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Determinants of China's technological trade flows with Central Asian countries (CACs): a panel gravity approach

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Abstract. The purpose of this study is to examine the determinants of Chinese technological trade flows with Central Asian countries (CAC) with a revealed comparative advantage and the gravity model using two estimation techniques. The present study employs the Ordinary Least Square (OLS) and the Poisson pseudo-maximum likelihood (PPML) on the data set from 2003 to 2018 panel dataset. Results from the Gravity model demonstrates that low-tech, medium-tech, and high-tech trade flows boost economic development in China and Central Asian nations, adversely affecting all technology trade flows in geographical distance. The research indicated that exchange rates showed a negative indication in bilateral trade, medium-tech trade, and high-tech trade. In contrast, the low technology trade showed a positive flow between China and Central Asia. Furthermore, the results reveal that openness to trade and membership of the WTO show a positive indication. The trade openness policy on both sides thus has a major beneficial effect on trade volumes. It proposed increased liberalization of trade policy and greater involvement in global commerce. In addition, Central Asia and export industries should take additional initiatives to enhance and diversify high-tech exports. A competitive international market provides perfect equality in reciprocal trade interactions.

Keywords: China, Central Asia, gravity model, revealed comparative advantage, Technological trade, Panel data.

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Introduction

As the phenomenon of economic globalization progresses, a movement towards regional economic integration is taking place. Regional economic integration promotes an effective redistribution of development factors, an effective distribution of labour and capital. It also helps to improve the productivity of the regional economy in its entirety and enhance social security by removing barriers to trade between participating countries (Ahsan et al., 2021). For countries striving to improve their international competitiveness, initiatives need to be paired with a positive engagement in regional economic cooperation to reduce the danger of trade and investment. In the case of China, substantial strides have been made in terms of trade cooperation with other countries in the region with the steady opening of Chinese markets and the rapid economic growth of the country in recent years. By actively engaging in regional economic cooperation, China will strengthen its economic and political ties with other developed nations. At the same time, engaging on the grounds of shared advantage and reciprocity helps promote participation in the globalization process. As a result, China's successful role in regional economic cooperation is political, diplomatic, and economic. The current study provides a window to understand the trade pattern between China and Central Asian Countries (CACs), as well as how China can improve the economic condition of the CACs. It should be note that since her separation from the Soviet Union, China had played a crucial role in developing long-term economic relations with the CACs [1].

The approach to the global economic partnership by China stresses the exploitation of its geographical position, by emphasizing pro-active participation in different modes of cooperation with neighbouring countries. This is mirrowed in the China's Trade and Investment Liberalization Mechanism for Commercial, Technological Collaboration, and Collaborative Growth with the five Central Asian Countries (CAC): Kazakhstan, Uzbekistan, Kyrgyzstan, Tajikistan, and Turkmenistan. Central Asia (CA) occupies a geographical role in the Eurasian territory and unites Europe and Asia. It also has enormous petroleum reserves and other highly sought-out commodities. Given that the economies of CA are in transition alongside their geographical closeness and strong potential for positive relationships with other economies, bilateral trade and trade ties have grown rapidly in recent times [2]. For the CA economies, the global economic situation has been more complex as global trade has traditionally maintained slow growth as a result of the deceptive expansion in the developing markets. For instance, the global capital flows are being reduced as investors search for safer investment havens, which has been provoked by the fluctuations in oil prices and increasing global uncertainties that pose a great challenge for economies in the region's eastern part. Interestingly, the China's total export to CACs jumped from US$ 2 billion in 2003 to US$ 23 billion in 2018 while its total imports from CACs experienced a peak of US$ 27 billion in the year 2013 and declined to US$ 19 billion in the year 2018 (Figure 1).

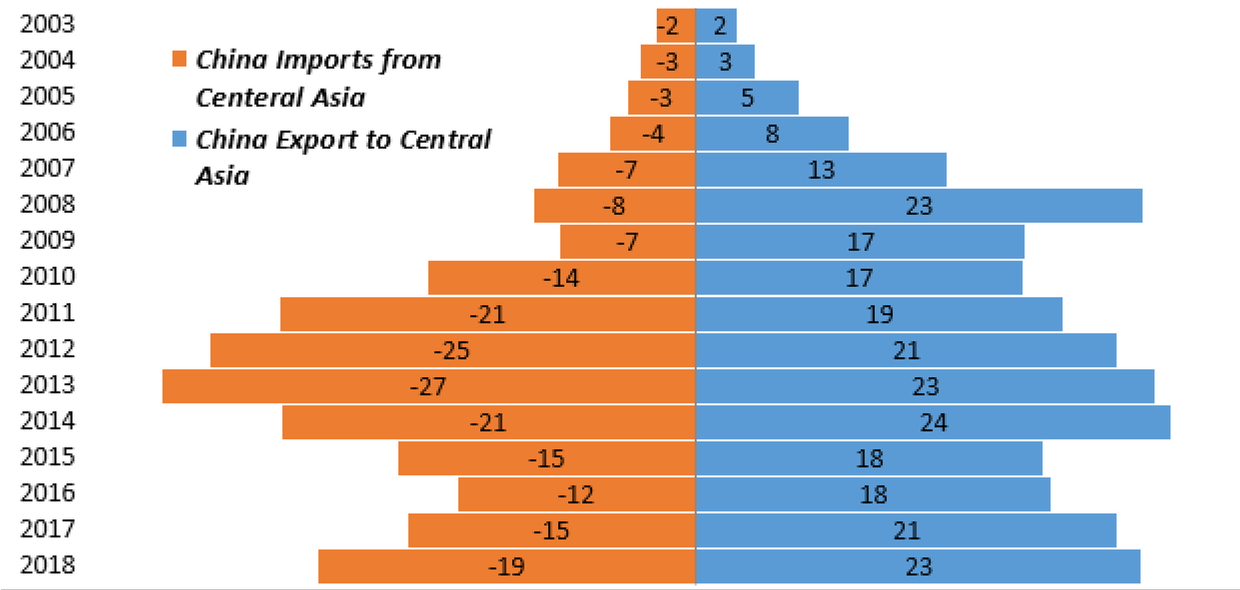

Figure 1 China and Central Asia trade history in US dollar billion [3]

