DOI: 10.15838/esc.2024.4.94.4
UDC 332.1+339.9, LBC 65.9(2Rus...)+65.428

Long-Term Dynamics of the Impact of Gravitational Factors on Foreign Trade of the Russian Far East

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Abstract. The aim of the research is to assess the dynamics of the impact of gravitational factors on foreign trade of the Russian Far East; the factors include physical distance, size of economies participating in trade, and the presence of a land border. The data array generated for the Far East in the "new" territorial boundaries for 2000–2021 indicated the focus of foreign trade of the Russian macroregion on the neighboring and large economies of Northeast Asia with a gradual dominance of China, as well as a decrease in the share of the southern Far East regions in trade turnover with border countries. Based on the technique of solving the "distance puzzle", estimates of gravity dependence indicate an increase in the positive impact of the size of economies on the foreign trade of the Far East by 9.1% by 2021 compared with 2000 and a decrease in the negative impact of physical distance by 4.3%, respectively. According to the estimates obtained, we reveal the long-term dynamics of the Far East economy "gravitating" toward the foreign rather than domestic market. The positive impact of the presence of a land border on the foreign trade of the Far East regions was determined only in the 2000s. It contributed to an increase in their trade turnover by 209% in 2000 and by 86% in 2009. The leveling of the positive impact of the land border on the foreign trade of the Far East border regions in 2010–2021 was revealed due to the following reasons: mass exports to China from regions that do not have a land border with China; orientation of border regions toward the market of the rest of the Russian regions; decrease in the intermediary role of border regions between China and other Russian regions; small scale, volatility and specificity of trade with Mongolia and the DPRK; negative impact of quarantine measures related to the pandemic. It is assumed

For citation: Izotov D.A. (2024). Long-term dynamics of the impact of gravitational factors on foreign trade of the Russian Far East. *Economic and Social Changes: Facts, Trends, Forecast*, 17(4), 75–92. DOI: 10.15838/esc.2024.4.94.4

that in the context of current restrictions in relation to Russia, an important aspect of the development of the Far East economy should include diversification of trade interactions between the regions of the Far East and China, including through promoting cross-border cooperation.

Key words: trade, gravitational factors, physical distance, GDP, GRP, land border, foreign market, region, macroregion, Northeast Asia, China, Russia, Far East.

Introduction

In a spatial context, Russia's economic potential is declining dramatically from west to east (Baklanov, 2015). Given the need to smooth out such spatial asymmetries, as well as the desire to diversify foreign economic interactions over the past decade and a half, Russian economic development prospects are closely linked to the strategy of its "turn to the East" (Minakir, 2017). A major component of Russia's policy in the eastern direction is advanced development of Far East economy, primarily by expanding foreign economic activity of this Russian macroregion both globally and sub-globally (Minakir, 2015). The Russian Far East occupies a special place in the national economy: it has access to the seas of the Pacific Ocean, territorial proximity to the countries of the Asia-Pacific region (APR) and Northeast Asia (NEA). At the same time, the Far East is remote from the more developed western regions of Russia This macroregion has been functioning for a relatively long time due to the active exploitation of its resource and transit advantages (Minakir, 2006) with its close economic contacts with the foreign market.

Due to its relatively small size[1] and relatively high openness, the Far East economy is able to experience "attraction" to neighboring and large foreign economies (Baklanov, 2015); this fact can be explained by the influence of gravitational factors on trade in the macroregion. The main ones include the physical distance and size of the interacting economies. In addition, a number of Far Eastern regions have a land border with some NEA countries, which in general can contribute to the emergence of various kinds of contact structures (Baklanov, 2018) based on the functioning of border infrastructure facilities and transport crossings and, in turn, be considered as an additional gravitational factor influencing trade in the Far East.

All other things being equal, the influence of these major gravitational factors on trade is one of the fundamental principles that quite accurately explain the relationship and dynamics of commodity exchange between different economic systems (Chaney, 2018). Empirical estimates obtained for the national and sub-national levels clearly indicate the deterrent effect of physical distance on trade and the stimulating effect of the size of interacting economies (Overman et al., 2003; Pal, Kar, 2021). At the same time, integration/disintegration processes, as well as various endogenous effects, can in one way or another distort the impact of the main gravitational factors on commodity exchange. While the impact of the size of economies on trade does not provoke any noticeable complaints in the research community[2], the impact of physical distance, on the contrary, has become an object of discussion (Berthelon, Freund, 2008; Brun et al., 2005; Disdier, Head, 2008) due to methodological problems associated with the presence of the so-called "distance puzzle" (Lin, Sim, 2012), i.e. the non-decreasing (modulo) negative impact of this factor, which did not correspond to reality, since in the context of globalization and regionalization

[1] At the same time, in terms of area, the Far East is the largest Russian macroregion.

[2] Except for the choice of an indicator characterizing the size of economies – the absolute or relative value of GDP (Mayer, 2008; Zmuk, Josic, 2021).

processes, there was a decrease in transport costs and various barriers in interactions between countries. We should point out that over the past decade and a half, thanks to notable theoretical progress (Yotov, 2012), a methodological solution to the "distance puzzle" has been found, which contributed to obtaining reliable estimates of the influence of gravitational factors on trade interactions between economies. As for the presence of a land border with a foreign country, in most cases this factor has a positive impact on trade (Eichengreen, Irwin, 1998). However, due to the noticeable differences in the rules of operation of checkpoints between interacting economies (Carter, Poast, 2020), organization specifics of trade between countries (Bernardini Papalia, Bertarelli, 2015), and the use of border position advantages (Alamá-Sabater et al., 2015), as well as the peculiarities of political relations between bordering countries (Hussain, 2017), the impact of the presence of a land border on trade can be both invariant and negative.

