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Bilateral Trade Transformation under Economic Restrictions: a Gravity Model Approach to Russian-Turkish Trade Relations

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Bachelor Thesis

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1. Introduction

1.1. Trade adaptations under sanctions

International conflicts have a significant negative impact on the structure of global trade (Glick Taylor, 2010; Berger et al., 2013; Fisman et al., 2014), and this phenomenon is partly explained by the growing spread of economic sanctions in connection with such disputes (Hufbauer & Oegg, 2009; Kaempfer & Lowenberg, 1988). Although research generally shows that sanctions negatively affect the volume of bilateral trade and the operational performance of the enterprises they target (Crozet & Hinz, 2020; Ahn & Ludema, 2020; Draca et al., 2022), the combined effectiveness of these measures remains questionable. This ambiguity arises from incomplete compliance with the requirements and the ability of organizations and firms subject to sanctions to mitigate their impact by reorienting trade flows or identifying alternative sources of supply (Bergeijk, 1995; Haidar, 2017).

The comprehensive economic sanctions imposed on the Russian Federation following the outbreak of the conflict in February 2022 represent one of the largest and most coordinated sanctions regimes in modern history. These sanctions targeted key sectors of the Russian economy, including energy, finance, defense, and technology, posing challenges to Russia's economic stability and international trade ties. By March 2022, Russia had become the country subject to the largest number of sanctions in the world, overtaking Iran, Syria and North Korea, with Western countries imposing more than 11,000 individual sanctions (Mulder, 2022). The package of sanctions included the freezing of assets of major Russian banks, disconnection from the SWIFT payment system, restrictions on the export of high-tech products and personal sanctions against individuals. However, the instruments of restrictive measures against Russia were not only the sanctions themselves, but also the reputational risks that arose - the mass withdrawal of many multinational companies from the Russian market after the introduction of these sanctions. Since the beginning of hostilities, a large number of global brands, including major players in retail, technology, and finance, have left Russia, which has significantly changed the structure of Russian imports and further increased the economic impact of sanctions. Collectively, the massive corporate outflow combined with sanctions has changed the structure of Russian trade and supply chain, leading to shortages and import substitution dynamics in various sectors (Mamonov & Pestova & Ongena, 2022).

Russia's economic landscape underwent dramatic transformation as a result. The initial shock caused the ruble to lose nearly 40% of its value against the US dollar in March 2022, before the Central Bank of Russia implemented capital controls and raised interest rates to 20% (World Bank,

2023). While Russia avoided an immediate economic collapse—with GDP contracting by 2.1% in 2022 rather than the 8-10% initially predicted by international financial institutions—the long-term structural consequences have been profound (International Monetary Fund, 2023). Russia's federal budget deficit grew to 2.3% of GDP in 2022, partly due to increased military spending and declining energy revenues as European nations began diversifying away from Russian energy supplies. The transformation of Russia's external trade has been particularly striking. Prior to the sanctions, the European Union constituted approximately 37% of Russia's foreign trade turnover, with Germany, the Netherlands, and Italy serving as key trading partners (Russian Federal Customs Service, 2023). By the end of 2022, this structure had dramatically shifted toward what Russian economists term the "asianization" of trade. China rapidly emerged as Russia's dominant trading partner, with bilateral trade increasing by 28% in 2022 and projected to exceed 200 billion dollars by 2024 (Ministry of Economic Development of Russia, 2023). Simultaneously, trade with western nations declined precipitously: Germany (-23%), Italy(-20%), and the United States (-34%).

Within this context of geopolitical realignment, Turkey has emerged as a critical economic lifeline for Russia. The historically complex Russian-Turkish relationship, characterized by periods of cooperation and conflict spanning centuries, has entered a new phase of pragmatic economic partnership. Turkey's unique position - simultaneously a NATO member, EU candidate, and regional power with strong economic ties to Russia - has enabled it to adopt a neutral political stance regarding the Russia-Ukraine conflict while significantly expanding economic cooperation with Russia. This economic expansion has been remarkable in both scale and scope. According to the Russian Customs Service, Russian-Turkish trade increased by an unprecedented 84% in 2022, reaching 62.1 billion dollars. By 2023, Turkey had become Russia's fifth-largest trading partner globally. Several factors underpin this dramatic growth. First, Turkey maintained direct air connections with Russia after most Western airlines suspended flights, positioning Istanbul as a key transit hub for Russians traveling abroad. Second, the Turkish banking sector continued processing Russian transactions after major Russian banks were excluded from SWIFT, with five Turkish banks adopting Russia's Mir payment system (though later partially suspending it under Western pressure). Third, Turkish exports of goods no longer available to Russia from Western sources increased substantially, including machinery, electronic equipment, and industrial components.

The geographical proximity and historical economic complementarity between Russia and Turkey further facilitated this trade expansion. Russia has traditionally exported energy resources to Turkey—providing approximately 45% of Turkey's natural gas imports - while importing Turk-

ish agricultural products, textiles, and machinery (Budarina and Ibragimov, 2020). This pattern has intensified under sanctions, with additional trade diversification into previously Western-dominated sectors. Turkish construction companies, already active in Russia with projects worth over 85 billion dollars, have expanded their presence as European competitors withdrew (Shlykov, 2024).

Perhaps most significantly, Turkey has emerged as a key intermediary for parallel imports into Russia—legally imported Turkish products subsequently re-exported to Russia, often containing components from Western countries that have imposed export restrictions. This mechanism has proven particularly important for semi-conductors, industrial machinery and consumer electronics. Russian imports from Turkey in these categories increased by over 130 % in 2022 (Russian Federal Customs Service, 2023), suggesting significant re-export activity. The establishment of special economic zones and logistics hubs near the Black Sea has further facilitated this intermediary function.

These developments raise important theoretical and empirical questions about the effectiveness of sanctions regimes in an interconnected global economy. While sanctions aim to isolate target countries economically, their unintended consequences often include trade restructuring rather than complete suppression and Russian-Turkish case demonstrates how geopolitically positioned intermediary countries can significantly mitigate sanctions effects through various trade mechanisms including parallel imports, alternative payment systems, and sectoral diversification (Tetik and Alboulout, 2023).

1.2. An overview to the sanctions on the Russian economy

Sanctions against Russia were initially introduced in response to the incorporation of most of the territory of the Crimean Peninsula into the Russian Federation in 2014 and the outbreak of armed conflict in Eastern Ukraine. These early measures primarily targeted specific individuals and companies and were followed by Russian counter-sanctions, such as the ban on importing various food products from the EU, the US, and the UK. Studies found that these sanctions and countermeasures led to a general decline in Russia's trade with sanctioning countries (Crozet and Hinz, 2020), increased prices for affected goods (Hinz and Monastyrenko, 2022), weaker performance among sanctioned firms (Ahn and Ludema, 2020), and possibly even strengthened public support for the Russian government (Peeva, 2019).

Sanctions are typically implemented through formal legal mechanisms, including executive orders, regulations, and legislative acts. They are enforced by governmental bodies such as the U.S. Department of the Treasury's Office of Foreign Assets Control (OFAC), the European Council,

and equivalent agencies in other countries. These measures often include asset freezes, travel bans, export/import restrictions and financial limitations.

During the development of the conflict between the countries sanctions were dramatically expanded in February 2022. These sanctions evolved through multiple waves, with ten major packages adopted by mid-March 2022. The measures extended to bans on exports of arms, advanced and dual-use technologies, semiconductors, quantum computing, oil industry equipment, sensitive machinery and luxury goods. They also included restrictions on investments, imports of coal, steel, and wood, aviation and freight services, financial transactions—particularly with Russia's Central Bank—and travel bans affecting over 1,200 individuals and more than 100 entities.

1.3. Shifts in specific commodity categories

Following the imposition of sanctions in 2022, trade between Russia and Turkey has undergone significant shifts, particularly in specific commodity categories. On one hand, Turkey increased its imports of Russian energy resources, including crude oil, refined petroleum products, and coal (HS2: 27), due to the redirection of Russian exports away from European markets (CREA, 2024). On the other hand, Russia became an active importer of Turkish goods, particularly in the categories of machinery and mechanical appliances (HS2: 84), electrical machinery and equipment (HS2: 85), vehicles (HS2: 87), and optical, photographic, and measuring instruments (HS2: 90). Many of these goods are classified as dual-use items and may have applications in the defense sector (U.S. Bureau of Industry and Security, 2023). Given these developments, the following HS2-level commodity groups are of particular interest when analyzing post-2022 bilateral trade flows between Russia and Turkey:

HS 27 – Mineral fuels, oils, and products of their distillation

HS 84 – Machinery and mechanical appliances

HS 85 – Electrical machinery and equipment

HS 87 – Vehicles

HS 90 – Optical, photographic, and measuring instruments

Approaching the purpose of this study, it is aimed at solving the following research question: *How have economic sanctions changed the bilateral trade relations between Russia and Turkey?* Using the gravity model approach, we analyze monthly two-way trade data at the 2-digit level Harmonized System, as well as aggregated data covering the period from January 2014 to February 2025. Our analysis allows us to test three key hypotheses:

1. The imposition of sanctions had a positive impact on trade between Turkey and Russia. In other words, Turkey benefits from the restrictions imposed on Russia.

2. The effect of sanctions on trade varies significantly between product categories, with the most pronounced increases in Turkish exports observed in clusters of goods that faced import restrictions from the EU and other Western sources. These categories likely correspond to goods previously subject to embargoes or export bans, such as advanced technology, industrial equipment, and dual-use items, as identified on EU sanction lists.