Note: Authors' compilation based on UN Comtrade database 2021

Trade between China and the CACs is a key market for the export and import of goods and services. The value of natural resources to meet potential demands for oil and gas in CACs is well recognised in China. For instance, a significant source of budgetary revenue for Kazakhstan and Uzbekistan is the export of energy products. In totality, imports from the two countries alongside Turkmenistan represent 3.4 percent of the overall Chinese energy imports [4]. In addition, China receives 21 percent of its imports of zinc, 20.9 percent of its lead and 10 percent of its imports of inorganic chemicals from CA. According to data from the customs service of China, trade turnover of more than US$41.7 billion with the five CACs in 2018 has been recorded (Table 1). Although CA represents 0.8 percent and 0.9 percent of Chinese imports and exports respectively, China's reliance on CACs is apparently on the rise. For instance, China currently accounts for around 22 percent of all exports from CA and 37 percent of its imports [5]. The CACs have asymmetrically based trading ties with China. It is imperative to note that most Chinese exports to CA (over 35% in 2018) include items of high value-added such as machinery and equipment, electronics and spare parts, and China has, in the last three decades, been an independent ally for CACs (i.e., Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan).

Table 1

China's Trade with Central Asia in billion USD

Year	Kazakhstan	Kyrgyz Republic	Tajikistan	Turkmenistan	Uzbekistan	Central Asia
2003	3.29	0.31	0.04	0.08	0.35	4.07
2004	4.5	0.6	0.07	0.1	0.58	5.84
2005	6.81	0.97	0.16	0.11	0.68	8.73

2006	8.36	2.23	0.32	0.18	0.97	12.06
2007	13.88	3.78	0.52	0.35	1.13	19.66
2008	17.55	9.33	1.5	0.83	1.61	30.82
2009	14	5.28	1.4	0.95	1.91	23.55
2010	20.43	4.2	1.43	1.57	2.48	30.11
2011	24.92	4.98	2.07	5.48	2.17	39.61
2012	25.68	5.16	1.86	10.37	2.88	45.94
2013	28.6	5.14	1.96	10.03	4.55	50.27
2014	22.45	5.3	2.52	10.47	4.28	45.01
2015	14.29	4.34	1.85	8.64	3.5	32.62
2016	13.1	5.68	1.76	5.9	3.61	30.05
2017	17.94	5.42	1.35	6.94	4.22	35.88
2018	19.86	5.6	1.5	8.44	6.27	41.66

Note: Authors' compilation based on UN Comtrade database 2021 [6].

The key aims of this study include – an evaluation of China's technological trade flows into the CACs as well as joint and separate review of the sectoral competitive advantage of China [7]. In addition, this study estimates a gravity model for the disaggregated trade data through technological trade flows such as low-tech, medium-sized and high-tech trade flows. The study contributes to the literature in three key areas – (i) the study follows an econometric estimation of the gravity model known as a workhorse in the analysis of China-CACs trade relations from 2003 and 2018, and incorporates variables that cut across economic, political and geographical architectures in implementing the gravity model; (ii) the study uses the Balassa's (1965) Revealed Comparative Advantage (RCA) competitive index to provide a comprehensive image of the China's comparative advantage among the CACs; and (iii) the study employs the Poisson Pseudo Maximum Likelihood (PPML) in line with Silva and Tenreyro (2006, 2011) mathematical model estimation in analysing the movements of the Chinese technology with the CACs [8]. New-fangled lessons can be taken from the existing study for policymakers and industry in China and Central Asia [9].

The paper is structured as follows – following the Introduction in the current section (Section 1), Section 2 reviews the literature on the gravity model as a theoretical basis for the study alongside overview and analyses of China's technological trade relations with the CACs. Section 3 outlines the methodology, while Section 4 carries the empirical results and discussion of findings. Finally, Section 5 concludes the study [10].

Literature Review

Stylised Facts on China's Technological Trade Relations with the CACs. China's economic recovery since 1978 and its effective adjustment to globalization is one of the most important contemporary times. China's economy is now one of the largest economies in the world. China's entrance into the World Trade Organization (WTO) in 2001 has strengthened its standing

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regionally and globally. This section examines the present situation, and the study of trade flows between China and Central Asia (Kazakhstan, Kyrgyzstan, Turkmenistan, Tajikistan and Uzbekistan). Whereas, three countries like Kazakhstan, Kyrgyzstan and Tajikistan shared with China a common border running for almost 2,800 km. Intensive commercial, scientific and cultural collaboration between the Chinese and CA peoples has been established for many years [11]. At the time of the Great Silk Road, the nations in the CA area were acting as a transport route between Europe and China (until the middle of the second millennium AD). They were well-developed business, financial and industrial hubs. China has always been a major supplier of scientific knowledge and modern technology for Central Asia. China has become a rising economic powerhouse in Asia with a rising share of its imports and exports with its Asian partners. China is now the most important export destination to several nations in the world [12]. In 2018, China was CAC's main trade partner, with high-tech CAC exports accounting for US$ 2261million and imports in the same year, at US$ 37million (figure 2). Aerospace, computers and office equipment, electronic-telecoms, pharmaceuticals, scientific instruments, electrical machinery, chemicals, non-electrical machinery and weaponry are the high-tech items. Whereas China's medium-tech goods exported to CAC accounted for US$ 5230 million, and imports from CA recorded US$ 910 million in 2018 respectively. Medium tech goods include Chemicals, weapons, electrical equipment, motor vehicles, transport equipment, petroleum products, rubber and plastic, non-metallic mineral, metals, ships and boats, machinery and equipment [13]. Similarly, China's major exports to CAC are low-tech products which are recorded at US$ 11083 million, and imports from CAC are US$ 396 million in the year 2018 (figure 2). Low-tech products include foods, beverages, tobacco, textiles, apparel, leather, wood, paper and furniture [14].