Despite the relevance and apparent simplicity of obtaining quantitative estimates of the influence of the abovementioned gravitational factors on the trade of the Far East, the amount of studies carried out in this direction is rather insufficient. For the mid-2000s, it was determined that physical distance negatively affected the integration of markets in some border regions of the Far East and China (Ryzhova, 2013). As for earlier studies on the Far East in previously existing territorial boundaries, we can point out the following: for 1999–2018 a decrease in the negative impact of physical distance was found (Izotov, 2021a), and the overall positive impact of the presence of a land border (Izotov, 2021b) with China on the overall intensity of trade between the macroregion and the Asia-Pacific countries was determined; for 2008–2017 the overall positive impact of the size of economies on trade turnover of the Far East with major trading partners of the macroregion and the negative impact of physical distance, as well as, depending on the specifications of gravity models used, a statistically unstable influence of the presence of land border (Tochkov, 2018) were revealed. While direct influence of the abovementioned gravitational factors in dynamics on the trade of the Far East has not been studied sufficiently in terms of its interactions with the entire set of foreign countries within the long-term period. Despite the high comparative intensity of trade between the Far East and the domestic market (Izotov, 2021b), trade turnover of the macroregion with foreign countries showed much higher value volumes. This circumstance suggests that gravitational factors in the long term strengthened the trend of expanding trade between the Far East and foreign countries in comparison with the domestic market.

At the end of 2018 the territorial configuration of the Far East changed due to the inclusion of two Siberian regions – the Republic of Buryatia and the Trans-Baikal Territory (Minakir, 2019); thus, the impact of gravitational factors on trade of the macroregion in the "new" borders was not assessed, among other things, due to the complexity of collecting and streamlining statistical data reflecting trade interactions of the macroregion with various markets. For this reason, an important task of this study is to determine the influence of gravitational factors on the trade of the Far East within the "new" territorial boundaries. The legality of considering the Far East within these borders until 2018 is based, among other things, on the fact of existence of the Interregional Association of Economic Cooperation of the Subjects of the Russian Federation "Far East and Transbaikalia", established in the early 1990s as part of the modern territorial configuration of the macroregion[3].

An earlier study (Izotov, 2023), based on gravity dependence, determined a long-term tendency toward reducing the negative impact of physical

[3] Minakir P.A. (Ed.). (2002). Far East and Transbaikalia – 2010. Program for economic and social development of the Far East and Transbaikalia until 2010. Moscow: Ekonomika.

distance on trade in the Asia-Pacific region as part of a methodological approach to solving the "distance puzzle". It is assumed that in order to study the influence of gravitational factors on trade at the macroregional level, i.e. for the Far East, it is possible to apply this methodological approach, taking into account necessary additions to the gravity dependence.

Thus, the aim of the research is to assess the dynamics of influence of gravitational factors on the foreign trade[4] of the Russian Far East, which include physical distance, size of trading economies and presence of a land border. Achieving the goal involves addressing the following tasks: 1) determine the influence of physical distances, size of the economy and presence of a land border on the dynamics of foreign trade in the Far East in the "new" borders; 2) select a methodology and form an array of statistical data; 3) assess the dynamics of influence of gravitational factors on the foreign trade of the Far East. The study covers the period from 2000 to 2021[5]. The Russian Far East is considered within the territorial boundaries of the Far Eastern Federal District (macroregion) as of the end of 2018 and includes 11 regions: Amur Region, Jewish Autonomous Region (JAR), Trans-Baikal Territory, Kamchatka Territory, Magadan Region, Primorye Territory, Republic of Buryatia, Republic of Sakha (Yakutia), Sakhalin Region, Khabarovsk Territory, Chukotka Autonomous Area (ChAA).

Foreign the trade of the Far East: the role of physical distance, size of the economy, and land border

Foreign trade expansion has become a key source of economic growth in the Far East. During the period under consideration, the volume of foreign trade in the Far East increased more than 9-fold – from 5.2 billion US dollars in 2000 to 48.0 billion US dollars in 2021, noticeably exceeding the value of trade turnover of the macroregion with the domestic market, while in the early 2000s these volumes were comparable *(Fig. 1)*.

In the framework of the Far East's trade with foreign countries, there was a gradual increase in trade turnover with the nearby largest economies of the NEA – China, Republic of Korea and Japan[6], whose share in the macroregion's foreign trade increased from 57% in 2000 to 80% in 2021. The Far East's trade turnover with the NEA countries grew mainly due to the expansion of trade with China, whose share in the macroregion's foreign trade increased from 26% in 2000 to 47% in 2021, despite the COVID-19 pandemic in the early 2020s, trade between the macroregion and the People's Republic of China grew due to gradual orientation of various projects in Far Eastern regions toward the fast-growing and capacious Chinese market; for example, supplying crude oil via pipeline to the Chinese market amid increasing complications in this sphere with other countries, namely geographical de-diversification of export of timber industry goods of Far Eastern regions in favor of China in the context of prohibitive export customs duties imposed since the late 2000s, which negatively affected the supply of untreated wood to developed countries of the Asia-Pacific region; increase in trade and non-trade barriers to Russia's trade with some developed countries that imposed sanctions on the Russian economy after 2014[7].

The current geographical structure of foreign trade interactions between the Far East and the dominant largest economies of the NEA, on the one hand, is explained by specifics of trade and

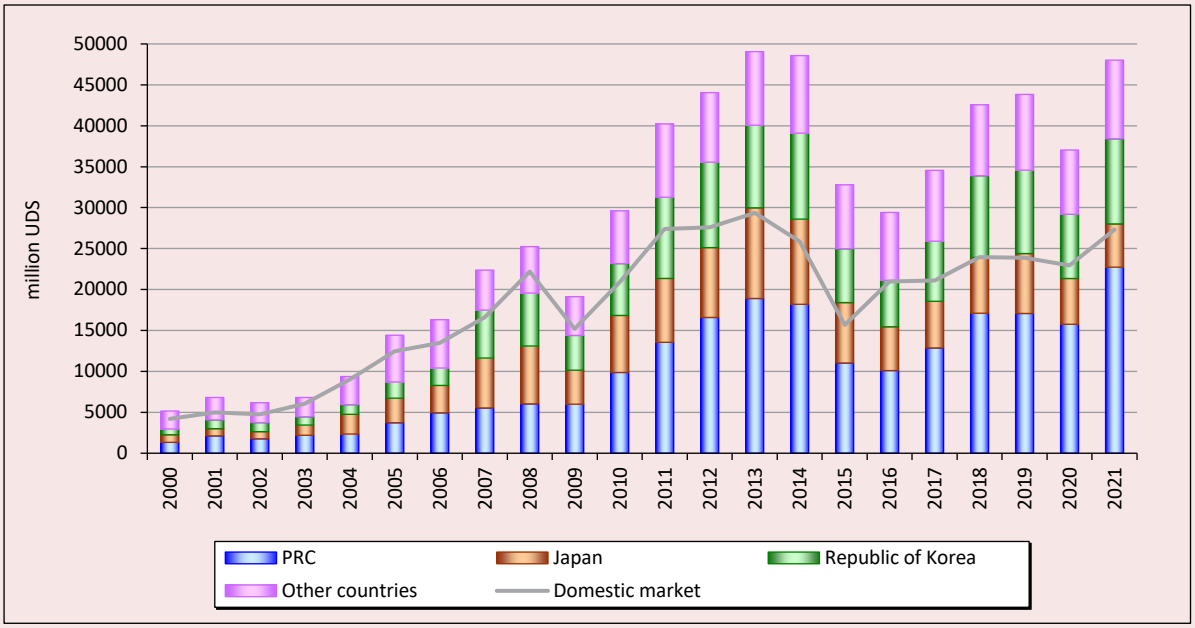
[4] Here and elsewhere, foreign trade of the Far East means its trade with foreign countries.