3. There are moderating effects on sanctions and they are caused by macroeconomic factors (exchange rates and oil prices).

The structure of this study will be as follows. First, we will provide an updated overview of the sanctions regime that Russia has been operating under for the past nine years, highlighting key developments and their scope. Then, we will describe the empirical model used for analysis, explaining its main components and methodology. Finally, we present the results obtained, followed by conclusions and a critical discussion of their implications.

2. Literature review

The examination of bilateral trade relations between countries has garnered significant academic attention, particularly in instances where geopolitical events fundamentally alter established trading patterns. This review of the literature synthesizes and analyzes the existing scholarly discourse on bilateral trade relations, with particular emphasis on the Russia-Turkey economic nexus in the context of international sanctions.

2.1. Theoretical foundations of international trade analysis

2.1.1. The gravity model: evolution and applications

The gravity model of international trade represents one of the most robustly validated empirical frameworks in international economics. Initially formulated by Jan Tinbergen(1962), the model posits that bilateral trade flows are directly proportional to the economic sizes of trading nations and inversely proportional to the geographical distance between them. The theoretical underpinnings of the gravity model have been progressively refined and strengthened by subsequent scholars. Linnemann(1966) expanded upon Tinbergen's original formulation by incorporating additional variables, while Anderson(1979) and Bergstrand(1985) provided more rigorous microeconomic foundations for the model. These refinements integrated critical factors such as tariffs, transportation costs, and various non-tariff barriers into the analytical framework, enhancing the model's explanatory power and theoretical coherence.

A particularly significant advancement in gravity model theory came with Anderson and Wincoop's (2003) introduction of "multilateral resistance terms." This innovation acknowledged that trade flows between two countries are influenced not only by their bilateral relationship but also by their respective trading relationships with all other nations. The inclusion of these terms addresses a critical omission in earlier formulations, as unobserved trade frictions had previously created estimation biases that violated ordinary least squares (OLS) assumptions, leading to inconsistent results. The gravity model's theoretical justification can also be derived from the Walrasian general equilibrium model, where each country possesses distinct supply and demand functions for all goods. Under this conceptualization, aggregate national income determines demand in importing countries and supply capacity in exporting countries Oguledo & Macphee(1994). While Anderson's analysis operates at the aggregate level, Bergstrand(1985,1989) developed microeconomic foundations for the gravity model, characterizing it as a reduced-form equation of general equilibrium demand and supply systems. In his formulation, trade demand equations for each country

are derived by maximizing constant elasticity of substitution (CES) utility functions subject to income constraints in importing nations. In contrast, trade supply equations emerge from profit maximization processes in exporting countries, with resource allocation determined through constant elasticity of transformation (CET). The gravity model of trade flows, typically measured by value, is then established under market equilibrium conditions where trade demand precisely equals trade supply(Karemera,1999). Bergstrand contends that since the reduced form eliminates endogenous variables from the explanatory component of each equation, both income and prices can legitimately serve as explanatory variables for bilateral trade. Rather than substituting out all endogenous variables, Bergstrand treats income and certain price terms as exogenous and solves the general equilibrium system while retaining these variables as explanatory factors.

2.1.2. Empirical applications of the gravity model

The gravity model has been extensively applied to investigate diverse aspects of international trade dynamics. Tinbergen's seminal work established that trade volume between nations is determined by their economic dimensions and the geographic distance separating them. This foundational framework has been progressively enhanced through subsequent research. Notably, Byers(2000) employed a parsimonious gravity model to examine trade flows among Baltic nations following the dissolution of the Soviet Union, revealing not only a quantitative decrease in trade but also a qualitative reorientation toward former Soviet republics.

The model's versatility is evidenced by its application across varied research contexts. Porojan(2001) analyzed spatial effects on trade flows within the European Union, while Martinez-Zarzoso (2003) utilized the model to evaluate the impact of preferential trade agreements across 47 countries over a twenty-year period (1980-1999). Additional studies by Papazoglou(2007), Okubo(2007), and Xuegang(2008) have explored multifaceted dimensions of international trade through gravity models, incorporating factors such as "regional trade agreements", "trade block effects", and the influence of specific variables including GDP and geographic determinants.

Of particular relevance to this study, the gravity model has been increasingly deployed to analyze the impact of economic sanctions on international trade patterns. Yang(2004) applied the model to examine United States sanctions from 1980 to 1998, concluding that american sanctions inadvertently increased trade between targeted countries and alternative partners such as the European Union and Japan.

Similarly, Ziaee Bigdeli et al.(2012) investigated sanctions' effects on Iran's trade flows, determining that sanctions resulted in approximately a 0.09% reduction in Iran's trade with partner nations.

Mirza & Zitouna(2010) utilized the gravity framework to analyze how oil price fluctuations affected U.S. imports, revealing that oil price shocks increased the trade share of geographically proximate U.S. trading partners.

Nevertheless, traditional gravity model applications often confront significant methodological challenges, particularly regarding omitted variable bias and the treatment of zero trade flows. The latter issue is especially pertinent, as the absence of trade between certain country pairs is common in international trade data and can introduce sample selection bias into analyses. To address these limitations, Santos, Silva & Tenreyro(2006) introduced the Poisson Pseudo-Maximum Likelihood (PPML) estimator, which offers robust performance under heteroskedasticity and naturally accommodates zero trade flows—characteristics that render it particularly suitable for modeling trade flows under sanctions regimes.Moreover, recent research highlights that the differences between OLS and PPML estimates stem not only from heteroskedasticity but also from heterogeneity in trade elasticities across country pairs. PPML estimates the elasticity of the average trade flow, while OLS estimates the average elasticity, leading to different interpretations of coefficients. Empirical evidence suggests that heterogeneity bias is often larger than heteroskedasticity bias, reinforcing the recommendation to use PPML, especially when dealing with heterogeneous trade relationships. Alternative estimators like Gamma Pseudo-Maximum Likelihood (GPML) also exist, but PPML remains preferred due to its robustness and interpretability in the presence of zero trade flows and heteroskedasticity.

2.2. Comparative trade relations: Russia and Turkey in global context

There exists substantial academic literature comparing Russia and Turkey's trade relationships with other countries and trade blocs. Turkey, as a potential European Union candidate, has been analyzed in relation to both United Nations members and other EU candidates, and compared with the Commonwealth of Independent States, where Russia maintains membership. A detailed comparative analysis of Russian and Turkish export performance in common commodities sectors conducted by Gunes & Tan(2017) builds upon Yilmaz(2003)'s competitive analysis of Turkey and European nations, with both studies implementing sectoral classification methodology Hufbauer & Chlas(1974).

A considerable volume of papers examines Russia and Turkey from a competitive perspective. For instance, Gunes and Tan(2017) employed both static and dynamic Revealed Comparative Advantage (RCA) metrics to analyze fourteen common goods sectors exported by both Russia and Turkey during the period 2007-2014. Their findings demonstrated "a strong advantage of Turkey over Russia" across all examined sectors at both bilateral and multilateral levels, though

they projected that Russia might potentially overcome Turkey's advantage over the longer term. Results emphasize the necessity for both nations to transition toward producing and exporting higher value-added goods to enhance national prosperity.

Given that the present study aims to estimate the effect of sanctions on trade between Turkey and Russia, it is instructive to examine comparable historical scenarios involving sanctions regimes, such as those imposed on Iran, North Korea, and other nations. For such analytical purposes, gravity models, difference-in-differences estimations (particularly when examining groups of countries), and dynamic data analysis techniques such as Vector Error Correction Models (VECM) or Autoregressive Distributed Lag (ARDL) models are commonly employed. A closer examination of these methodological approaches through the lens of previous empirical studies is warranted.

2.3. Sanctions and trade: historical case studies and empirical evidence

2.3.1. Sanctions studies

The impact of economic sanctions on international trade has been extensively documented in academic literature, with Iran representing one of the most comprehensively studied cases. Hufbauer & Elliott(1997) examined the impact of U.S. economic sanctions on American trade using a gravity model framework. Their analysis quantified trade losses and assessed sanctions' impact on the U.S. economy, revealing that among six countries studied, Iran ranked second in terms of economic damage inflicted on the American economy.

Amuzegar(1997) critically evaluated the efficacy of U.S. sanctions against Iran, concluding that they failed to yield significant results as evidenced by the absence of observable changes in Iran's behavior, decision-making processes, or foreign policy orientation. Similarly, Alikhani(2000) investigated the political and historical implications of sanctions against Iran, concluding that such policy measures had proven largely ineffective.

Askari(2001) conducted a quantitative assessment of sanctions' economic impact on Iran, estimating trade sanctions effects at approximately $27 million and financial sanctions effects between $1,160 and $1,321 million annually. Their calculations placed the total annual cost of sanctions on Iran between $1,160 and $1,348 million. Despite these substantial economic costs borne by both Iran and the United States, the authors observed that Iran maintained its policy trajectory without significant alterations.

The humanitarian dimension of sanctions regimes was examined by Heine-Ellison(2001), who focused on human rights conditions in sanctioned countries including Iraq, Yugoslavia, Angola,

and Sierra Leone. This research challenged the hypothesis that "targeted sanctions are more humane than comprehensive sanctions," noting that even carefully targeted sanctions can produce unintended humanitarian consequences, as evidenced in Sierra Leone, suggesting the need for extreme caution in sanctions implementation.