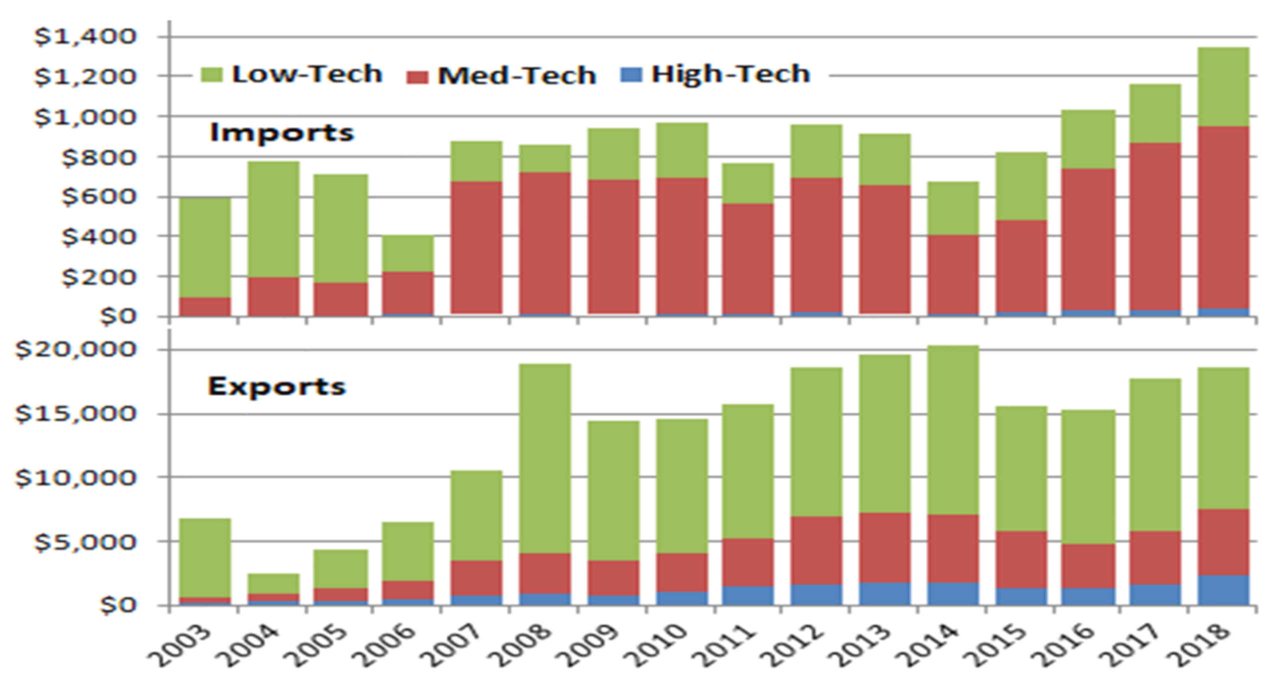

Figure 2 China's technological trade history with CACs in US$ million

Note: Authors'compilation based on UN Comtrade database 2021 [14]

Kazakhstan is a major trading partner of China compared with other Central Asian Countries. China's low-tech exports to Kazakhstan accounted for US$ 5.6 billion, med-tech US$ 2.4 billion and high-tech US$ 1.4 billion in the year 2018 (figure 3). Again, China's imports from Kazakhstan are very narrow, though with a major share of medium-tech goods, which accounted for US$ 905 million in 2018. Turkmenistan is the second major trading partner of China, where China mainly exported her medium-tech goods to the tune of US$ 1.25 billion in 2018 [15]. China exports to Uzbekistan mainly consist of medium-tech goods worth US$ 1.76 billion and imported low-tech goods worth US$ 340 million in 2018 (figure 3).