[5] It is impossible to analyze foreign trade of Far East regions after 2021 due to the temporary suspension of publication of statistical data on Russian regions by the Federal Customs Service (FCS) and the Federal State Statistics Service (FSSS) of Russia.

[6] While Japan's share in the Far East's foreign trade was declining in the 2010s.

[7] European Union (EU-28), United States, Canada, Australia, Iceland, Japan, Liechtenstein, Norway, New Zealand and Switzerland.

Figure 1. Trade of the Far East with foreign and domestic markets



Note: trade of the Far East with the foreign market is broken down by country.

Source: calculated according to Federal Customs Service, Federal State Statistics Service, sector statistics of Russia.

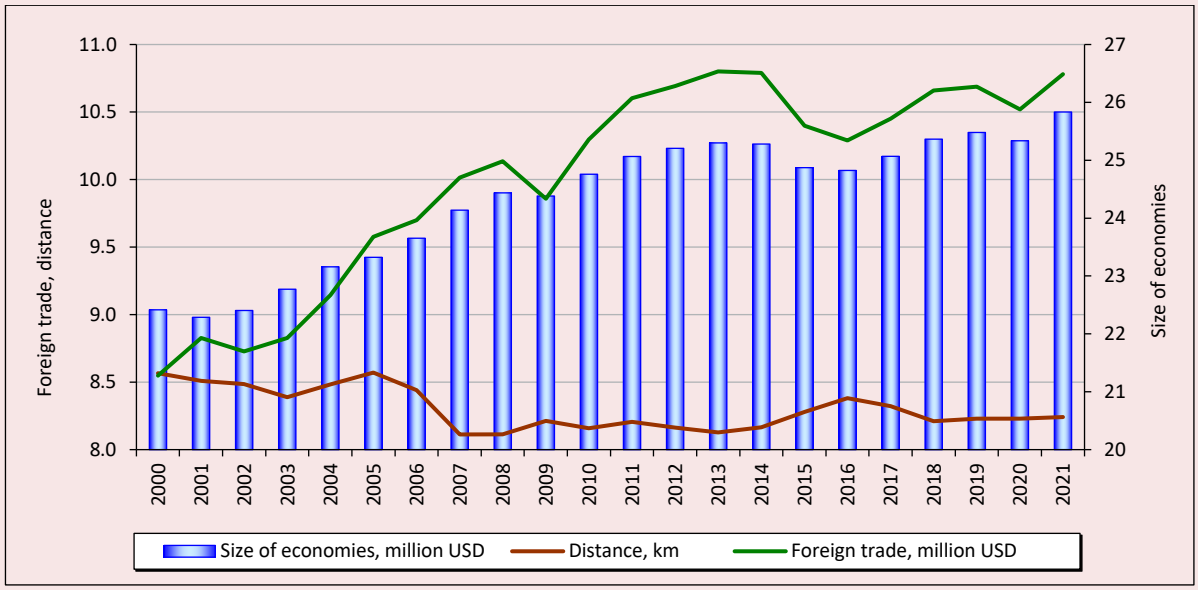
economic policy, as well as foreign policy vector of Russia as a whole. On the other hand, foreign trade of the relatively small economy of the Far East, geographically remote from the national market, began to shift toward the close and large markets of the NEA countries due to the manifestation of gravitational "attraction" of economies. The validity of this provision is substantiated by comparing the dynamics of foreign trade in the Far East with the weighted average values of the size of trading economies (Far Eastern regions and foreign countries) and physical distance between them. Over the long-term period, there was a tendency toward increasing the size of the Far Eastern and global economies, as well as reducing the weighted average values of physical distances between the regions of the Far East trading with each other, on the one hand, and foreign countries, on the other[8] *(Fig. 2)*.

Besides objective reasons for shifting the focus of trade toward close and large economies, the dominance of trade in the Far East with the foreign market over trade with the domestic market was explained, among other things, by the implementation of large export-oriented commodity projects. Since the second half of the 2000s, the commissioning of oil and gas fields in the Sakhalin Region on the basis of previously large-scale foreign direct investments from developed countries[9] has significantly expanded the export of crude oil and liquefied natural gas to the Asia-Pacific market, mainly to the NEA countries. Moreover, since the mid-2010s, crude oil supplies to the Chinese market via a pipeline from the Republic of Sakha (Yakutia) have expanded, contributing to a noticeable increase in exports from the Far East and becoming the second largest source of supplies to the foreign

[8] The weighted average physical distance decreased from 5,246 km in 2000 to 3,795 km in 2021.

[9] Thornton J., Ziegler Ch.E. (Eds.). (2002). Russia's Far East: A region at risk. The National Bureau of Asian Research. Pp. 165–187.

Figure 2. Trade of the Far East with foreign countries, weighted average size of trading economies, and weighted average physical distance between them, logarithm



Note: The size of trading economies and the distance between them are weighted averages of the value of trade between them. The size of the economies in the figure reflects the sum of the logarithms of this indicator for foreign countries and regions of the Far East trading with each other.