Evenett(2002) analyzed sanctions imposed by eight industrialized nations on South African imports, concluding that comprehensive American sanctions against the apartheid regime demonstrated the greatest efficacy among the measures studied. Caruso (2003) examined the impact of economic sanctions on U.S. foreign trade from 1960 to 2000, identifying a negative and statistically significant relationship between sanctions implementation and foreign trade volumes.

More recent scholarship has continued to probe the multi-dimensional effects of sanctions regimes. Linderman Reema (2007) analyzed the various mechanisms through which economic sanctions imposed by countries and international institutions affected Iran. Their research determined that sanctions operated through diverse channels including shipping contracts, insurance arrangements, and financial institutions, significantly impacting Iran's business sector and, consequently, its foreign trade patterns.

Ajdari & Hosseinzadeh(2013) investigated the effects of intensified economic sanctions on Iran's foreign trade (both exports and imports) and its major economic partners during 2011-2012. Their findings indicated substantial fluctuations in both export and import volumes attributable to sanctions, with China, Iraq, UAE, Afghanistan, and India emerging as Iran's principal export destinations during this period.

Neuenkirch & Neumeier(2015) conducted a comparative analysis of sanctions imposed by the United States and the United Kingdom on the economic growth of 68 target countries from 1976 to 2000. Their results indicated that British sanctions reduced per capita GDP growth by 2.3% to 3.5% on average, while U.S. sanctions exhibited a more modest effect, reducing target countries' GDP growth by 0.5% to 0.9% on average over seven years.

Khodadadi(2018) examined sanctions' effects on Iran's trade with major partners in the sports industry from 1992 to 2013 using Dynamic Ordinary Least Squares (DOLS) methodology. They determined that mild sanctions negatively affected Iran's trade with most partners except Kazakhstan and Kyrgyzstan, while severe sanctions paradoxically demonstrated positive effects on Iran's overall trade. The authors found that mild sanctions from previous periods negatively impacted trade with all partners except China, while strong sanctions from previous periods negatively affected trade specifically with China, Kazakhstan, and Kyrgyzstan.

Devarjan & Mottaghi(2015) analyzed sanctions' effect on Iran's trade with 28 major trading partners from 2000 to 2014. According to their findings, severe economic sanctions imposed by

the European Union and the United States reduced Iran's export revenue by $17.1 billion between 2012 and 2014. The authors projected that sanctions relaxation would reorient Iran's imports toward the United States, Germany, the Netherlands, and Asian nations including South Korea, China, and Singapore.

Yadollahi & Daliri(2018) evaluated the potential impact of oil-sales sanctions on Iran's economy and possible mitigation strategies. Their research concluded that sanctions designed to alter the Islamic Republic's political behavior had not achieved their intended objectives, with the United States failing to compel the suspension of Iran's nuclear activities through sanctions pressure. Rasoulinezhad & Popova(2017) investigated the relationship between sanctions (both financial and non-financial), oil price shocks, and bilateral trade flows between Iran and Russia from 1991 to 2014. Their findings indicated that financial sanctions, non-financial sanctions, and oil price volatility all negatively affected Iranian-Russian trade relations, with financial sanctions exerting the most pronounced negative impact compared to non-financial sanctions and sharp oil price fluctuations.

An important methodological advancement in sanctions research is observed in the study by Ghodsi,Karameliki(2019), who examined the impact of sanctions imposed by the European Union against Iran on their bilateral trade. Their research methodology incorporated a specialized variable, S_t^I and S_t^{II}, which quantifies the number of sanctions imposed by the European Union on specific legal entities (including companies, banks, and foundations) and individuals (including military personnel, judges, and others). This nuanced approach to measuring sanctions intensity, which distinguishes between targeted and general sanctions, represents a methodological innovation that will be adopted in our present study of Russia-Turkey trade relations under sanctions.

2.3.2. Russia sanctions studies

Following Western sanctions in 2014, several scholars have analyzed the economic implications of these punitive measures. Tuzova & Qayum(2016) examined the effects of U.S. and EU sanctions on Russia's oil sector and broader economy using a Vector Autoregression (VAR) model with quarterly data spanning from 1999 to 2015. Their analysis revealed that economic sanctions had imposed significant negative impacts on the Russian economy.

Gurvich and Prilepsky(2015) expanded this analysis by focusing on the financial channel of sanctions, in particular restrictions on foreign borrowing and capital flows. Their study showed that capital inflows stopped abruptly in 2014, and private sector foreign liabilities decreased by $37 billion (compared with an increase of $115 billion in 2013). The authors also found that the medium-term scenarios assume a decrease in investment and consumption due to higher cost of

loans and limited refinancing opportunities for sanctioned organizations (for example, Sberbank, Rosneft), cumulative GDP losses in 2014-2015 will amount to 1.1% due to capital outflows and limited access to international markets.

2.3.3. Broader economic implications of sanctions

Beyond direct trade effects, sanctions often generate broader economic repercussions within targeted economies. Sadat, Akhavi, Hosseini(2017) evaluated sanctions' inflationary effects in Iran, identifying both direct impacts on price levels and indirect effects mediated through liquidity channels. Additionally, they determined that exchange rate fluctuations induced by sanctions contributed to imported inflation. Gharehgozli(2017) employed synthetic control methodology to estimate that international sanctions targeting Iran's energy sector and financial system access reduced Iran's real GDP by more than 17% between 2011 and 2014, with the most severe contraction occurring in 2012. Complementing this macroeconomic perspective, Moghaddasi,Nistico(2021) found that sanctions reduced manufacturing employment growth in Iran by 16.4 percentage points in 2012. Hussain, Fard(2021) examined economic resilience among Economic Cooperation Organization (ECO) member states, identifying Iran as a leading resilient member due to its low external debt levels, which enhanced its capacity to absorb external economic shocks to a certain degree.

2.4. Research gap: Russia-Turkey trade under sanctions

A notable lacuna in the existing literature concerns the specific role of Turkey as an intermediary in Russia's international trade under Western sanctions. Turkey's unique strategic location at the intersection of Europe and Asia, combined with its established economic ties with Russia, positions it distinctively as a trade partner within the context of economic sanctions.While previous research has extensively examined sanctions' impact on trade flows involving countries such as Iran, South Africa, and North Korea, the particular dynamics characterizing Russia-Turkey bilateral trade under sanctions remain comparatively unexplored.

The present study aims to address this knowledge gap by employing the Poisson Pseudo-Maximum Likelihood (PPML) estimator within the gravity model framework to analyze Russia-Turkey bilateral trade under sanctions. By explicitly accounting for multilateral resistance terms and zero trade flows, this research promises to enhance understanding of how international trade patterns reconfigure in response to geopolitical constraints and economic sanctions.

2.5. Methodological approaches to studying sanctions' impact on trade

2.5.1. Gravity model applications in sanctions research

The gravity model has been widely employed to investigate the impact of economic sanctions on international trade flows. As previously noted, Yang(2004) utilized the model to examine U.S. sanctions' effects from 1980 to 1998, while Ziaee, Bigdeli(2012) applied it to analyze sanctions' impact on Iran's trade flows. These applications demonstrate the model's versatility in capturing the complex dynamics of trade under restrictive policy regimes.

2.5.2. Panel data methods and time series analysis

Beyond the gravity model, researchers have employed various econometric techniques to analyze sanctions' effects on trade. Difference-in-difference estimation has proven valuable when examining how sanctions affect treatment groups (sanctioned countries) compared to control groups (non-sanctioned countries). This approach helps isolate sanctions' causal effects by controlling for pre-existing differences and common temporal trends. For time series analysis, Vector Error Correction Models (VECM) and Autoregressive Distributed Lag (ARDL) models have been instrumental in capturing the dynamic relationships between sanctions and trade flows. Tuzova & Qayum(2016)'s VAR model analysis of sanctions' effects on Russia's economy exemplifies this methodological approach.

2.5.3. Autoregressive Distributed Lag (ARDL) Approach

The Autoregressive Distributed Lag (ARDL) model has emerged as a powerful econometric technique for analyzing dynamic relationships in time series data, particularly in contexts involving potential structural breaks and mixed orders of integration. As an approach to cointegration analysis, ARDL offers several distinct advantages over traditional methods, making it increasingly popular in trade and sanctions research. The ARDL model's theoretical underpinnings rest on the flexible specification of lag structures that allow variables to affect outcomes with different time dynamics. This approach recognizes that economic relationships often involve complex temporal patterns where past values influence current outcomes, and exogenous shocks may have both immediate and delayed effects - a characteristic particularly relevant when analyzing sanctions' impact on bilateral trade relations.

For an ARDL model to yield valid results, several key assumptions must be satisfied. Firstly, the absence of autocorrelation among error terms is essential, as serial correlation can lead to inefficient estimators and invalid inference. Secondly, the model requires homoscedasticity, mean-

ing the variance of error terms must remain constant across observations. Third, the data should follow a normal distribution to ensure the validity of hypothesis tests. Finally, and critically for sanctions research, the variables must be stationary at either I(0) or I(1) levels, but not I(2) or higher—a requirement that accommodates the mixed integration orders commonly found in macroeconomic and trade data.