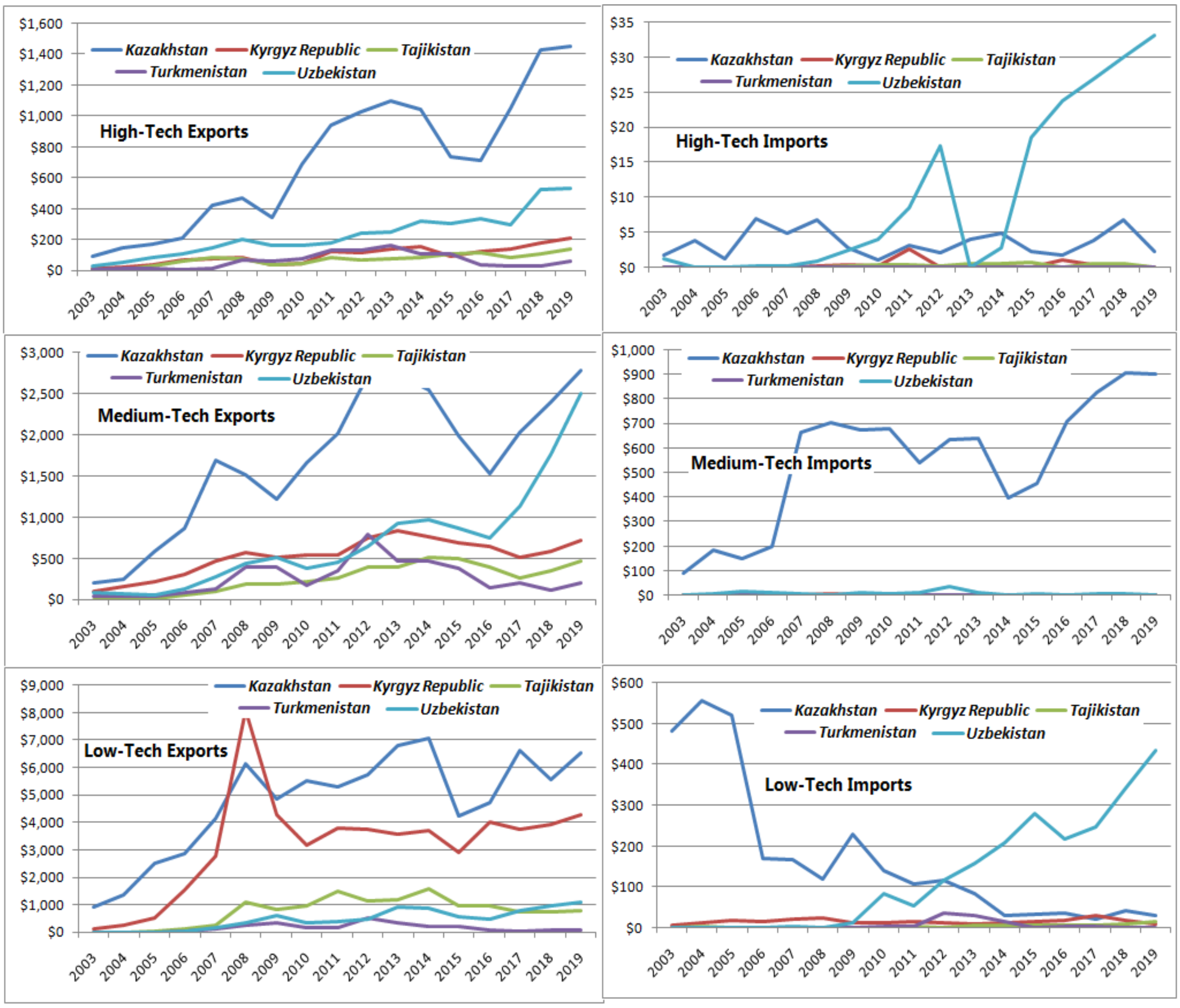

Figure 3 China's technological trade flows with CACs (US$ million)
Note: Author compilation. based on UN Comtrade database 2021 [15]

Empirical Literature

The earliest prominent analysis of trade flows dates back to 1962, with Jan Tinbergen's paper entitled"Shaping the global economy: ideas for an international economic strategy". Based on the Newton's gravitation rule, Tinbergen (1962) argues which states that trade between two nations might be a function of their economic sizes and remoteness apart. Thereafter, other researchers like, Anderson and Wincoop (2003), Guttmann and Richards (2004) further contributed to the Tinbergen's theoretical underpinning. By that time, scientists had developed empirical econometric methods to the estimation of the gravity model via multiple real and mannequin or dummy variables in examining different nations' trade flows. For example, after the fall of the Soviet Union, Byers et al. (2000) used a frugal gravity model for the three Baltic republics of Estonia, Latvia, and Lithuania. Their findings confirmed that these countries' trade flows were decreased and moved to former the Soviet Union members [16].

Rasoulinezhad (2016) examined how Iran's international trade with Russia was affected by the gravity model in over the period, 1994-2013, and the multiple fined and non-financed sanctions and oil prices. The negative linkages between financial, non-financial and petroleum price shocks between Iran and Russia were established.Irshad and Anwar's (2019) study revealed that bilateral trade volumes are optimistically affected by economic size, mutual exchange rates, differentiated salaries, shared faith, the border, and trade agreements. Research by Iqbal & Nosheen (2020) indicates that trade costs are substantial and adversely connected to trade flows between Pakistan and its trading partners. In contrast, Hoang et al. (2020) measured trading connections between Taiwan and the ASEAN nations using a gravity model for the period 2000-2017 based on the PPML. The study submitted that ASEAN's economic size and per capita income are far more important than that of Taiwan. Irshad et al. (2021) discovered that medium-tech, high-tech, and low-tech trade flows all contribute to economic development in Pakistan and ASEAN. However, all technical trade flows have a negative effect on geographical distance [17].

In line with the foregoing, this study is dedicated to analysing the Chinese technological trade flows with Central Asian Countries (CACs) using the gravity model. To conquer the narrative of the current study, some important studies are reviewed in this section. Whereas, Balassa's (1965) Revealed Comparative Advantage (RCA) competitive index was used to provide a comprehensive image of China's comparative advantage in CACs research, many researchers have used these indicators to evaluate export competitiveness and comparatives advantages for different datasets of commodities between countries (Balassa, 1989; Irshad & Xin, 2017). For instance, Lucke and Rothert (2006) studied the comparative international trade advantage of Central Asia based on pricing and transportation cost, chronological production prototypes, and current developments in geographical and merchandise composition of the CA trade. The study used index and regression analyses methods to evaluate trade-in bilateral agricultural goods using data from 2001-2012. The analyses indicate that all bilateral trade patterns for agricultural products altered over the inspection period (Jian et al., 2014). In another study, Shuai et al. (2018) examined the China's photovoltaic (PV) goods' global competitiveness as well as assessed the long-term international competitive trends for photovoltaic solar goods from 2007 to 2016. The findings suggest that the global competitiveness of solar photovoltaic goods in China showed an increasing trend. Also, the comparative advantages of key solar PV goods are substantial, whilst the illogical structure remains a significant element inhibiting the China's global export competitiveness of solar PV goods [18].

Methodology

Theoretical Framework and the Model. The study utilized two different approaches – (i) the RCA and gravity model of trade in which technological trade flows were further disaggregate into low-tech, medium-tech and high-tech trade flows. The concept of RCA has been revised and further updated so that there are already an excessive number of RCA steps. Following studies (Balassa, 1989; Batra, 2005; Irshad and Xin, 2017) that have estimated the comparative advantage, the current study utilized the RCA equation using dissimilar datasets and trading partners. China is believed to enjoy a revealed comparative advantage in a specified product i when her ratio of exports of product i to her total exports surpasses the same ratio for the world as a whole [19]. That is, the China's RCA is based on the following equation:

$$RCA_{Ci} \quad = \quad \frac{\frac{x_{Ci}}{\sum_{j\in P} x_{Cj}}}{\frac{x_{wi}}{\sum_{j\in P} x_{wj}}} \geq 1 \qquad (1)$$

where P is the set of all products (with i ∈ P), X_{Ci} is the China's exports of product i to partners in the particular period, X_{wi} is world's exports of product i, while $\sum_{(j\in P)} X_{Cj}$ represents the China's total exports of all products j in P, and $\sum_{(j\in P)} X_{wj}$ is the world's total exports of all products j in P. Note that when a country has a revealed comparative advantage for a given product (RCA > 1), it is assumed to be a competitive producer and exporter of that good in comparison to a nation that produces and exports the same good at or below the global average. Thus, a country's export strength is defined as its competitive advantage in product i. The greater the value of a country's RCA for a certain product i, the greater the country's export strength in that commodity [20].