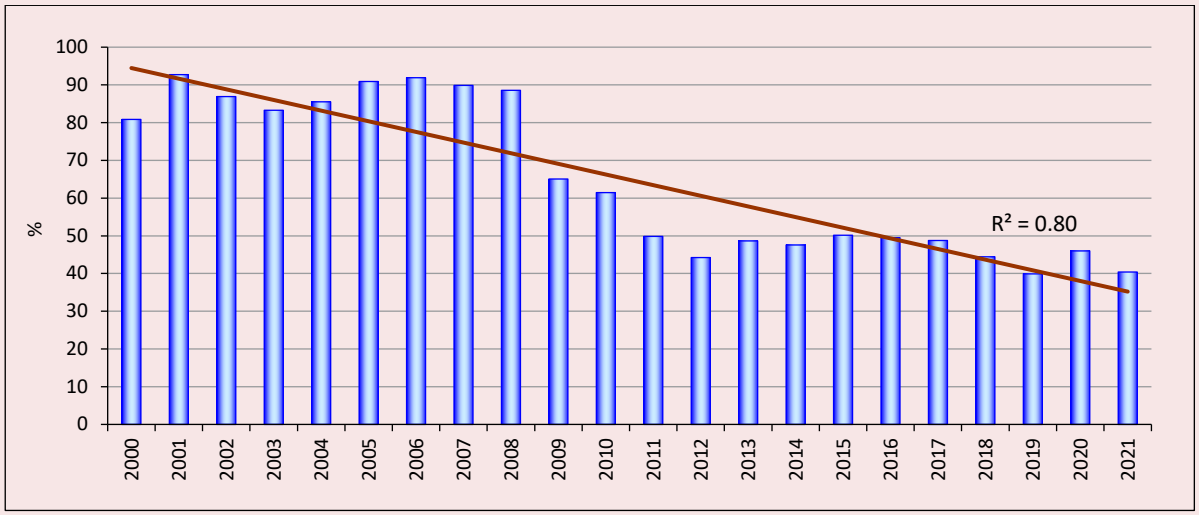
Source: own calculation using data from the Federal Customs Service, Federal State Statistics Service of Russia, industry statistics of Russia, IMF, World Bank, data of "calculators" of physical distances and materials from the Economic Research Institute of the Far Eastern Branch of the Russian Academy of Sciences.

market for the macroregion after the Sakhalin Region. Thus, the two regions have become leaders in the field of direct investment, foreign economic activity and attracting labor resources for the Far East as a whole (Minakir, 2019).

As noted earlier, advantage in expanding foreign trade can be gained by the Far Eastern regions that have a land border with foreign countries. The regions located in the south of the Far East have the following characteristics: the Trans-Baikal Territory, Amur Region, JAR, Khabarovsk Territory and Primorye Territory have a land border with the People's Republic of China, two regions (Republic of Buryatia and Trans-Baikal Territory) border Mongolia, and one (Primorye Territory) borders the DPRK. Despite the advantages associated with the border position, within the period under consideration the share of these regions of the south of the Far East in the total trade turnover of the macroregion with border countries showed a long-term downward trend, having halved – from 80.8% in 2000 to 40.4% in 2021 *(Fig. 3)*.

We should note that in the trade turnover of the macroregion, export flows have always been greater than imports, while in the 2010s the total value of exports of the Far East exceeded the corresponding import volumes by four times. Despite the fact that the regions of the southern Far East maintained a high share in the macroregion's imports from border countries, which reached 90% during the analyzed period, their share in exports to these countries decreased significantly – from 79.0% in 2000 to 23.8% in 2021. Therefore, in general, the share of southern regions of the Far East in the total trade turnover of the macroregion with border countries decreased. For objective reasons, the trade

Figure 3. Share of border regions of the Far East in total trade turnover of the Far East with border countries



Source: own calculation using data from the Federal Customs Service and industry statistics of Russia.

turnover of southern regions of the Far East with border countries was formed almost exclusively by trade interactions with China. The trade of the Primorye Territory with the DPRK and the Trans-Baikal Territory with Mongolia was episodic during the period under consideration due to the lack of opportunities to increase trade with these countries, including those dictated by the small size of their economies, specifics of the functioning of economic systems, and also due to the specifics of their trade and economic interactions with foreign markets. These circumstances indicate a decrease in the positive effects of the border situation for trade in southern regions the Far East compared to other Far Eastern regions.

Assessment methodology and data

Assessment methodology. Gravitational modeling is a reliable tool for obtaining ex-post estimates of the impact of various factors on trade. In this study, the following theoretically substantiated dependence is used as a basic theoretical model for assessing the influence of gravitational factors on the foreign trade of the Far East (Anderson, van Wincoop, 2004):

$$X_{ij} = \frac{Y_i E_j}{Y}\left(\frac{t_{ij}}{P_i P_j}\right)^{1-\sigma}, \quad (1)$$

where X_{ij} – flow of goods from economy i to economy j; Y_i – size of economy i; E_j – size of economy j; Y – size of the world economy; t_{ij} – cost of bilateral trade between i and j; σ – constant elasticity of substitution in the consumption of goods in j to goods imported from i; P_i – prices in i, reflecting external multilateral resistance for i; P_j – prices in j, reflecting internal multilateral resistance for j. The parameter P_j reflects costs of consumers j if they purchased goods on the foreign market, and P_i, respectively, denotes costs faced by producers in i if they supplied their products to the foreign market. The log-linear form of equation (1) is expressed as follows:

$$\ln X_{ij} = k + \ln E_j + \ln Y_i - \ln Y_t + (1-\sigma)\ln t_{ij} - (1-\sigma)\ln \Pi_i - (1-\sigma)\ln P_j + \varepsilon_{ij}, \quad (2)$$

where k – constant, ε – random error. The t_{ij} parameter includes costs of overcoming spatial distance between i and j and other factors affecting trade interactions, i.e. $t_{ij} = b_{ij} d_{ij}^{p}$ (d_{ij} – physical

distance between *i* and *j*, *p* – elasticity of trade costs by distance; b_{ij} – effect of other factors between *i* and *j*). Other factors, as a rule, include presence of a border, common language, *i* and *j* being part of a single colonial system in the past, etc. (Yotov et al., 2016). As a result, this aggregated parameter is estimated as follows: $b_{ij} = b^{1-\delta_{ij}}$, where δ_{ij} – dummy variable equal to one for any feature characterizing *i* and *j*, and zero otherwise. Taking into account the decomposition of parameter t_{ij}, dependence (2) in dynamics is as follows:

$$\ln X_{ij,t} = k + \ln E_{j,t} + \ln Y_{i,t} - \ln Y_t + (1-\sigma)\rho \ln d_{ij} + \\ + (1-\sigma)\ln b_{ij} - (1-\sigma)\ln P_i - (1-\sigma)\ln P_j + \varepsilon_{ij,t} \quad (3)$$

