbaijan	19.55962	28.46167	21.01492	24.35736	16.09358	8.08418	11.37575
Azerbaijan	20.18986	28.60614	21.02647	24.43355	16.10339	8.08418	11.37575
Azerbaijan	19.64637	28.62536	21.03735	24.57581	16.11205	8.08418	11.37575
Azerbaijan	19.79703	28.67185	21.04760	24.59809	16.12052	8.08418	11.37575
Azerbaijan	18.46273	28.61223	21.05715	24.47730	16.12736	8.08418	11.37575
Azerbaijan	21.65577	28.78674	21.06513	24.72371	16.13178	8.08418	11.37575
Iran	23.09035	28.46167	21.01492	26.85004	18.23803	7.92820	13.81659
Iran	23.33965	28.60614	21.02647	26.91077	18.25232	7.92820	13.81659
Iran	23.58981	28.62536	21.03735	26.52744	18.26540	7.92820	13.81659
Iran	22.70156	28.67185	21.04760	26.37135	18.27640	7.92820	13.81659
Iran	21.65577	28.61223	21.05715	26.20280	18.28475	7.92820	13.81659
Iran	21.24958	28.78674	21.06513	26.60857	18.29198	7.92820	13.81659
Kazakhstan	19.91445	28.46167	21.01492	25.64528	16.69437	8.17391	14.86558
Kazakhstan	20.86956	28.60614	21.02647	25.84010	16.70798	8.17391	14.86558
Kazakhstan	20.60357	28.62536	21.03735	25.91255	16.72112	8.17391	14.86558
Kazakhstan	21.30607	28.67185	21.04760	25.92544	16.73402	8.17391	14.86558
Kazakhstan	21.13468	28.61223	21.05715	25.86541	16.74701	8.17391	14.86558
Kazakhstan	20.41873	28.78674	21.06513	26.00704	16.76000	8.17391	14.86558
Turkmenistan	18.18430	28.46167	21.01492	24.31148	15.58512	7.82568	13.24589
Turkmenistan	18.12728	28.60614	21.02647	24.35891	15.60199	7.82568	13.24589
Turkmenistan	18.13583	28.62536	21.03735	24.43110	15.61806	7.82568	13.24589
Turkmenistan	17.52913	28.67185	21.04760	24.53506	15.63333	7.82568	13.24589
Turkmenistan	17.62182	28.61223	21.05715	24.56129	15.64816	7.82568	13.24589

(continued on next page)

(continued)

Country Name	Ln_trade	Ln_GDP_India	Ln_Pop_India	Ln_GDP_partner	Ln_Pop_partner	Ln_Distance	Ln_served_area
Turkmenistan	18.56745	28.78674	21.06513	24.94201	15.66268	7.82568	13.24589
Russia	22.60971	28.46167	21.01492	27.87537	18.78770	8.52232	15.40484
Russia	23.03773	28.60614	21.02647	28.08477	18.78877	8.52232	15.40484
Russia	22.93539	28.62536	21.03735	28.13623	18.78864	8.52232	15.40484
Russia	22.93126	28.67185	21.04760	28.15759	18.78814	8.52232	15.40484
Russia	22.86296	28.61223	21.05715	28.02937	18.78583	8.52232	15.40484
Russia	23.21061	28.78674	21.06513	28.20695	18.78149	8.52232	15.40484

References

- Abtin, A., & Lashari, F. B. (2016). *The Caspian Sea Journal*.
- Akbulaev, N., & Bayramli, G. (2020). Maritime transport and economic growth: Interconnection and influence (an example of the countries in the Caspian Sea coast; Russia, Azerbaijan, Turkmenistan, Kazakhstan and Iran). *Marine Policy, 118*, Article 104005.
- Alati, L. A., & Kaur, H. (2023). The economies of West Asia. In *Research Anthology on Macroeconomics and the Achievement of Global Stability* (pp. 103–120). IGI Global.
- Amidi, S., & Fagheh Majidi, A. (2020). Geographic proximity, trade and economic growth: A spatial econometrics approach. *Annals of GIS, 26*(1), 49–63.
- Anderson, J. E. (1979). A theoretical foundation for the gravity equation. *The American Economic Review, 69*(1), 106–116.
- Anderson, J. E. (2011). The gravity model. *Annual Review of Economics, 3*(1), 133–160.
- Aydin, U., & Azhgaliyeva, D. (2019). Assessing energy security in the Caspian region: the geopolitical implications to European energy strategy. In *Achieving Energy Security in Asia: Diversification, Integration and Policy Implications* (pp. 257–290).
- Bagwell, K., & Staiger, R. W. (1988). A theory of managed trade.
- Bahgat, G. (2005). Energy Security: The Caspian Sea. *Minerals & Energy-Raw Materials Report, 20*(2), 3–15.