Over the last half a century, the gravity models, driven from the Newton law of gravitational forces, have been extensively used to explain the bilateral trade flows amongst nations. According to the Tinbergen's economic gravity model, trade between the countries is the function of GDPs and distance (Tinbergen, 1962). Other contributors to the Tinbergen's gravity model include Linnemann (1966); Anderson and Wincoop (2003); Wei, (2017); Huang et al., (2020); and Komal et al., (2021).

Fundamentally, the gravity model can be specified as follows:

$$ln(BT_{ijt}) = \sigma_0 + \sigma_1 \; ln(GDP_{it} * GDP_{jt}) + \sigma_2 \, ln(TC_{ijt}) + \varepsilon_{ijt} \qquad (2)$$

where ln is the natural log notation, BT_{ijt} is the bilateral trade volume between the country i (China) and country j (CACs) in the specified period, ε_ijt is the error term, σ_i (where i = 0, 1, 2), represents the intercept term and the slope coefficients of the variables, while GDP_{it}*GDP_{jt} represents the product of the China's gross domestic products and that of the CACs in a particular year, and TC_{ijt} represnets the trade cost (proxied by the distance between the countries). The current study employs the Ordinary Least Squares (OLS) technique in estimating Equation 3, while the Poisson Pseudo Maximum Likelihood (PPML) is used to estimate Equation 4 in line with Silva and Tenreyro (2006, 2011) in examining the determinants of the China's trade with CACs. The choice of the PPML technique is that it performs better in the presence of heteroscedasticity and can provide consistent results in zero trade observation (Silva & Tenreyro, 2006, 2011). Thus, the augmented gravity equations used in this study are as follows:

$$BT_{ijt}/HTT_{ijt}/MTT_{ijt}/\ LTT_{ijt}= \alpha_0+\alpha_1 Ln(GDP_{it}*GDP_{jt})+\alpha_2\, Ln(TC_{ijt})+\alpha_3\,(REF_{ijt}) +\alpha_4\, Ln(Exrate_{ijt})+\alpha_5\, Ln(To_{it}*To_{jt})+\ \alpha_6\,(CB_{jt}) +\alpha_7\,(WTO_{jt})+\mu_j+\pi_t+\varepsilon_{ijt} \quad (3)$$

$$BT_{ijt}/HTT_{ijt}/MTT_{ijt}/LTT_{ijt} =exp\{\beta_0+\beta_1 Ln(GDP_{it}*\ GDP_{jt}) + \beta_2\, Ln(TC_{ijt}) + \beta_3\,(REF_{ijt}) +\beta_4\, Ln(Exrate_{ijt}) + \beta_5\, Ln(To_{it}*To_{jt})+\ \beta_6\,(CB_{jt}) +\beta_7\,(WTO_{jt})+\mu_j+\pi_t+\varepsilon_{ijt}\} \quad (4)$$

Where HTT_{ij} stands as the high technological trade; MTT_{ij} is medium technological trade and LTT_{ij} is low technological trade. The study also evaluates the magnitude of total bilateral and fragmented trade flows between China and the *CACs.* GDP_{it} * GDP_{jt} is the product of the GDP of China and the CACs. To capture trade costs (TC_{ijt}), the study uses the geographical distance between China and the CACs (i.e., the distance between the capital cities measured in kilometres). Factor endowment (REF_{ijt}) is used as a proxy for the difference between the China's per capita GDP and that of the CACs. *(Where* $(REF_{ijt})= [ln(PCGDP_{it}) - ln\ (PCGDP_{jt})]$ per capita gross domestic product of China and partner country). Consequently, the price increases when the supply is large and the currency appreciates. The exchange rate is likely to be superior when the prices are disclosed since the nation exports are more than her imports. It may be considered to depreciate when capital loses its value. To observe this occurrence, this study incorporates the bilateral exchange rates $(Exrate_{ijt})$ into the model. Also, trade freedom reduces prohibitions on the free flow of products between countries or other obstacles. Thus, trade-to-GDP ratios for China and the *CACs* $(To_{it}$ *and* $To_{jt})$ are used as proxies for openness in this study. In addition, two dummy variables have been incorporated to examine the impact of common boundaries(CB_{jt}) and membership to the *WTO* (WTO_{jt}). Whereas (CB_{jt}) takes the value of 1 if both countries share the same border, it takes the value of 0 if otherwise. Similarly (WTO_{jt}) takes the value of 1 if the partner country is a member of the WTO and 0 if otherwise.

Equations 3 and 4 have also been applied to other factors, such as the Global Boom and busts of Silva and Tenroy (2011; 2015), to help to track endogenous problems. Since trade is affected by geographical and political factors, these factors are accounted for in determining export or import determinants, thus, country-specific fixed results are considered more appropriate (μ_j, π_t). It is important to note that some possible weaknesses of the gravity model including the likelihood of endogeneity have been highlighted in Trefler (1993), alongside the zero-exchange endogeneity Helpman et al., 2008, and the question of heterogeneity. The endogenous problem was figured out using variations in the results of fixed-effect and intercept models Baier & Bergstrand, 2007.

Data source

The dataset is an unbalanced panel comprised of annual bilateral trade flows that have been disaggregated according to distinct technology trade flows (i. e., trade flows in low-, medium-, and high-technology goods) between China and CA countries. The data collection period is 2003–2019, and the variables used in the gravity regression equation are presented in the following table, alongside data sources [21].