The ARDL approach offers distinct methodological advantages that make it particularly suitable for analyzing the Russia-Turkey trade relationship under sanctions. A significant contribution to the development and advocacy of this approach came from Pesaran & Shin(1996), Pesaran (1997,2001), Pesaran & Smith(1998), who introduced the ARDL bounds testing procedure as an alternative to conventional cointegration techniques. As emphasized by Ghatak & Siddiki(2001), ARDL models are particularly advantageous when working with smaller sample sizes, which aligns with the relatively limited timeframe of comprehensive data available on Russia-Turkey trade under the current sanctions regime. Additionally, while traditional cointegration methods like Johansen's technique require all variables to have the same order of integration, ARDL accommodates a mix of I(0) and I(1) variables—eliminating the need for precise pre-testing and classification of variables' integration properties, which can be subject to considerable uncertainty in empirical work Pahlavani(2005). As Bahmani,Oskooee(2004) observed, determining the degree of integration for each variable in cointegration analysis is inherently problematic because different unit root tests often yield contradictory results. The ARDL approach circumvents this issue by allowing for variables with different integration orders, making it more robust to such ambiguities Pahlavani(2005).

The application of ARDL models to examine the relationship between trade and economic growth has generated substantial empirical insights relevant to the present study. The theoretical foundation for analyzing trade-growth relationships through ARDL rests on classical and neo-classical economic theories positing that trade enhances economic growth through various mechanisms. As articulated by Helpman & Krugman(1985), trade promotes competition that leads to efficient resource allocation across economies. Similarly, Bhagwati(1988) contended that export expansion facilitates economic growth through upgrading human capital and technological advancement via knowledge transfer.

Recent empirical applications of ARDL to trade-growth analysis offer methodological guidance for the present study. Agarwal(2023) utilized the ARDL approach to investigate the trade-growth relationship between India and the United Kingdom, revealing bidirectional causality between merchandise trade components and economic growth—a finding that highlights the importance of disaggregating trade flows when examining economic impacts. The mixed empirical evidence

regarding export-led growth hypotheses illustrates the complexity of trade-growth relationships that sanctions may disrupt. While numerous studies support export-led growth Amirkhalkhali & Dar(1995), Yaghmaian & Ghorashi(1995), Coppin(1994), Sheehey(1992), Alam(1991), Dodaro(1991), Otani & Villaneuva(1990), others find evidence for growth-led exports Panas & Vamvoukas(2002) or bidirectional relationships Ramos(2001), Awokuse(2007), suggesting that sanctions' impacts may vary according to pre-existing trade-growth dynamics.

Hye (2013)'s application of ARDL to six South Asian Association for Regional Cooperation countries demonstrated heterogeneous trade-growth relationships even among relatively similar economies - a finding that underscores the importance of country-specific analysis when assessing sanctions' impacts on bilateral trade. Their research revealed that import-led growth applied universally across the studied countries, while export-led growth models were applicable to all except Pakistan—highlighting that sanctions disrupting different trade channels may have asymmetric economic effects.

Several recent empirical studies demonstrate ARDL's effectiveness in analyzing bilateral trade relationships and the impact of exogenous shocks similar to sanctions. Tran(2023) employed ARDL cointegration methods to investigate bilateral trade between Vietnam and Korea and its impact on Vietnam's economic growth. Controlling for factors including FDI, gross capital formation, government expenditure, and household spending, the study confirmed that bilateral trade had both short-run and long-run impacts on Vietnam's economic growth, measured in terms of both GDP and GDP per capita. The research revealed that despite Vietnam's high level of trade openness (164.7% of GDP in 2019), its significant bilateral relationship with Korea—facilitated by Korean investors like Samsung and LG - influenced Vietnam's trade balance and overall economic trajectory. This application demonstrates ARDL's utility in isolating the effects of bilateral trade amid complex global economic relationships - a methodological advantage particularly relevant for analyzing Russia-Turkey trade under sanctions.

Similarly, Asumadu, Sarkodie and Owusu(2017) utilized both VECM and ARDL models to investigate the relationship between carbon dioxide emissions and agriculture in Ghana. Their comparative methodological approach revealed that ARDL bounds testing was particularly effective in identifying long-run equilibrium relationships between variables, even with relatively limited time series data. This methodological insight is valuable for the present study, as the relatively recent imposition of comprehensive sanctions against Russia limits the available data points for time series analysis.

Karno(2017) applied the ARDL model to examine bilateral trade between Indonesia and China, using annual data from 1987 to 2014. The study identified market size and currency

exchange rates as significant factors influencing bilateral trade opportunities between the two countries. This application demonstrates ARDL's effectiveness in isolating specific determinants of bilateral trade relationships—a capability that will prove valuable in disentangling sanctions' effects from other factors influencing Russia-Turkey trade.

Derouez(2023) employed both ARDL and VECM approaches to investigate the effects of renewable and non-renewable energy, technological advancement, and other factors on economic growth in Saudi Arabia. Their methodological approach involved a three-step process: first identifying the order of integration through ADF and DF-GSL tests, then verifying long-run cointegration relationships using bounds testing and the Wald test, and finally applying ARDL to capture each variable's long-term effect on economic growth. This methodological sequence represents best practice for applying ARDL in the context of complex economic relationships like those characterizing Russia-Turkey trade under sanctions.

In the context of examining sanctions' effects on Russia-Turkey trade, the ARDL approach offers several key advantages. First, it accommodates the mixed integration orders likely to characterize trade data under sanctions regimes. Second, it simultaneously estimates both short-run and long-run coefficients, providing insights into both immediate sanctions impacts and longer-term adaptations in bilateral trade patterns. Third, it performs well with the relatively small sample sizes available for post-2022 sanctions analysis. Finally, the inclusion of error correction terms in ARDL models provides insights into the speed of adjustment toward long-run equilibrium following sanctions-induced shocks - revealing how quickly trade relationships reconfigure in response to geopolitical constraints.

The significant error correction terms typically found in ARDL models confirm that deviations from long-run equilibrium in trade relationships are corrected over time. For instance, Pahlavani(2005) found that deviations from long-term growth rates in Iran's GDP were corrected between 46 and 60 percent in the year following exogenous shocks - suggesting that trade imbalances arising from exogenous shocks such as sanctions tend to stabilize eventually through structural adjustments in trade flows. This feature makes ARDL particularly suitable for analyzing how Russia-Turkey trade might dynamically adjust to sanctions regimes over time, potentially identifying both short-run disruptions and longer-term adaptations in bilateral trade patterns.

3. Empirical Analysis

3.1. Data description

The main purpose of this study is to study the impact of economic sanctions on bilateral trade flows between the Russian Federation and Turkey under conditions of external economic restrictions. Economic intuition, based both on both observations of political developments and practical experience of russian customers, including changes in the structure of imports, the growing presence of Russian companies in Turkey and shifts in the product range, suggests that in the face of growing sanctions pressure from Western countries, Turkey has become an alternative trading partner for Russia. In this context, Turkey acts as a "new corridor" facilitating both the export of Russian goods, primarily oil, and the import of goods that would otherwise be unavailable due to sanctions. However, while these intuitive observations are a valuable starting point, they require careful empirical verification using statistical data and reliable econometric methods.

It is important to note that after the introduction of international restrictions in 2022, Russia suspended the publication of foreign trade statistics and several other key macroeconomic indicators that were previously distributed by the Central Bank of the Russian Federation and the Federal Customs Service. Consequently, this study uses exclusively data published by the Turkish Statistical Institute, which continues to systematically provide detailed and disaggregated information on Turkey's foreign trade by country and product group. Despite the fact that using data from only one side of a trade relationship can lead to certain limitations, such as discrepancies arising from different accounting methods, TUIK's data is considered reliable and is widely used in academic and international research. Moreover, the use of data from a single consistent source ensures comparability and consistency throughout the study period.

The created dataset includes monthly observations covering the period from January 2014 to February 2025. For greater analytical clarity, the data is divided into three groups:

- **Trade indicators**: they reflect the volume of Russian exports to Turkey, Russian imports from Turkey, and the total volume of bilateral trade between countries.
- **Macroeconomic indicators**: they include the gross domestic product (GDP) of Russia and Turkey, which are key components of the classical gravity model and serve as indirect indicators of the economic potential of the respective countries. The GDP data was obtained from the official websites of Rosstat for Russia and TUIK for Turkey. Given that GDP figures are presented in national currencies, as well as taking into account the significant inflation volatility that both countries faced during the study period, these data were

adjusted using effective exchange rates provided by the Bank for International Settlements (BIS). This adjustment is aimed at eliminating distortions related to currency fluctuations and improving the comparability of economic indicators. In addition to GDP, the model takes into account the price of Urals crude oil, reflecting Turkey's significant dependence on Russian oil imports. According to the International Energy Agency's report "Energy Policy of the IEA Countries: A Review of Turkey for 2021," approximately 50% of Turkey's oil imports come from Russia. Therefore, fluctuations in oil prices are expected to have a direct and significant impact on trade flows between the two countries. The oil price data was obtained from OPEC's monthly oil market report for March 2025.

- **Institutional indicators**: the model includes a binary institutional variable representing the legalization of parallel imports in Russia. This legislative change serves as a political tool aimed at partially offsetting trade restrictions imposed as a result of sanctions, and thus potentially affecting the dynamics of bilateral trade. On March 8, 2022, Federal Law No. 46 was adopted, granting the Russian government or its authorized bodies the right to determine the list of goods allowed for import under the parallel import mechanism. Subsequently, on March 29, 2022, the Government of the Russian Federation issued Resolution No. 506, appointing the Ministry of Industry and Trade responsible for compiling a list of such goods. After that, on April 19, 2022, the Ministry approved Order No. 1532, which established an initial list of specific goods allowed for import under the parallel import scheme. Thus, this binary variable reflects a critical institutional shift that expands trade opportunities in response to sanctions pressure and allows us to assess how this policy change affects the dynamics of foreign trade.