- Bekele, W. T., & Mersha, F. G. (2019). A dynamic panel gravity model application on the determinant factors of Ethiopia's coffee export performance. *Annals of Data Science, 6*, 787–806.
- Bilgin, M. (2009). Geopolitics of European natural gas demand: Supplies from Russia, Caspian and the Middle East. *Energy Policy, 37*(11), 4482–4492.
- Black, M., Ebener, S., Aguilar, P. N., Vidaurre, M., & El Morjani, Z. (2004). *Using GIS to measure physical accessibility to health care* (pp. 3–4). World Health Organization.
- Bowles, S., & Boyer, R. (1995). Wages, aggregate demand, and employment in an open economy: An empirical investigation. *Macroeconomic Policy after the Conservative Era, 143–171*.
- Cai, M. (2021). Doubly constrained gravity models for interregional trade estimation. *Papers in Regional Science, 100*(2), 455–474.
- Caner, H. I., & Aydin, C. C. (2021). Shipyard site selection by raster calculation method and AHP in GIS environment, Iskenderun, Turkey. *Marine Policy, 127*, Article 104439.
- Christerson, B. (1994). World trade in apparel: An analysis of trade flows using the gravity model. *International Regional Science Review, 17*(2), 151–166.
- Christie, E. (2002). Potential trade in South-East Europe: A gravity model approach. *SEER-South-East Europe Review for Labour and Social Affairs, 04*, 81–101.
- Cyril, M., Kotova, M., & Devonshire-Ellis, C. (2022, February 16). INSTC to improve India-Russia connectivity with cheaper Multi-Modal Transit Routes. Retrieved March 19, 2023, from <https://www.russia-briefing.com/news/instc-to-improve-india-russia-connectivity-with-cheaper-multi-modal-transit-routes.html>/Russia's RZD Logistics Eyes increased Caspian & INSTC shipments. (2022, April 21). Retrieved March 19, 2023, from <https://www.russia-briefing.com/news/russia-s-rzd-logistics-eyes-increased-caspian-instc-shipments.html>.
- Delgado, J. A., Gross, C. M., Lal, H., Cover, H., Gagliardi, P., McKinney, S. P., ... & Shaffer, M. J. (2010). A new GIS nitrogen trading tool concept for conservation and reduction of reactive nitrogen losses to the environment. *Advances in Agronomy, 105*, 117–171.
- egger, P. (2000). A note on the proper econometric specification of the gravity equation. *Economics Letters, 66*(1), 25–31.
- Felipe, J., & Kumar, U. (2012). The role of trade facilitation in Central Asia: A gravity model. *Eastern European Economics, 50*(4), 5–20.
- Ghasemi, A., Miandoabchi, E., & Soroushnia, S. (2021). The attractiveness of seaport-based transport corridors: An integrated approach based on scenario planning and gravity models. *Maritime Economics & Logistics, 23*, 522–547.
- Gogna, S. (2019). Assessing India's Engagements in the INSTC and Analysing its Implications on India's Commercial and Strategic Interests. *Strategic Analysis, 43*(1), 1–12. <https://doi.org/10.1080/09700161.2019.1573747>
- Grosche, T., Rothlauf, F., & Heinzl, A. (2007). Gravity models for airline passenger volume estimation. *Journal of Air Transport Management, 13*(4), 175–183.
- Gutiérrez, J., & García-Palomares, J. C. (2008). Distance-measure impacts on the calculation of transport service areas using GIS. *Environment and Planning B: Planning and Design, 35*(3), 480–503.
- Hassan Khayat, S. (2019). A gravity model analysis for trade between the GCC and developed countries. *Cogent Economics & Finance, 7*(1), Article 1703440.
- Hawash, E., El-Hassanin, A., Amer, W., El-Nahry, A., & Effat, H. (2021). Change detection and urban expansion of Port Sudan, Red Sea, using remote sensing and GIS. *Environmental Monitoring and Assessment, 193*, 1–22.
- Hirway, I. (2012). Missing labour force: An explanation. *Economic and Political Weekly, 67–72*.
- Hsu, C., Fan, C., & Mostafavi, A. (2021). Limitations of gravity models in predicting fine-scale spatial-temporal urban mobility networks. *arXiv preprint arXiv:2109.03873*.
- Hua, C. I., & Porell, F. (1979). A critical review of the development of the gravity model. *International Regional Science Review, 4*(2), 97–126.
- Jadhav, S., & Ghosh, I. (2023). Future prospects of the gravity model of trade: A Bibliometric Review (1993–2021). *Foreign Trade Review, 00157325221140154*.
- Jamagidze, L. (2022). Georgia-Romania Economic Cooperation and The New Regional Challenges. *EURINT, 9*(1), 133–150.