Table 2

Description of Variables

Variables	Unit	Type	Expected Sign	Data Source
BT_{ijt}	US$ 1000	Time-Variant	-	UN Comtrade Database
HTT_{ij}	US$ 1000	Time-Variant	-	UN Comtrade Database
MTT_{ij}	US$ 1000	Time-Variant	-	UN Comtrade Database
LTT_{ij}	US$ 1000	Time-Variant	-	UN Comtrade Database
$GDP_{it}*GDP_{jt}$	US$ 1000	Time-Variant	Positive	WDI, World Bank
TC_{ijt}	Km	Time-Invariant	Negative	CEPII database
REF_{ijt}	US$ 1000	Time-Variant	Ambiguous	WDI, World Bank
$Exrate_{ijt}$	US$	Time-Variant	Ambiguous	WDI, World Bank
$TO_{it}.TO_{jt}$	%	Time-Variant	Positive	WDI, World Bank
CB_{jt}	(0/1)	Time-Invariant	Positive	Asia Regional Integration Center https://aric.adb.org/fta-country
WTO_{ijt}	(0/1)	Time-Invariant	Positive	World Trade Organization

Note: Authors' compilation 2021 [21].

Results and Discussion

Revealed Comparative Analysis. The purpose of this study is to establish methodologies for determining China's comparative advantage with selected Central Asian nations in light of current changes in the geographical and product composition of CA trade. Raw or semi-processed commodities now dominate central Asia's exports. Exceptional export items differ slightly amongst nations, ensuring that Central Asian nations are not forced to compete in the same items. Numerous trade flows are likewise negligible in terms of prospective markets. China plays a vital role in CA trade in recent years and has a clear comparative advantage in many sectors [22]. The agriculture sector has a comparative advantage in Uzbekistan and

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Turkmenistan, whereas the chemical sector does not appear beneficial for China in the CACs. Machinery manufacturers and textile have a comparative advantage in all five CA economies whereas, food, fuel and ores & metals have prominent disadvantages (Figure 4).

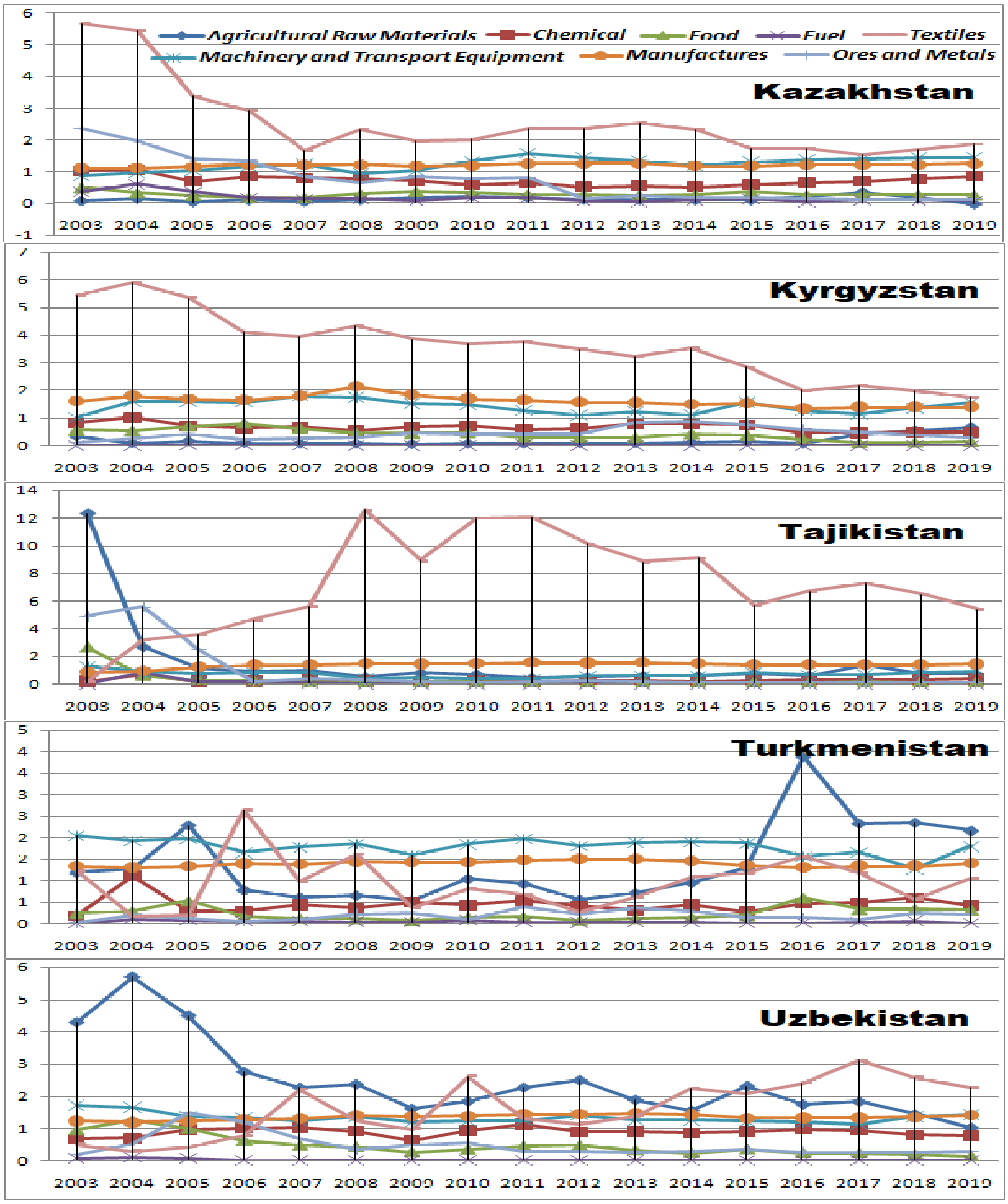

Figure 4 China's revealed comparative advantage analysis with CACs [23]