The **central explanatory variable** in this study is "Sanctions" variable, which quantifies the intensity of sanctions pressure over time. This variable was compiled manually based on data from the Interfax X-Compliance information system and reflects the monthly number of existing sanctions restrictions against Russian individuals and legal entities. The dataset includes both individual and sectoral sanctions imposed by a wide range of countries and international organizations, including the European Union, the United Kingdom, the United States, Canada, Switzerland, Australia, Japan, and Poland. The main data sources include official sanctions lists and restrictive measures published by organizations such as the European Union, the British Treasury, OFAC (USA), the Canadian Ministry of Finance, SECO (Switzerland), DFAT (Australia), the Japanese Ministry of Finance, BIS (USA), as well as the EU Flight Safety List and the sanctions list. Combining these measures into a cumulative monthly indicator, the variable "Sanctions" reflects the overall external economic pressure exerted on Russia at any given time.

Although not all sanctions directly affect trade flows, this quantitative indicator provides greater variability and analytical sensitivity compared to a simple binary indicator, allowing us to identify periods characterized by both increased and decreased sanctions pressure.

Table 1: Description of variables

Variable	**Unit**	**Notes**
Sanctions variable	Count	Key explanatory variable
Russian exports	Thousand USD	Monthly trade flow
Russian imports	Thousand USD	Monthly trade flow
Total trade	Thousand USD	Sum of exports and imports
GDP Turkey	Thousand TRY	Gravity model key variable
GDP Russia	Billion RUB	Gravity model key variable
Effective exchange rates	Index	Currency/inflation adjustment
Urals oil price	USD/barrel	Monthly average price
Parallel imports	Binary (0/1)	Institutional dummy

3.2. Descriptive statistics

The introduction to the data structure and the specifics of each variable began with the application of descriptive statistics methods. A first look at the trade flows data (Fig. 1) revealed distinct structural transformations in Russian-Turkish economic interactions, which can be roughly divided into chronological stages. The initial (within our time limits) stage of the reduction fell on 2015-2016 and was caused by a combination of economic and political factors. The decline played a role in this. in world prices for hydrocarbons and metals, which led to an almost twofold reduction in Russian energy exports to Turkey. In addition, the weakening of the ruble during this period led to an increase in the cost of imports and a decrease in the purchasing power of Russian consumers. Finally, the restrictive measures imposed by Russia at the end of 2015 in response to the downing of a Russian military aircraft by Turkey had a significant impact: from January 1, 2016, the import of some Turkish goods (17 categories, including fruits, vegetables, flowers and salt) was banned, charter flights between the countries were suspended, and the intergovernmental commission The Trade and Economic Cooperation Commission has ceased its activities.

Table 2: Descriptive statistics of log-transformed variables

Variable	**Min**	**1st Quartile**	**Median**	**Mean**	**3rd Quartile**	**Max**
log(Bilateral Trade)	20.90	21.36	21.54	21.66	22.05	22.69
log(GDP_{RU})	9.759	10.014	10.215	10.296	10.575	11.002
log(GDP_{TR})	6.213	6.573	6.982	7.353	8.175	9.509
log(Ural Oil Price)	2.810	3.944	4.138	4.111	4.283	4.695
log(Sanctions)	0.000	5.236	5.371	5.709	6.589	7.792
log(Import)	18.36	19.44	19.71	19.73	20.11	20.71
log(Export)	20.77	21.19	21.38	21.50	21.85	22.56

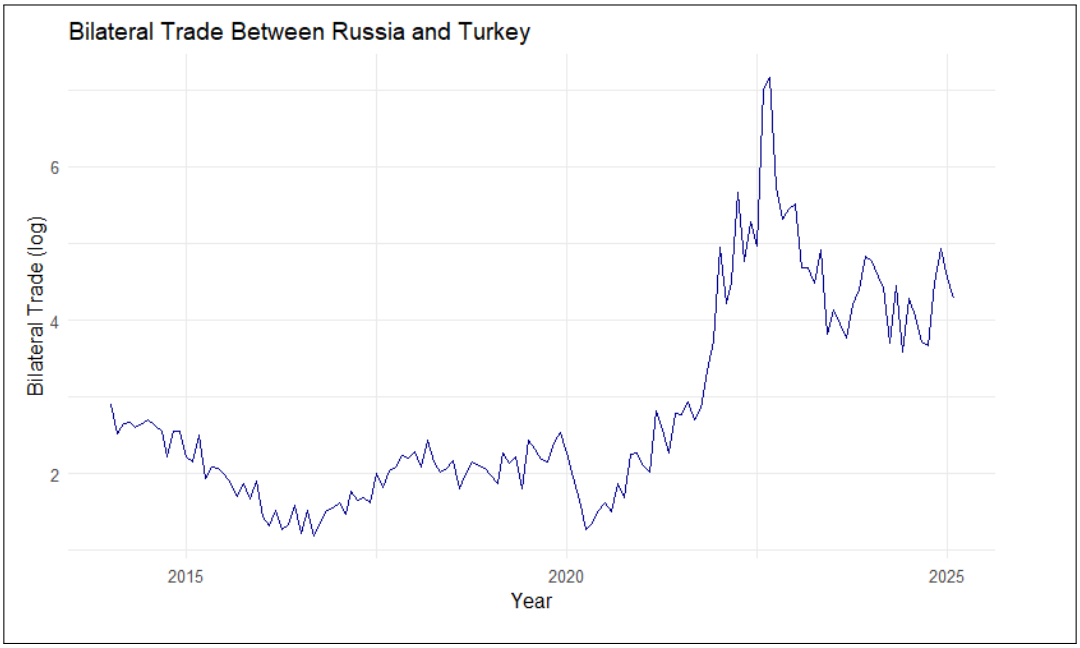

Figure 1: Bilateral trade dynamics 2014–2025

Thus, the reduction in trade turnover in 2016 reflects the combined impact of unfavorable external market conditions, currency depreciation, and politically motivated trade restrictions. The most noticeable changes occurred during the growth phase (2021-2025), when the volume of bilateral trade not only recovered, but also significantly exceeded the pre-sanctions level, increasing by about 400% compared to the low of 2016.

A longitudinal analysis of Russian-Turkish trade flows (Fig. 2) shows a stable structural asymmetry characterized by a significant trade surplus in favor of Russia. Russian exports to Turkey consistently and significantly exceed Russian imports from Turkey, and this structural asymmetry can be viewed from the point of view of Russia's resource supply to Turkey, namely gas, oil and coal. According to Kepler statistics, the hydrocarbon component alone accounted for approximately 62% of the total value of Russian exports to Turkey during the analyzed period.

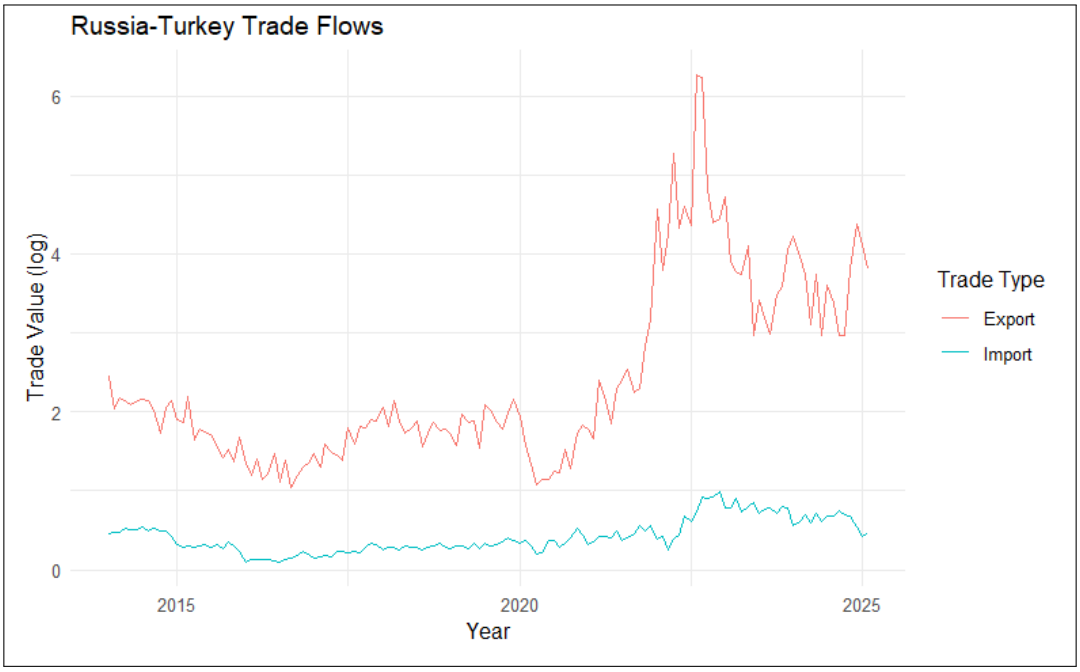

Figure 2: Russian import from Turkey and Russian export to Turkey dynamics 2014-2025

The import portfolio (Fig.3) of the Russian Federation has undergone some changes: the share of vehicles (excluding railway and tram rolling stock) increased from 13.3% to 22.5%, indicating increased domestic demand for imported cars and transport equipment. At the same time, there is a slight decrease in the share of boilers, machinery and mechanical devices from 54.2% to 50.8%. Imports of electrical machinery and equipment decreased from 11.8% to 7.9%, which may reflect the development of domestic production in this sector. The share of imports of edible fruits and nuts also increased from 4.8% to 6.6%, indicating increased attention to consumer goods and agricultural products.