In turn, based on theoretical and empirical studies within the framework of gravitational modeling, dependence (3) needs to be adjusted so as to obtain correct estimates based on specific recommendations that were taken into account for assessing the impact of the above factors on the foreign trade of the Far East. First, the initial array is formed as panel data, and the Poisson quasi-maximum likelihood estimator is used for evaluation; in its framework the dependence takes on an exponential form in order to include "zero" trade flows in the array and to avoid model specification errors (Burger et al., 2009). Second, obtaining correct estimates for the factors requires taking into account deviation of trade in favor of the domestic market in the model; this implies that the data array should include domestic market trade (Yotov, 2021). Third, for the long-term period it is recommended to use interval data in order to simplify calculations of the impact of the above factors on trade (Egger et al., 2022). Fourth, multilateral resistance is controlled by fixed effects on exporter's and importer's economies, taking into account time. Fifth, the impact of all time-independent bilateral costs is controlled by fixed effects for trading pairs of economies (Yotov et al., 2016).

Since our study assesses the impact of physical distance and size of economy on trade, fixed effects for all trading pairs of economies cannot be included in the model. Methodologically, this problem can be dealt with by extending fixed effects only to trade in the domestic market so as to solve the "distance puzzle" (Borchert, Yotov, 2017; Yotov, 2022). In this case, the estimates of foreign trade factors will be relative to the corresponding estimates for the domestic market, which will allow us to determine trends in the influence of gravitational factors on the Far East trade. Also, based on this toolkit, we can more unambiguously determine the impact of land border on the foreign trade of the Far East in comparison with previous estimates (Tochkov, 2018).

As a result, based on an earlier study for the sub-global level (Izotov, 2023), the dynamics of impact of gravitational factors on trade in the Far East was estimated as follows[10]:

$$X_{ij,t} = \exp[\beta_0 + \sum_{T=2000}^{2021} \beta_T \ln DIST_{T_{ij}} + \\ + \sum_{T=2000}^{2021} \beta_T \ln GDP_{T_{ij}} + \sum_{T=2000}^{2021} \beta_T CNTG_{T_{ij}}] \times \\ \exp[\pi_{i,t} + \chi_{j,t} + INTRA_{ij} + \varepsilon_{ij,t}], \quad (4)$$

where X_{ij} – exports from economy (region/country) *i* to economy (region/country) *j* (this indicator also includes X_{ii} – domestic trade of Far Eastern region *i*); $\ln DIST_{T_{ij}}$ – natural logarithm of physical distance between *i* and *j* for each year *T* (this indicator includes $\ln DIST_{T_{ii}}$ – natural logarithm of physical distance within Far Eastern region *i* for each year *T*); $\ln GDP_{T_{ij}}$ – aggregate size of economies trading with each other, which is represented by the sum of natural logarithms GRP/GDP *i* and *j* for each year *T* ($\ln GDP_{T_i} + \ln GDP_{T_j} = \ln(GDP_{T_i} * GDP_{T_j})$), this indicator also includes ln – natural logarithm of GRP of Far Eastern region i for each year T;

[10] Due to the estimation of the impact of factors on trade only for the Russian Far East, data on trade interactions in the world economy as a whole and, accordingly, world GDP are not included in model (4).

$CNTG_{T\,ij}$ – dummy variable equal to one for land border between Far Eastern region i and country j for each year T and equal to zero in its absence; β_0 – constant; T – year; t – time period; π_{it} – fixed effects for the exporting economy, taking into account the year; χ_{jt} – fixed effects for the importing economy, taking into account the year; $INTRA_{ij}$ – fixed effects for pairs of trading Russian regions (trade of Far Eastern regions among themselves and with other regions of Russia, trade within Far Eastern regions); ε – error vector.

Data for assessment. The array of the dependent variable was formed using statistics reflecting value volumes of trade between Far Eastern regions and foreign and domestic markets (within each Far Eastern region, between Far Eastern regions and with the rest of Russia).

The array of indicators characterizing trade between the Far East and the foreign market was formed using statistical data from the Federal Customs Service of Russia. Further, this array was supplemented with statistics from regional departments of the FSSS of Russia and industry statistics[11]. To make a correct assessment of the impact of physical distance on trade in the Far East, an important aspect was to form such an array of data that would maximally cover the number of foreign trading partner countries for Far Eastern regions. As a result, an array of data on trade between Far Eastern regions and the foreign market was formed, which presents interactions with 150 foreign countries and equivalent economic territories for 2000–2021.

In addition to trade between Far Eastern regions and the foreign market, an important aspect for calculating the above effects of gravitational factors is to include trade between Far Eastern regions and the domestic market in (4). Expanded statistics on the import and export of consumer and industrial goods, compiled by the FSSS of Russia for 2000–2021, served as the basis for an array of data on trade between Far Eastern regions and the domestic market. Due to the fact that the FSSS of Russia does not gather statistics on value volumes of import and export of goods by Russian regions for 2017–2021, the values of these indicators were calculated using available information on their physical volumes and producer price indices at the level of more than two hundred enlarged commodity groups. Further, the value volumes of a number of commodity groups[12] previously excluded by the FSSS of Russia from import and export statistics were estimated according to industry and microeconomic statistics. As a result, we determined value volumes of trade of Far Eastern regions among themselves and with other regions of Russia, as well as within Far Eastern regions for the specified long-term period.