Note: Authors' compilation based on UN-Comtrade data 2021

Gravity Model Analyses. Panel Cross-Section Dependence Test. Cross-section dependency (CD) in panel data regression has received much attention in recent decades. A global common shock with varying effects across nations, such as the oil crises of the 1970s or the global financial crisis of 2008, may cause such a link. It may also be caused by local spillover effects across nations or areas [24]. Prior to estimating the gravity model, the CD test was used to determine whether there is a cross-sectional dependence or independence. Otherwise, the conclusions of the gravity equation might be skewed and irreconcilable (Pesaran, 2004). The residual CD test of Pesaran (2004) is anchored in the pairwise correlation coefficients 〖 Ĉ〗_ij in the following fashion:

$$CD = \sqrt{\frac{2}{N(N-1)}} \sum_{i=1}^{N} \sum_{j=i+1}^{N} \sqrt{T_{ij}} \hat{C}_{ij} \qquad (5)$$

Given that the CD test cannot detect time-invariant variables in the gravity equation, this study only estimated the time-variant variables (Rasoulinezhad, 2017; Rasoulinezhad & Kang, 2016; Irshad et al, 2018). Also, dummies are not specified in the CD test, however, the current study calculates them using the whole sample. Table 3 shows that the null hypothesis (no CD in residuals) may be rejected at the 5% level by Pesaran (2004). This shows that all panel time series are cross-sectionally dependent.

Table 3

Results of Pesaran's (2004) CD test

Variables	Pesaran's CD test	Prob.
$\boldsymbol{lnBT_{ijt}}$	11.60	0.00
$\boldsymbol{lnHTT_{ijt}}$	10.27	0.00
$\boldsymbol{lnMTT_{ijt}}$	11.29	0.00
$\boldsymbol{lnLTT_{ijt}}$	11.72	0.00
$\boldsymbol{GDP_{it}*GDP_{jt}}$	12.96	0.00
$\boldsymbol{REF_{ijt}}$	11.07	0.00
$\boldsymbol{Exrate_{ijt}}$	11.49	0.00
$\boldsymbol{TO_{it}.TO_{jt}}$	8.54	0.00

Note: Authors' compilation from STATA 14.0.

Gravity Model Outcomes. After confirming the cross-sectional dependency in our variables, the regression outcomes of the gravity Equation 4 are presented in (Table 4). The gravity model was estimated with two estimation techniques – the OLS and PPML. The PPML estimator is known as the standard approach for modelling discrete data. However, it has gained popularity as a viable alternative for estimating multiplicative models where the dependent variable is non-negative. Usually, these models are estimated by linear regression applied to a dependent variable that has been transformed into a log. But, as in the OLS estimator, the only necessary assumption for the consistency of the PPML estimator is the correct specification of the conditional average of the dependent variable. The current study benchmarks its estimation on the PPML, which has been explained accordingly. The findings reveal a good R-squared value, and all the variables appear with the expected signs and prominent significant values in all the models and estimations [25].

The results show that the variables such as GDP, WTO, and trade openness exert a significant positive impact on bilateral trade flow, while variables such as trade cost, relative factor endownment, common boundaries, distance, and exchange rate have a negaitive influence on bilateral trade flow. The results are in line with previous studies, most of which assume that the country with the biggest economic size has a large production capacity, which increases its export. Therefore, it can be deduced that the higher the GDP of the partner country, the more it trades with the partner country. In this regard, this study proves the classic gravity model's hypothesis, which states that the greater the economy of the trade partner, the greater the volume of bilateral trade. The results also the exchange rate has a significant negative impact on bilateral trade. This is because many Central Asian currencies have shown high volatility over the years. The theoretical foundation of the gravity model sees distance variable as a factor representing transport costs, which could appear in trade activities. The basic gravity model's idea is that the smaller the distance, the greater the bilateral trade between countries. Many studies claim that adjacency is an aspect that results in the growth of trade value around 65% if countries share borders and may lead to transportation costs as well. Relative factor endowment (REF) appeared with a significant positive sign in the case of low-technological trade high-tech and medium-tech trade but adverse in case of total trade. The elasticity of REF is quite strong, although this rejects the Linder hypothesis, it indicates that the Heckscher-Ohlin theorem successfully explains bilateral trade between China and CACs [26].

Table 4

Gravity Model Outcomes

OLS	(1) Bilateral Tade	(2) High Tech	(3) Medium Tech	(4) Low Tech
$GDP_{it}*GDP_{jt}$	1.099***	0.598***	0.782***	1.129***
TC_{ijt}	-17.30***	4.427*	-6.001	-17.66***
$REFi_{jt}$	0.0741	0.0969	-0.0330	0.340**
$Exrate_{ijt}$	-0.607***	0.313***	-0.0998	-0.528***
$TO_{it}.TOj_{t}$	0.575**	0.751***	0.595***	0.970***
CB_{jt}	-2.419***	1.386***	0.710	-1.105
$WTOi_{jt}$	-0.0588	0.166	0.606**	0.150*
Constant	112.9***	-56.22***	27.48*	108.8**
N	85	85	85	85
R-Square	0.89	0.93	0.83	0.84
PPML	**(1)** ***ln*BT**	**(2)** ***ln*HTT**	**(3)** ***ln*MTT**	**(4)** ***ln*LTT**
$GDP_{it}*GDP_{jt}$	0.811***	0.677***	0.689***	0.592***

TCi_{jt}	-12.78***	2.484*	-0.702	-9.683***
REF_{ijt}	-0.114	0.151***	0.156**	0.133
$Exrate_{ijt}$	-0.488***	0.224***	0.0948	-0.163**
$TO_{it}.TO_{jt}$	0.431	0.675***	0.885***	0.824***
CB_{jt}	-1.938***	1.110***	0.493**	0.169**
WTO_{ijt}	0.01	0.022	0.039	0.077
Constant	87.83***	-42.26***	-16.13	64.09***
N	85	85	85	85
R-Square	0.94	0.97	0.96	0.89

Note: * p<0.05, ** p<0.01, *** p<0.001

Note: Authors calculations based on Equations 3 and 4.

The dummy variable for WTO membership has a negative sign. Note that the countries in question (i.e., China, Kyrgyzstan, Kazakhstan, Uzbekistan, Tajikistan) are all members of the WTO. If Turkmenistan were to join the WTO, it could potentially facilitate better growth in international trade [27].