- Jones, S. G., Ashby, A. J., Momin, S. R., & Naidoo, A. (2010). Spatial implications associated with using Euclidean distance measurements and geographic centroid imputation in health care research. *Health services research, 45*(1), 316–327.
- Joseph, M., Wang, F., & Wang, L. (2014). GIS-based assessment of urban environmental quality in Port-au-Prince, Haiti. *Habitat International, 41*, 33–40.
- Jung, W. S., Wang, F., & Stanley, H. E. (2008). Gravity model in the Korean highway. *Europhysics Letters, 81*(4), 48005.
- Kahouli, B. (2016). Regional integration agreements, trade flows and economic crisis: A static and dynamic gravity model. *International Economic Journal, 30*(4), 450–475.
- Karatayev, M., & Hall, S. (2020). Establishing and comparing energy security trends in resource-rich exporting nations (Russia and the Caspian Sea region). *Resources Policy, 68*, Article 101746.
- Karemera, D., Oguledo, V. I., & Davis, B. (2000). A gravity model analysis of international migration to North America. *Applied Economics, 32*(13), 1745–1755.
- Kavalski, E. (2019). The Puzzle of India's Relations with "Central Eurasia". *Asian Security, 15*(3), 304–322. <https://doi.org/10.1080/14799855.2018.1463990>
- Khan, I. A., & Rahman, S. (2021). Review and analysis of blockage of Suez Canal region due to giant container ship. *Marine Technology Society Journal, 55*(5), 39–43.
- Khan, K. H., & Mihr, A. (2023). Introduction: Background to the Book. In K. H. Khan, & A. Mihr (Eds.), *Europe-Central Asia Relations. Europe-Asia Connectivity* (p. 1–10.). Singapore: Palgrave Macmillan. https://doi.org/10.1007/978-981-19-8707-6_1
- Khan, K. H., & Omid, A. (2023). China-India counterbalancing measures through international corridors and ports: The focus on Chabahar And Gwadar Ports. *Journal of Liberty and International Affairs, 9*(2), 144–163. <https://doi.org/10.47305/JLIA2392171k>
- Khan, S., & Khan, D. (2013). An empirical analysis of Pakistan's bilateral trade: A gravity model approach. *Romanian Economic Journal, 16*(48).
- Lawal, O., & Onuchuku, O. (2020). Modelling catchment area of economic activity using GIS-based Huff Gravity Model: A case of Edo State, Nigeria. *Ghana Journal of Geography, 12*(1), 171–197.
- Lewer, J. J., & Van den Berg, H. (2008). A gravity model of immigration. *Economics Letters, 99*(1), 164–167.
- Li, E., Lu, M., & Chen, Y. (2020). Analysis of China's importance in "belt and road initiative" trade based on a gravity model. *Sustainability, 12*(17), 6808.
- Li, J. B., & Oh, Y. S. (2010). A research on competition and cooperation between Shanghai port and Ningbo-Zhoushan port. *The Asian Journal of Shipping and Logistics, 26*(1), 67–91.
- Lisovski, S., Neumann, R., Albrecht, T., Munclinger, P., Ahola, M. P., Bauer, S., ... Briedis, M. (2021). The Indo-European flyway: Opportunities and constraints reflected by Common Rosefinches breeding across Europe. *Journal of Biogeography, 48*(6), 1255–1266.
- Meena, A. (2020). The Trade Game: Engaging with Central Asia. *Asian Affairs, 51*(3), 709–711. <https://doi.org/10.1080/03068374.2020.1814530>
- Ministry of Commerce and Industries, M. O. (2022, January 22). Welcome to Department of Commerce, Government of India. Retrieved March 2, 2023, from <https://commerce.gov.in/wp-content/uploads/2022/02/English-Annual-Report-2021-22-Department-of-Commerce.pdf>.
- Mishra, M. K. (2020). The Silk Road Growing Role of India.
- Mohapatra, N. K. (2022). Geopolitics of 'Imaginary Greater Eurasia' and Russia's dilemma of Asia-Pacific vs Indo-Pacific strategy: An analysis from India's strategic perspective. *Journal of the Indian Ocean Region, 18*(2), 173–199. <https://doi.org/10.1080/19480881.2022.2135075>
- Notteboom, T., & Rodrigue, J. P. (2017). Re-assessing port-hinterland relationships in the context of global commodity chains. In *Ports, cities, and global supply chains* (pp. 67–82). Routledge.
- Yusifov, O., Masim, E., Kulu, O., Korkmaz, T., Mammadov, O., & Parviz, H. (2019). Logistics sector in Azerbaijan economy: Structural improvements and orientations strategic development. *EUREKA: Social and Humanities, 2*, 29–38.
- Onifade, S. T., Erdoğan, S., Alagöz, M., & Bekun, F. V. (2021). Renewables as a pathway to environmental sustainability targets in the era of trade liberalization: Empirical

- evidence from Turkey and the Caspian countries. *Environmental Science and Pollution Research*, 28, 41663–41674.