The export structure (Fig.4) shows more pronounced transformations. The share of mineral fuels, oils and their distillation products increased significantly from 57.3% to 67.1%, which strengthens Russia's position as a major energy exporter and reflects the growing global demand for these resources. Exports of copper and its products have become a significant category (7.6%), which previously had no significant weight in the period 2014-2019. Aluminum exports increased from 4.8% to 7.5%, indicating the expansion of metallurgical exports beyond traditional cast iron and steel products. The share of grain crops in exports doubled from 1.4% to 2.7%, reflecting the growth of agricultural exports from Russia. At the same time, the share of other export categories dropped sharply from 22.4% to 3.7%, indicating a concentration of export activity in a specific commodities.

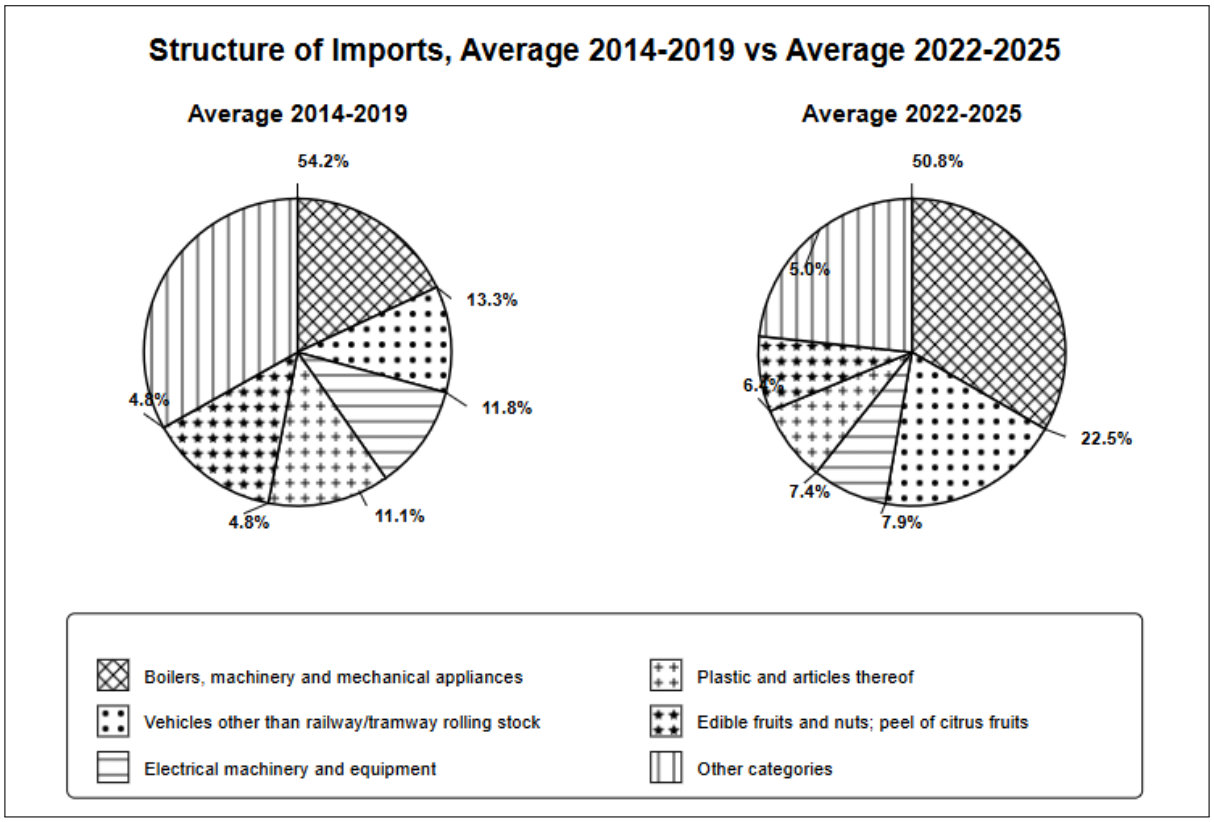

Figure 3: Structure of imports 2014-2025

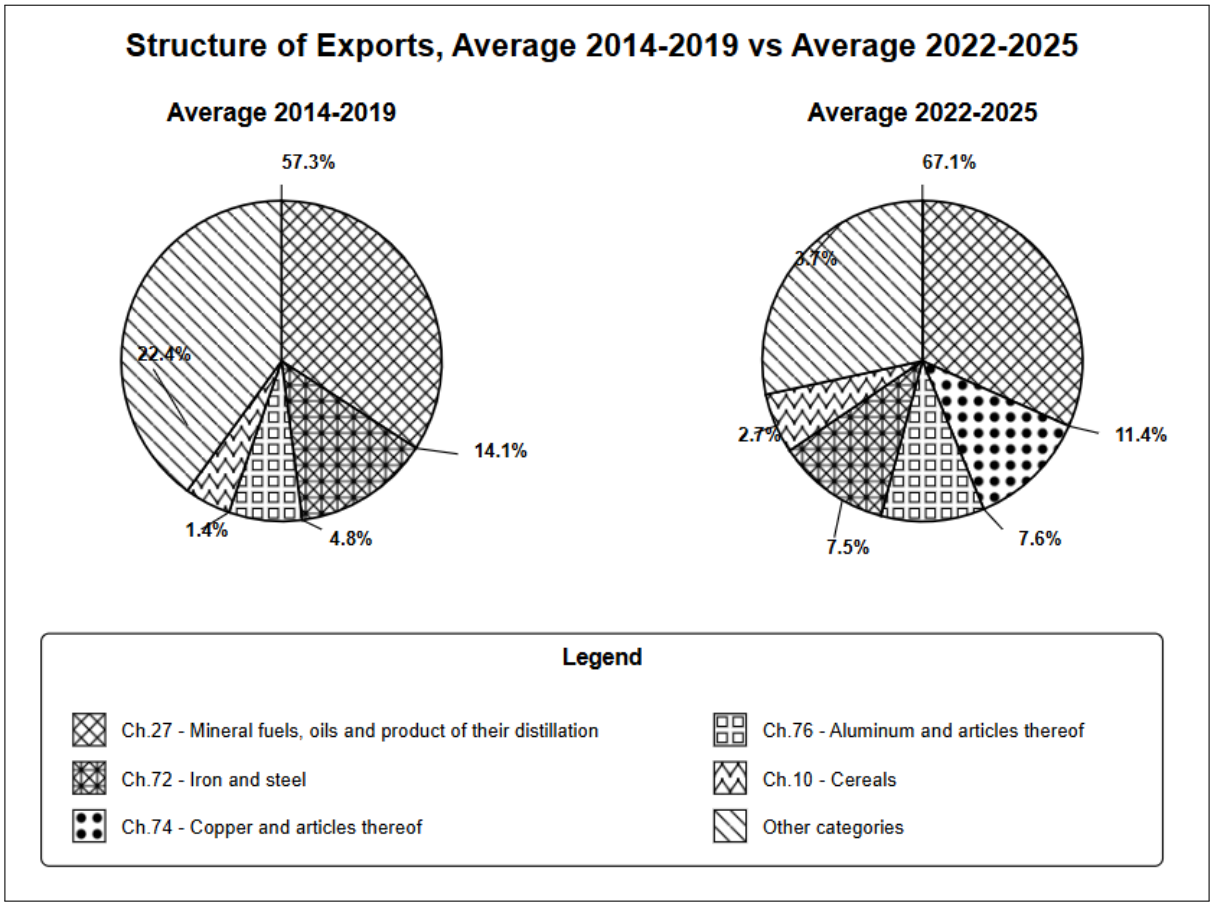

Figure 4: Structure of exports 2014-2025

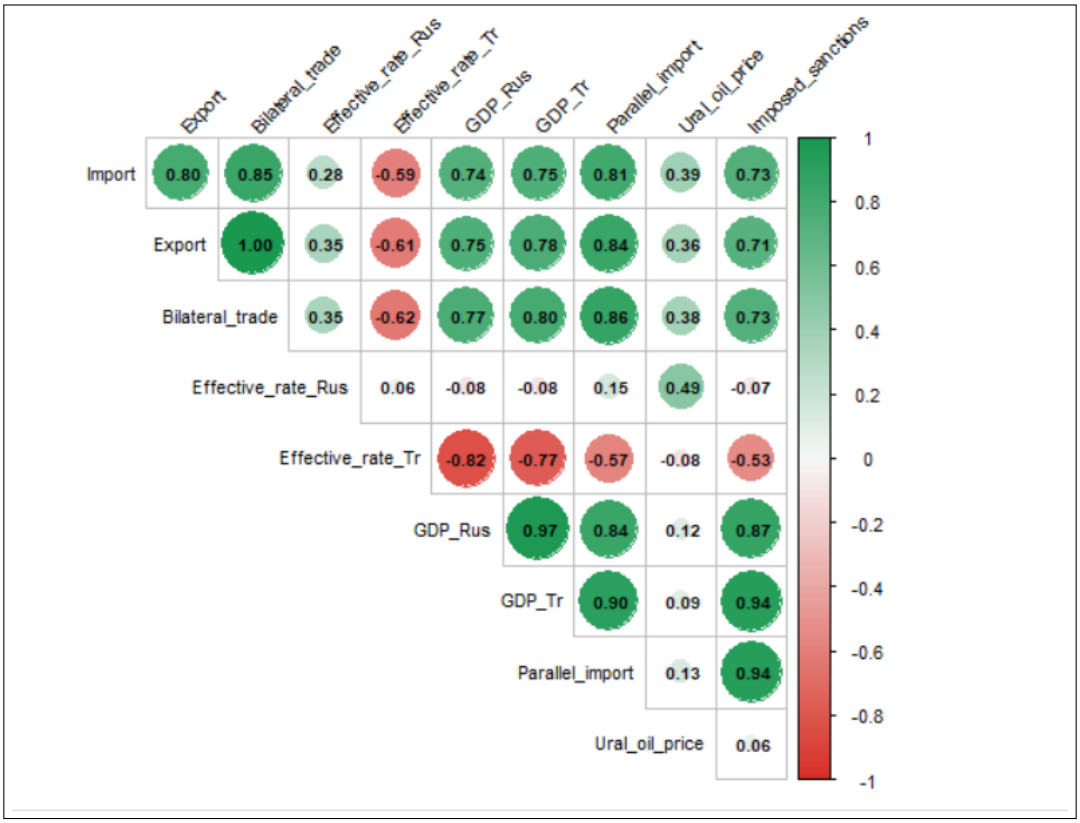

Figure 5: Correlation matrix

We also performed an analysis of the correlation matrix (Fig. 5), which allowed us to draw several key conclusions about the two-way linear relationships between variables.