Then an array of data on independent variables was generated. Physical distance is a major gravitational factor affecting trade. Physical distances are determined with the help of "distance calculators"[13]; physical maps and tables of sea and land distances formed at the Cartography Laboratory of Economic Research Institute of Far Eastern Branch of the Russian Academy of Sciences (Khabarovsk). Data on physical distances are calculated on the basis of land and sea transport routes, since the bulk of goods is transported via these routes. To determine the values of physical distances between Far Eastern regions and foreign countries, the administrative centers of Far Eastern regions and the capitals of foreign countries were used as departure and arrival points. Accordingly, between Far Eastern regions the distances between their administrative centers were calculated, and within Far Eastern regions –

[11] By taking into account the following commodity groups: bunker fuel; fish and crustaceans, mollusks and other aquatic invertebrates sold outside the Russian customs border; crude oil supplies from the Republic of Sakha (Yakutia) to the Chinese market.

[12] Commercial wood; ores of ferrous and non-ferrous metals; extracted oil, including gas condensate; potatoes; fresh fruits and vegetables, etc.

[13] Distance calculator. Available at: https://www.distance.to; Sea-distances. Available at: https://sea-distances.org/; Sea route & distance. Available at: http://ports.com/sea-route/

between the administrative center and the second most populous city in the region. As for physical distances between Far Eastern regions and the rest of Russia, they were calculated as weighted averages between the administrative centers of Far Eastern regions and the rest of the Russian regions and equivalent cities of federal significance, based on the scale of bilateral trade relations[14]. Among alternative transport routes (land, sea and mixed), the shortest one was chosen. Physical distances from most of the countries of Eurasia, as well as the rest of Russia and southern regions of the Far East to the most remote Far Eastern northern regions[15] were calculated as mixed: first by rail to Vladivostok, and then by sea to the destination.

The size of economies of foreign countries was reflected by absolute values of their GDP presented by IMF statistics[16]. The size of Far Eastern regions' economies is represented by absolute values of their GRP, and the rest of Russia's regions by sum of their GRP according to FSSS data.

Finally, data on the presence of a land border between the following Far Eastern regions and foreign countries were used as a dummy variable: Amur Region, JAR and Khabarovsk Territory – PRC; Republic of Buryatia – Mongolia; Trans-Baikal Territory – PRC and Mongolia; Primorye Territory – PRC and DPRK.

To simplify the estimates, interval panel data with a lag of three years were used (2000, 2003, 2006, 2009, 2012, 2015, 2018 and 2021). Cost indicators are presented in million US dollars at current prices to obtain correct estimates by analogy with a previously conducted study (Izotov, 2023) *(Tab. 1)*.

Descriptive statistics of the array indicated a large variation in the values of the independent variable in the sample due to the fact that the Far East unites various regions, which differ markedly in the scale of their interactions with both foreign and domestic markets. Expansion of the data array by taking into account less traditional trading partner countries for certain Far Eastern regions inevitably manifested itself in a high proportion of zero values, which, nevertheless, does not pose a problem for subsequent assessment within the framework of exponential model (4).

Assessment results

The estimates obtained using model (4) indicate that statistically significant impact on the foreign trade of the Far East throughout the period in question was exerted by major gravitational factors: physical distance between Far Eastern regions and countries that were their trading partners; size of the economies of these regions and countries *(Tab. 2)*.

Table 1. Descriptive statistics of the data array used

Variable	Mean	Standard deviation	Min.	Max.
Trade between economies (X_{ij}), million USD	11.3	170.8	0	10389.3
Size of economy (GDP_i), million USD	205074.4	1127142.1	113	23315075
Physical distance ($DIST_{ij}$), km	12618.4	5183.4	33	26147
Land border ($CNTG_{ij}$)	0.01	0.1	0	1
Source: own calculations.				

[14] During the assessment, it was determined that the physical distances between Far Eastern regions and the rest of Russia roughly correspond to the distance of Far Eastern regions from/to Moscow, which is explained by the Russian capital's function as the country's largest transportation and warehousing logistics center.

[15] Kamchatka Territory, Magadan Region and Chukotka Autonomous Area.

[16] World Economic Outlook Database, IMF. Available at: https://www.imf.org/en/Publications/WEO/weo-database/2024/April/select-country-group

Table 2. Model (4) assessment results

Variable	β	Standard error	p-value
$\ln DIST_{2000}$	-1.96	0.14	0.00
$\ln DIST_{2003}$	-1.96	0.14	0.00
$\ln DIST_{2006}$	-1.83	0.14	0.00
$\ln DIST_{2009}$	-1.95	0.15	0.00
$\ln DIST_{2012}$	-1.92	0.14	0.00
$\ln DIST_{2015}$	-1.91	0.14	0.00
$\ln DIST_{2018}$	-1.89	0.15	0.00
$\ln DIST_{2021}$	-1.88	0.16	0.00
$\ln GDP_{2000}$	0.54	0.11	0.00
$\ln GDP_{2003}$	0.58	0.11	0.00
$\ln GDP_{2006}$	0.47	0.11	0.00
$\ln GDP_{2009}$	0.61	0.11	0.00
$\ln GDP_{2012}$	0.51	0.10	0.00
$\ln GDP_{2015}$	0.50	0.11	0.00
$\ln GDP_{2018}$	0.48	0.10	0.00
$\ln GDP_{2021}$	0.59	0.10	0.00
$CNTG_{2000}$	1.13	0.72	0.09
$CNTG_{2003}$	1.27	0.60	0.04
$CNTG_{2006}$	2.03	0.62	0.00
$CNTG_{2009}$	0.62	0.28	0.03
$CNTG_{2012}$	-0.31	0.37	0.40
$CNTG_{2015}$	0.34	0.43	0.43
$CNTG_{2018}$	-0.12	0.42	0.78
$CNTG_{2021}$	-0.60	0.48	0.21
Constant	4.21	2.29	0.07
Pseudo log-likelihood	-131559	–	–
Pseudo R^2	0.82	–	–
RESET-test (Prob > chi2)	0.01	–	–
Number of observations	17226	–	–
$\Delta\ln DIST_{2000\text{-}2021}$, %	-4.3	2.30	0.08
$\Delta\ln GDP_{2000\text{-}2021}$, %	9.1	5.99	0.09

Notes. $\Delta\ln DIST_{2000\text{-}2021} = ([\ln DIST_{2021} - \ln DIST_{2000}] / \ln DIST_{2000}) \times 100\%$. $\Delta\ln GDP_{2000\text{-}2021} = ([\ln GDP_{2021} - \ln GDP_{2000}] / \ln GDP_{2000}) \times 100\%$.
Source: own calculations.