- Palu, R., & Hilmoila, O. P. (2023). Future potential of trans-caspian corridor. *Logistics*, 7(3), 39.
- Passi, R. (2017). Money matters: Discussing the economics of the INSTC. *ORF occasional paper*, (112).
- Poot, J., Alimi, O., Cameron, M. P., & Maré, D. C. (2016). The gravity model of migration: The successful comeback of an ageing superstar in regional science.
- Poprawe, M. (2015). On the relationship between corruption and migration: Empirical evidence from a gravity model of migration. *Public Choice*, 163(3–4), 337–354.
- Porojan, A. (2001). Trade flows and spatial effects: The gravity model revisited. *Open Economies Review*, 12, 265–280.
- Raballand, G. (2003). Determinants of the negative impact of being landlocked on trade: An empirical investigation through the Central Asian case. *Comparative Economic Studies*, 45, 520–536.
- Sarma, A. S. (2010). *India and Central Asia*. Pentagon Press.
- Schultz, T. P. (1982). Lifetime migration within educational strata in Venezuela: Estimates of a logistic model. *Economic Development and Cultural Change*, 30(3), 559–593.
- Sen, A., & Smith, T. E. (2012). *Gravity models of spatial interaction behavior*. Springer Science & Business Media.
- Shahriar, S., Qian, L., Kea, S., & Abdullahi, N. M. (2019). The gravity model of trade: A theoretical perspective. *Review of Innovation and Competitiveness: A Journal of Economic and Social Research*, 5(1), 21–42.
- Shepherd, B., Doytchinova, H. S., & Kravchenko, A. (2019). *The gravity model of international trade: A user guide [R version]*. Bangkok: United Nations ESCAP. Available at: <https://www.unescap.org/resources/gravity-model-international-trade-user-guide-r-version>.
- Shohan, A. H. N. (2022). Exploring the factor relationship of international trade: A panel data gravity model approach. Available at SSRN 4177404.
- Stanojević, N., & Jovancai, A. (2015). Diversification of Serbia's export market-potentials for export to the countries of Caspian Basin. *Economic Themes*, 53(2), 278–297.
- Subasat, T., & Bellos, S. (2011). Economic freedom and foreign direct investment in Latin America: A panel gravity model approach. *Economics Bulletin*, 31(3), 2053–2065.
- Sundarakani, B., Lai, Y. S., Goh, M., & de Souza, R. (2019). Studying the sustainability of third party logistics growth using system dynamics. *Journal of Modelling in Management*, 14(4), 872–895.
- Suvankulov, F., & Guc, Y. (2012). Who is trading well in Central Asia? A gravity analysis of exports from the regional powers to the region. *Eurasian Journal of Business and Economics*, 5(9), 21–43.
- Sweezy, P. M. (1943). Professor Schumpeter's Theory of Innovation. *The Review of Economics and Statistics*, 25(1), 93–96.
- Thompson, C. A., Saxberg, K., Lega, J., Tong, D., & Brown, H. E. (2019). A cumulative gravity model for inter-urban spatial interaction at different scales. *Journal of Transport Geography*, 79, Article 102461.
- Tsekeris, T., & Stathopoulos, A. (2006). Gravity models for dynamic transport planning: Development and implementation in urban networks. *Journal of Transport Geography*, 14(2), 152–160.
- Van Bergeijk, P. A., & Brakman, S. (Eds.). (2010). *The gravity model in international trade: Advances and applications*.
- Vanderkamp, J. (1977). The gravity model and migration behaviour: An economic interpretation. *Journal of Economic Studies*, 4(2), 89–102.
- Vinokurov, E. Y., Ahunbaev, A., & Zaboev, A. I. (2022). International North-South Transport Corridor: Boosting Russia's "pivot to the South" and Trans-Eurasian connectivity. *Russian Journal of Economics*, 8(2), 159–173.
- Wajid, A., Kashif, H. K., & Harish, H. (2020). Innovations through Mergers and Acquisitions in the Pharmaceutical Sector. In G. Jain, H. Singh, S. Akter, A. Munjal, & H. S. Grewal (Eds.), *Technological Innovations for Sustainability and Business Growth* (pp. 91–104). Hershey: IGI Global. <https://doi.org/10.4018/978-1-5225-9940-1.ch007>.
- Weckström, A. (2013). Gravity model of trade and Russian exports.
- Zhang, C., Yang, Y., Feng, Z., Xiao, C., Lang, T., Du, W., & Liu, Y. (2021). Risk of global external cereals supply under the background of the COVID-19 pandemic: Based on the perspective of trade network. *Foods*, 10(6), 1168.
- Ziemanowicz, C. (1942). Joseph A. Schumpeter and innovation. *Socialism and Democracy*, 2(1), 2–4.