- There is a strong positive correlation (0.73) between the sanctions imposed and the volume of bilateral trade: the sanctions did not seem to limit economic cooperation, but served as a catalyst for deepening economic integration between Russia and Turkey. This suggests that the economic pressure aimed at isolating Russia is related to the development of partnership in international trade with Turkey.

- The presence of a strong positive correlation between the volume of bilateral trade and the GDP of Russia and Turkey (0.77 and 0.80, respectively) indicates that the growth rates of both economies are directly related to the expansion of trade, which indicates that these relations have become a structurally integral part of both economies and fulfill one of the prerequisites of the gravity model is that they are directly proportional.

Figure 6 shows the actual effective exchange rates for Russia and Turkey between 2014 and 2025.The real effective exchange rate (REER) is the weighted average of a country's currency in relation to the basket of other major currencies. REER values exceeding 100 indicate a decline in the country's competitiveness compared to the base period, while values below 100 reflect an improvement in competitiveness relative to that base period. The REER index reflects the

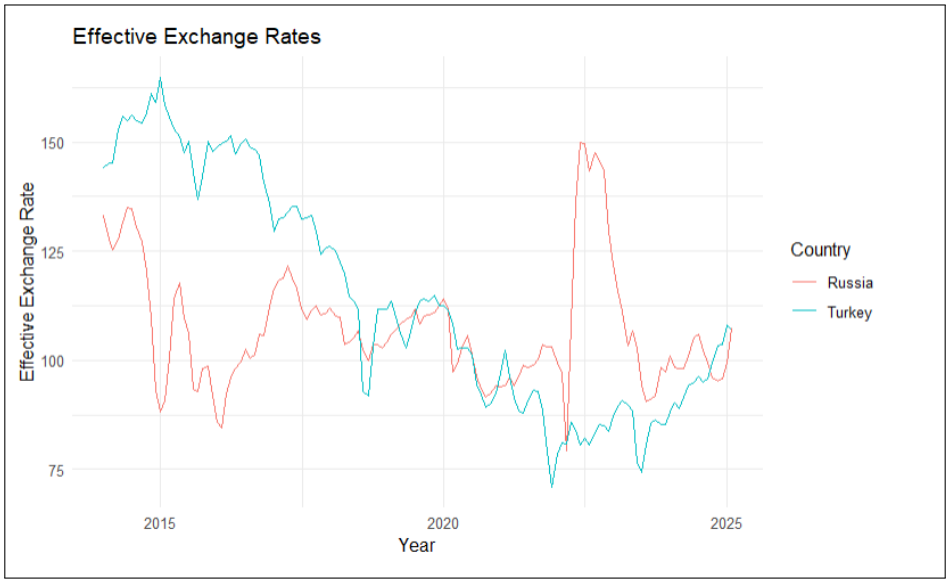

Figure 6: Effective exchange rates 2014-2025

weighted average exchange rate of a country's currency relative to its trading partners, adjusted for the difference in inflation. At the beginning of this period, the Turkish lira exchange rate was relatively high at about 150, but starting in 2020 it steadily declined, eventually dropping to about 75. This is about 50% of the real depreciation. Although this significantly increased the price competitiveness of Turkish exports, it also had a downside: the purchasing power of the population decreased, and imported goods and energy resources rose in price. On the other hand, the Russian ruble showed more episodic volatility between 2014 and 2015, falling sharply to about 85 rubles per dollar. Then there was a moderate rise until 2022, when there was a sudden but short-lived jump to almost 150. This jump was due to capital controls and mandatory conversion of export earnings, measures introduced in response to the tightening of sanctions. What is particularly interesting is the divergence in growth trends between 2021 and 2022: the ruble strengthened, while the lira weakened. This has created asymmetric trade incentives, which, in my opinion, partially explain the sharp increase in bilateral trade during this difficult geopolitical period. By 2023-2025, both currencies appear to have stabilized and even moved a little closer, suggesting a possible return to a more balanced exchange rate.

3.3. Empirical specifications

Review of the literature on international trade reveals that the gravity model is widely regarded as a robust framework for analyzing bilateral trade flows. It is important to note that the model assumes that the volume of trade between two countries is proportional to the size of their economies and inversely proportional to the distance between them. However, since this study focuses specifically on bilateral trade between Russia and Turkey over time, a constant distance value is excluded in our analysis. Instead, we expand the traditional specification to include variables specific to sanctions and other relevant economic factors.

The classical form of gravity model:

$$Trade_{TR} = A \cdot \frac{GDP_T \cdot GDP_R}{Dist_{TR}} \tag{1}$$

Firstly, the standard gravity model assumes that distance is a key determinant of trade flows.While geographical distance between Russia and Turkey remains constant, the "economic distance" has been altered by sanctions and changing institutional arrangements. Thus, our adapted model in equation (2) incorporates sanctions intensity and policy changes such as parallel import agreements as proxies for changes in economic distance and trade friction.

The adapted linear form of the model with control variables is as follows:

$$\begin{aligned} log(Trade_{RT,t}) = b_0 &+ b_1 log(GDP_{R,t}) + b_2 log(GDP_{T,t}) + b_3 log(Sanctions_t) + b_4 log(OilPrice_t) \\ &+ b_5 log(ExchangeRate_{R,t}) + b_6 log(ExchangeRate_{T,t}) + b_7 \\ &+ ParallelImport_t + \lambda_t + \epsilon_{RT,t} \end{aligned} \tag{2}$$

Consequently, the traditional OLS estimation of log-linearized gravity models has been shown to suffer from heteroskedasticity issues and inability to handle zero trade flows (Santos Silva and Tenreyro, 2006). This is particularly relevant in our context, where sanctions could potentially create discontinuities in certain trade categories. Moreover, the Jensen's inequality implies that the log-linearization of the gravity equation can lead to biased estimates in the presence of heteroskedasticity. To address these econometric challenges, we employ the Poisson Pseudo-Maximum Likelihood (PPML) estimator, which has become the standard approach in the international trade literature for gravity model estimation. The PPML estimator offers several advantages: it naturally handles zero trade flows without requiring arbitrary transformations, produces consistent estimates in the presence of heteroskedasticity, and allows for direct inter-

pretation of coefficients when dependent variables are specified in levels rather than logarithms. Additionally, our model includes time fixed effects (λ_t) to control for global macroeconomic fluctuations and other time-varying factors that might affect bilateral trade flows uniformly. This helps isolate the specific impact of sanctions on Russia-Turkey trade relations from broader global economic trends during the study period.

The PPML model has the following form:

$$\begin{aligned} Trade_{RT,t} = \exp\big[&b_0 + b_1 \log(GDP_{R,t}) + b_2 \log(GDP_{T,t}) + b_3 \log(Sanctions_t) + \log(b_4 OilPrice_t) + \\ &+ b_5 \log(ExchangeRate_{R,t}) + b_6 \log(ExchangeRate_{T,t}) \\ &+ ParallelImport_t + \lambda_t + \epsilon_{RT,t}\big] \end{aligned} \tag{3}$$

While the gravity model provides a solid theoretical foundation for analyzing bilateral trade determinants, our dataset exhibits explicitly temporal dynamics rather than cross-sectional or panel structure. The monthly time-series nature of our data necessitates addressing potential issues such as serial correlation, non-stationarity, and dynamic adjustments that standard gravity models may not adequately capture. Furthermore, the Russia-Turkey trade relationship demonstrates clear path dependency, with current trade flows likely influenced by historical patterns, adjustment lags in response to policy changes, and evolving institutional arrangements under sanctions regimes. To incorporate these temporal dynamics while maintaining the theoretical insights from the gravity framework, we adopt an Autoregressive Distributed Lag (ARDL) modeling approach. The ARDL model is particularly suitable for our analysis for several reasons. First, it accommodates variables of different integration orders (I(0) and I(1)), which is essential given the diverse nature of our economic indicators. Second, it explicitly captures both short-run dynamics and long-run relationships between variables. Third, it allows for different lag structures across variables, accommodating varying adjustment speeds to economic shocks and policy changes—a critical feature when analyzing trade responses to sanctions.