The estimation results indicate that bilateral trade flows between China and the CACs are primarily influenced by GDP, exchange rates, geographical distance, and common borders. As expected, the GDP of the CACs and China positively impacts bilateral trade flows between them. However, the results also show that trade costs, common borders, and exchange rates have a negative effect.

Conclusion

The study investigated the fundamental determinants of Chinese technological trade flows with Central Asian countries (CACs) over the period, 2003 – 2018. Based on the revealed comparative advantage and the gravity model, the study employed two estimation techniques - the Ordinary Least Square (OLS) and the Poisson pseudo-maximum likelihood (PPML) on a panel dataset. The gravity model outcomes show that low-tech, medium-tech, and high-tech trade flows are stimulated by economic growth in China and CACs, while geographical distance negatively influences all other technology trade flows. The study also found that exchange rates hamper bilateral trade flows between China and the CACs, as well as medium-scale, and high-tech trade flows. However, low-tech trade between China and the CACs showed a positive trend with exchange rates. The findings also demonstrate that WTO membership and openness to trade positively influence bilateral trade flows.

Based on these findings, the study recommends that both sides pursue open trade policies by increasing efforts towards economic globalization and trade liberalization. Given that exchange rates exert a significant negative impact on trade flows between China and the CACs, it is recommended that the central banks of the CACs efficiently manage exchange rate movements to boost trade. WTO membership appears to be beneficial for improving bilateral trade flows between China and the CACs. Therefore, the CACs that are not yet members of the WTO are encouraged to pursue membership, while those that are already members should be encouraged to increase their participation.

Authors' contributions.

Yerkinbayev K. – approval of the final version of the article for publication; consent to be responsible for all aspects of the work, writing a text , properly studying and resolving issues related to the reliability of data or the integrity of all parts of the article.

Irshad M.S. – collection, analysis and interpretation of work results; writing a text and critically reviewing its content, significant contribution to the concept of work.

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Қытайдың Орталық Азия елдерімен (ОАЕ) технологиялық сауда ағындарының анықтауыштары: панельдік гравитациялық тәсіл

Аннотация. Бұл зерттеудің мақсаты салыстырмалы артықшылықтарды анықтауға және бағалаудың екі әдісін қолдана отырып, гравитациялық модельді қолдануға баса назар аудара отырып, Қытай мен Орталық Азия елдері арасындағы технологиялық сауда ағындарына әсер ететін факторларды талдау болып табылады. Жұмыста 2003-2018 жылдар аралығындағы деректерді талдау үшін қарапайым ең кіші квадраттар (OLS) әдісі және Пуассонның псевдомаксимальды ықтималдығы (PPML) қолданылады. Гравитациялық модельдің нәтижелері төмен технологиялық, орта технологиялық және жоғары технологиялық сауда ағындары Қытайдың да, Орталық Азия елдерінің де экономикалық дамуына ықпал ететінін көрсетеді, ал географиялық қашықтық барлық технологиялық сауда ағындарына теріс әсер етеді. Зерттеу айырбас бағамдарының екіжақты саудаға, әсіресе орта технологиялық және жоғары технологиялық тауарлар саласында теріс әсерін анықтады. Сонымен қатар, жоғары технологиялық тауарлар саудасы Қытай мен Орталық Азия арасындағы оң динамиканы көрсетті. Сонымен қатар, зерттеу нәтижелері сауданың ашықтығы мен ДСҰ-ға мүшелік сауданың көлеміне оң әсер ететінін көрсетеді. Осылайша, екі жақтан да сауданы ашуға бағытталған саясат сауда операцияларының көлемін едәуір арттырады. Осыған байланысты сауда саясатын либерализациялауды күшейту және әлемдік саудаға белсенді қатысуды кеңейту ұсынылады. Бұдан басқа, Орталық Азия елдері мен экспорттық салалар жоғары технологиялық тауарлардың экспортын кеңейту және әртараптандыру үшін қосымша қадамдар жасауы тиіс. Бәсекеге қабілетті халықаралық нарық өзара сауда қатынастарына тең құқылы қатысу үшін жағдай жасайды.

Түйін сөздер: Қытай, Орталық Азия, гравитациялық модель, анықталған салыстырмалы артықшылықтар, технологиялық сауда, панельдік деректер.

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Факторы, определяющие технологические торговые потоки Китая со странами Центральной Азии (САС): подход с использованием панельной гравитации

Аннотация. Цель данного исследования заключается в анализе факторов, влияющих на технологические торговые потоки между Китаем и странами Центральной Азии (СЦА), с акцентом на выявление сравнительных преимуществ и применением гравитационной модели с использованием двух методов оценки. В работе используются метод обыкновенных наименьших квадратов (OLS) и псевдомаксимальное правдоподобие Пуассона (PPML) для анализа данных за период с 2003 по 2018 год. Результаты гравитационной модели показывают, что низкотехнологичные, среднетехнологичные и высокотехнологичные торговые потоки способствуют экономическому развитию как Китая, так и стран Центральной Азии, в то время как географическая удаленность оказывает негативное влияние на все технологические торговые потоки. Исследование выявило отрицательное влияние обменных курсов на двустороннюю торговлю, особенно в сфере среднетехнологичных и высокотехнологичных товаров. В то же время, торговля низкотехнологичными товарами продемонстрировала положительную динамику между Китаем и Центральной Азией. Кроме того, результаты исследования показывают, что открытость торговли и членство в ВТО оказывают позитивное воздействие на объемы торговли. Таким образом, политика, направленная на открытие торговли с обеих сторон, существенно повышает объемы торговых операций. В связи с этим рекомендуется усилить либерализацию торговой политики и активнее участвовать в мировой торговле. Помимо этого, странам Центральной Азии и экспортным отраслям следует предпринять дополнительные шаги для расширения и диверсификации экспорта высокотехнологичных товаров. Конкурентный международный рынок создает условия для равноправного участия во взаимных торговых отношениях.

Ключевые слова: Китай, Центральная Азия, гравитационная модель, выявленные сравнительные преимущества, торговля технологиями, панельные данные.

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