Estimates indicated that a 1% increase in GRP/GDP of Far Eastern regions and foreign countries engaged in mutual trade contributed to the expansion of trade turnover between them from 0.54% in 2000 to 0.59% in 2021. In the course of a more detailed analysis, it was revealed that in the early 2000s the increase in size of the Far East economy was on average comparable to that of the trading partner countries, while further economic growth of the partner countries was higher than that of Far Eastern regions. In fact, expansion of foreign trade in the Far East was generated mainly by foreign market growth. Nevertheless, the growth of the Far East economy also contributed to an increase in commodity supplies from foreign countries to the Far Eastern market. As a result, cumulative positive impact of the size of economies of Far Eastern regions and foreign countries trading with them on mutual trade increased by 9.1% by 2021 compared to 2000. Since this factor is comparative to the influence of the size of domestic market on trade in Far Eastern regions, the estimates obtained indicate a greater "attraction" of the small economy of the Far East to the foreign market than to the domestic one, despite existing bilateral trade barriers.

In turn, restraining influence of remoteness or physical distance factor on the foreign trade of the Far East had a long-term declining trend. A 1% increase in distance between Far Eastern regions and foreign countries restrained trade between them by 1.96% in 2000 and by 1.88% in 2021. As a result, during trade interactions, the cost of overcoming physical distance between the Far East and foreign countries decreased by 4.3% by 2021 compared to 2000. If we take into account that the estimates obtained are comparative for the physical distances of trade interactions between Far Eastern regions and the domestic market, this confirms the concentration of trade in these regions in favor of geographically close and capacious markets, among which the PRC occupied a leading place. As a result, the trade of the Far East over the specified timespan began to deviate more and more in favor of leading NEA countries, thereby optimizing transport routes for trade with foreign countries.

Accordingly, estimates indicating a weakening of the negative impact of physical distance and an increase in the positive impact of size of economies on the foreign trade of the Far East confirmed the trend of increasing "attraction" of Far Eastern regions' economies to the foreign market. During the period under consideration, for the Far East, concentration of foreign trade flows in favor of nearby NEA countries was reflected in a general reduction in transport costs and the dependence of foreign trade in Far Eastern regions on the growth of economies of these foreign countries. An increase in importance of the foreign market in comparison with the domestic one in the context of declining relative transport costs and the growth of foreign economies is confirmed by conclusions presented in a number of theoretical models (Hanson, Xiang, 2004).

In turn, the influence of land border with foreign countries on the foreign trade of the Far East was positive and statistically significant only for the 2000s. At the same time, over the specified decade, there was a decrease in the positive impact of this factor: in 2000, the presence of land border contributed to an increase in trade turnover between border regions of the Far East and border foreign countries by 209% ($(e^{0,62} - 1) \times 100\%$), and in 2009 – only by 86% ($(e^{1,13} - 1) \times 100\%$). Further, according to calculations, in the 2010s the impact of this factor on the foreign trade of the Far East was statistically insignificant. Consequently, the positive impact of border position as an "exclusive" stimulating factor for foreign trade in a number of Far Eastern regions in the 2010s was actually leveled.

The estimates obtained complement the conclusions formulated for the intensity of trade (Izotov, 2021b) and for trade itself (Tochkov, 2018) in the Far East in the previously existing territorial borders and require a detailed explanation of the reasons for leveling the impact of land border factor in 2010–2021. First, there was an increase in exports of hydrocarbons to the Chinese market from the Republic of Sakha (Yakutia) in the second half of the 2010s, as well as from the Sakhalin Region in the late 2010s; these regions do not have a land border with China. This contributed to a reduction in the share of border regions of the Far East in trade with China. Second, the estimates obtained indirectly confirm the formation of deeper trade and economic ties between the macroregion and the Chinese economy, reflecting the "leveling" of Far Eastern regions in terms of expanding their trade with the PRC market, since the early 2010s the share of trade between China and those Far Eastern regions that do not have land checkpoints with it began to increase markedly due to both exports and imports. Third, since estimates of the impact of the presence of land border with foreign countries on foreign trade of the macroregion are relative to the trade of Far Eastern regions with the domestic market[17], an important process that is supposed to have influenced the results is expansion of trade of Far Eastern border regions with the rest of Russia due to mass imports of various goods (Izotov, 2021a). Fourth, while in the early 2000s southern regions of the Far East were active trade "intermediaries" between the Chinese market and the market of other regions of Russia, then subsequently, amid large-scale network supplies of goods from China to the Russian market, bypassing border Far Eastern regions, these advantages weakened noticeably. Fifth, despite the fact that trade of Far Eastern border regions was determined mainly by their interactions with the PRC market, a decrease in the importance of land border factor on the foreign trade of Far Eastern regions in the 2010s is explained to some extent by the inclusion in the initial panel of two peripheral economies of the NEA – Mongolia and the DPRK[18], trade with which was characterized by low cost volumes, inconstancy of commodity exchange and specifics of bilateral relations. Sixth, quarantine measures in 2020–2021, introduced to curb the spread of COVID-19 and especially severe on the Chinese and North Korean sides, occasionally limited the volume of certain commodity groups transported by road and rail across the state border, which to a certain extent restrained trade between southern regions of the Far East and border countries of the NEA.

We should emphasize that the influence of gravitational factors on the trade of any economy is a fundamental pattern that will be observed in the context of sanctions, determining comparative negative effects of such restrictions. We note that given the difficult foreign policy relations between Russia and Western countries since 2022, from a research point of view, opportunities for analyzing Russian foreign trade factors are being limited due to the temporary suspension of official publication of customs statistics at the regional level. If such data are available in public domain, it will be possible to assess how significant the barriers to foreign trade of the Russian Far East were in such conditions.

Conclusion

Trade and economic cooperation with foreign countries has always been of great importance for the Far East economy. Abundance of natural resources, territorial proximity to the largest

[17] Since the estimates take into account fixed effects for pairs of trading Russian regions.

[18] On average, during the period under consideration, the value of trade between Mongolia and the DPRK amounted to less than 2% of the corresponding trade volumes with China for the border regions of the Far East.

economies of the NEA and relatively favorable global environment contributed to a noticeable expansion in foreign trade of the macroregion. Due to the presence of barriers to the economy of the Far East geographically remote from the national market, its foreign trade began to shift toward neighboring and large economies of the NEA (China, Republic of Korea, and Japan); while the implementation in the 2010s of Russia's foreign policy course on the development of economic relations in the eastern direction and the commissioning of large export-oriented commodity projects have only reinforced this trend. In the framework of "new" territorial borders, trade interactions between the Far East and China have become the main source of expanding foreign trade turnover of the former. By 2021, they accounted for slightly less than half of the macroregion's foreign trade. Despite the fact that the Far East has a long land border with some NEA countries, in 2000–2021 the share of border regions of the Far East in foreign trade of the macroregion with these countries decreased.

The present study assessed the influence of the following gravitational factors on the foreign trade of the Far East: size of trading economies; physical distance between them; presence of a land border. In order to obtain correct estimates, a quantitative analysis of the influence of gravitational factors on the trade of the Far East was carried out with the help of a methodological approach involving the solution of the "distance puzzle" in the framework of the econometric model used. The ex-post estimates obtained on the basis of this model, initially used to study the factors affecting trade between national economies, confirmed the possibility of applying this approach to the sub-national level.

According to the estimates obtained, we observe an increasing positive impact of the size of economies on foreign trade of the macroregion in the long term by 9.1% by 2021 compared to 2000. In turn, the deterrent effect of physical distance factor on the foreign trade of the Far East had a long-term declining trend: the cost of covering the distance decreased by 4.3% by 2021 compared to 2000. Since the estimates obtained are comparative for trade interactions between Far Eastern regions and the domestic market, the calculation results indicate a long-term growing "attraction" of the Far East economy to the foreign market. This circumstance confirms the existence of a deviation in the trade of Far Eastern regions in favor of geographically close and capacious markets located in the NEA, among which China started playing the main role; optimization of transport routes of the macroregion's foreign trade in the context of specialization of the Far East economy within the framework of specific geographical and commodity niches in the Asia-Pacific market. For the Far East, deviation of trade flows in favor of neighboring countries occurred due to a general reduction in transport costs and the dependence of foreign trade in Far Eastern regions on the growth of global economy in general and the leading NEA countries in particular.

Presence of a land border with foreign countries had a positive impact on the foreign trade of Far Eastern border regions only in the 2000s, contributing to an increase in their trade turnover with some NEA countries from 209% in 2000 to 86% in 2009. According to the estimates obtained, in 2010–2021 the influence of land border was leveled as a stimulating factor for foreign trade in border regions of the Far East, which is explained by mass exports to China from those Far Eastern regions that do not have a land border with the PRC; "binding" of border regions of the Far East to the market of the rest of Russia due to mass imports of various goods; decrease in the role of a trade "intermediary" for border regions of the Far East between the PRC and the rest of Russia; small scale, volatility and specificity of trade relations between

border regions of the Far East and peripheral economies of NEA – Mongolia and the DPRK; negative impact of quarantine measures related to the COVID-19 pandemic.

In the foreseeable future, the development of the Far East economy in its interaction with the foreign market apparently requires maintaining a balance between expanding relations with the Chinese market and distributing trade with the economically and politically heterogeneous Asia-Pacific region, some countries of which are currently implementing severe restrictions in relation to the Russian economy. The estimates obtained suggest that in the context of formation of foreign trade in the Far East, mainly due to the export of raw materials, in the price of which transport costs occupy a relatively large share compared to industrial products[19], the supply of low-value-added goods from the macroregion to geographically remote markets was relatively less effective. In the 2010s pipeline infrastructure was built to supply hydrocarbons from the Far East to the PRC market, which contributed to narrowing opportunities for geographical diversification of Far Eastern exports, as well as consolidating the Chinese market as the main direction of foreign trade relations for the macroregion as a whole. From this point of view, a long-term trend toward weakening the restraining influence of physical distance on the foreign trade of the Far East was generally extensive, since it was ensured by the deviation of exports from Far Eastern regions mainly in favor of a large, fast-growing and geographically close Chinese economy, which began to acquire features of an alternative foreign market for the macroregion until 2022. Indeed, excessive expansion of trade and economic interactions between the Far East and China may lead to Russia's voluntary isolation from the rest of Asia-Pacific countries (Minakir, 2009), submitting the Far Eastern economy, in terms of its large-scale exports of a limited group of raw materials, to the specifics of China's foreign trade policy that tends to introduce various restrictions on the supply of goods from abroad proceeding from their own ideas concerning protection of their own domestic market.

And even under increasing sanctions risks from Western countries in relation to the Russian economy, an important aspect is diversification of trade and economic interactions between Far Eastern regions and China, including by implementing mechanisms for cross-border economic cooperation. The assessments obtained during the study confirmed the presence of stagnation in cross-border economic cooperation between Russia and China due to significant barriers to such interactions on the Russian side (Larin, 2020), reflected, among other things, in the restriction of freedom to expand cross-border trade and economic relations at the regional level (Larin, 2014), which contrasts with the policy of developing cross-border cooperation in regions of the People's Republic of China (Larin, 2021). The lack of progress in the framework of cross-border cooperation to a certain extent conflicts with the concepts of development of southern regions of the Far East (Minakir, 2005) based on the expansion of their foreign economic interactions that imply processing part of raw export flows into products and services based on the openness of the macroregional economy, provided that Russia now participates in international cooperation only with "friendly" countries of the Asia-Pacific region. Another important aspect is the need to create a modern transport system in the Far East, including for the development of large reserves of natural resources, as well as for the export of raw materials and finished products from the centers of the extractive and manufacturing industries in the macroregion (Baklanov et al., 2018). It is

[19] Pricing of which, in turn, is carried out mainly within the framework of monopolistic competition mechanisms.

assumed that under current external restrictions, focusing on increasing the sub-global market and based on existing advantages, the Far East in the future will be able to retain its important role in the exchange of goods between the national economy and the nearest and largest economies of the NEA with expansion of direct investments in transport infrastructure and production of raw materials, which can be supplemented by using cross-border economic cooperation mechanisms.

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Received July 3, 2024.