The general form of our ARDL model can be expressed as:

$$\begin{aligned}\Delta \log(Trade_{RT,t}) =& \alpha_0 + \sum_{i=1}^{p} \beta_i \Delta \log(Trade_{RT,t-i}) + \sum_{i=0}^{q_1} \gamma_{1i} \Delta \log(GDP_{R,t-i}) \\ &+ \sum_{i=0}^{q_2} \gamma_{2i} \Delta \log(GDP_{T,t-i}) + \sum_{i=0}^{q_3} \gamma_{3i} \Delta \log(Sanctions_{t-i}) \\ &+ \sum_{i=0}^{q_4} \gamma_{4i} \Delta \log(OilPrice_{t-i}) + \sum_{i=0}^{q_5} \gamma_{5i} \Delta \log(ExchangeRate_{R,t-i}) \\ &+ \sum_{i=0}^{q_6} \gamma_{6i} \Delta \log(ExchangeRate_{T,t-i}) + \sum_{i=0}^{q_7} \gamma_{7i} \Delta ParallelImport_{t-i} \\ &+ \delta_1 \log(Trade_{RT,t-1}) + \delta_2 \log(GDP_{R,t-1}) + \delta_3 \log(GDP_{T,t-1}) \\ &+ \delta_4 \log(Sanctions_{t-1}) + \delta_5 \log(OilPrice_{t-1}) + \delta_6 \log(ExchangeRate_{R,t-1}) \\ &+ \delta_7 \log(ExchangeRate_{T,t-1}) + \delta_8 ParallelImport_{t-1} + \epsilon_t \end{aligned} \tag{4}$$

where $p, q_1, q_2, ..., q_7$ represent the lag orders for the dependent and independent variables, respectively. The coefficients β_i and γ_{ji} capture the short-run dynamics, while the δ coefficients represent the long-run relationships between the variables.

To implement this model, we first conduct appropriate unit root tests to verify the order of integration of each variable, ensuring none is I(2) or higher. Subsequently, we employ the bounds testing approach developed by Pesaran et al. (2001) to test for the existence of a long-run relationship among the variables regardless of whether they are I(0) or I(1). This approach involves testing the joint significance of the lagged level variables using an F-test with non-standard critical values. The ARDL specification offers several advantages over standard gravity models in our context:

1. It accounts for the persistence in trade flows, which is particularly relevant when analyzing adaptation to sanctions over time.

2. It distinguishes between immediate responses to policy changes (short-run dynamics) and equilibrium adjustments (long-run relationships), providing a more nuanced understanding of how sanctions reshape trade patterns.

3. By incorporating lagged dependent variables, it captures how past trading behaviors influence current patterns of bilateral trade.

4. Results

4.1. The effect of sanctions on trade

To test our main hypothesis about the impact of sanctions on bilateral trade flows, we followed a systematic econometric approach. The purpose of our analysis - to determine whether the strengthening of sanctions against Russia has had an impact on trade between Turkey and Russia and, if so, to what extent. At the initial stage of searching for the optimal model, we started with the ordinary least squares method. To do this, we evaluated 4 models (Table 3) and tested them for heteroscedasticity of the residuals, as the OLS model requires us to have homoscedasticity of residuals. It is important to note that during the construction, the variables were logarithmic, which gives us reason to interpret the resulting coefficients as pure elasticities between variables. However, we could not interpret them unambiguously, since the value of this coefficient changed depending on the inclusion of control variables in the model and became completely insignificant in the last model. It is also important to note that a model with the "Parallel import" variable was also built, but it showed a low value of the Breusch-Pagan p-value test, that is, it was biased due to the heteroscedasticity of residuals, and therefore this variable was excluded from the dataset.

Table 3: OLS Log-log trade model

	Model 1		Model 2		Model 3		Model 4	
Variable	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
Intercept	20.496***	0.000	22.223***	0.000	25.927***	0.000	24.390***	0.000
log_Sanctions	0.205***	0.000	−0.097**	0.004	−0.028	0.337	0.048	0.066
log_GDP_Rus	−−	−−	−0.369**	0.006	−0.717***	0.000	−0.671***	0.000
log_GDP_Tr	−−	−−	0.517***	0.000	0.382***	0.000	0.267***	0.000
Effective_rate_Rus	−−	−−	−−	−−	0.010***	0.000	0.007***	0.000
Effective_rate_Tr	−−	−−	−−	−−	−0.006**	0.002	−0.005***	0.000
log_Ural_oil_price	−−	−−	−−	−−	−−	−−	0.448***	0.000
Model statistics								
R^2	0.359		0.667		0.792		0.856	
Adjusted R^2	0.354		0.659		0.784		0.849	
F-statistic	74.01		83.96		94.51		122.2	
F-test p-value	0.000		0.000		0.000		0.000	
Observations	134		130		130		130	
Breusch-Pagan test (BP statistic, p-value)								
	32.529, 0.000		11.292, 0.010		10.112, 0.072		7.608, 0.268	

The gravity model was also evaluated using the PPML model (Table 4). Based on the results of the literature review, we found that this method is more reliable because it is designed to address both heteroscedasticity and the presence of zero-value trade flows in a more robust and theoretically consistent manner.

Table 4: Poisson Pseudo Maximum Likelihood Model

	Model 1		Model 2		Model 3		Model 4	
Variable	Estimate	p-value	Estimate	p-value	Estimate	p-value	Estimate	p-value
(Intercept)	3.022***	0.000	2.888***	0.000	2.669***	0.000	2.903***	0.000
log_Sanctions	0.009***	0.000	−0.005**	0.002	0.003*	0.023	0.001	0.390
log_GDP_Ru	−−	−−	0.008	0.533	0.005	0.702	−0.017	0.119
log_GDP_Tr	−−	−−	0.018***	0.000	0.017***	0.000	0.017***	0.000
log(Effective_rate_Rus)	−−	−−	−−	−−	0.057***	0.000	0.035***	0.000
log(Effective_rate_Tr)	−−	−−	−−	−−	−0.004	0.578	−0.010	0.096
log_Ural_oil_price	−−	−−	−−	−−	−−	−−	0.022***	0.000
Dispersion parameter	0.00550		0.00295		0.00194		0.00142	
Null deviance	1.121		1.121		1.121		1.121	
Residual deviance	0.717		0.380		0.246		0.178	
Degrees of freedom	131		129		127		126	
Breusch-Pagan test (BP statistic, p-value)								
	31.734, 0.000		2.114, 0.549		14.389, 0.013		13.264, 0.039	
Shapiro-Wilk normality test on residuals (W statistic, p-value)								
	0.960, 0.001		0.978, 0.033		0.982, 0.068		0.973, 0.009	

The analysis of the four models allows us to conclude that there is an ambiguous relationship between sanctions and trade. When switching from simple to more complex specifications, there is a change in the sign and statistical significance of the coefficient for the logarithm of Sanctions variable. While the basic model indicates a positive relationship, control over the size of economies (Model 2) reverses the direction of influence to a negative one. Further inclusion of effective rates (Model 3) again demonstrates a weakly positive relationship, however, in the most comprehensive specification (Model 4), the relationship becomes statistically insignificant. From the point of view of diagnostics, Model 4 seems to be the most preferable for interpretation. Given the ambiguous and sometimes contradictory results obtained from the analysis of the total volume of bilateral trade, and the continued insignificance of the sanctions imposed, we assume that sanctions may have different effects on imports and exports so we will evaluate PPML models separately for Russian imports from Turkey and Russian exports to Turkey to explore this possibility.

Table 5: Poisson Pseudo Maximum Likelihood Models for Trade Flows

	Model 1		Model 2		Model 3		Model 4	
Variable	Estimate	p-value	Estimate	p-value	Estimate	p-value	Estimate	p-value
A: Import Flows								
(Intercept)	2.924***	0.000	2.534***	0.000	2.370***	0.000	2.677***	0.000
log_Sanctions	0.010***	0.000	−0.010***	0.000	0.007**	0.001	−0.002	0.407
log_GDP_Ru	−−	−−	0.037	0.060	0.028	0.172	0.000	0.985
log_GDP_Tr	−−	−−	0.016*	0.020	0.016*	0.015	0.016**	0.007
log(Effective_rate_Rus)	−−	−−	−−	−−	0.063***	0.000	0.034**	0.008
log(Effective_rate_Tr)	−−	−−	−−	−−	−0.010	0.393	−0.018	0.103
log_Ural_oil_price	−−	−−	−−	−−	−−	−−	0.029***	0.000
Dispersion parameter	0.01082		0.00639		0.00531		0.00451	
Null deviance	1.850		1.849		1.849		1.849	
Residual deviance	1.420		0.824		0.675		0.568	
Degrees of freedom	131		129		127		126	
BP test (statistic, p-value)	29.731, 0.000		11.806, 0.008		37.840, 0.000		16.551, 0.011	
Shapiro-Wilk test (W, p-value)	0.972, 0.008		0.984, 0.119		0.994, 0.876		0.994, 0.816	
B: Export Flows								
(Intercept)	3.013***	0.000	2.914***	0.000	2.678***	0.000	2.908***	0.000
log_Sanctions	0.010***	0.000	−0.004**	0.008	−0.002	0.079	0.002	0.224
log_GDP_Ru	−−	−−	0.004	0.761	0.001	0.907	−0.020	0.086
log_GDP_Tr	−−	−−	0.019***	0.000	0.018***	0.000	0.018***	0.000
log(Effective_rate_Rus)	−−	−−	−−	−−	0.058***	0.000	0.037***	0.000
log(Effective_rate_Tr)	−−	−−	−−	−−	−0.003	0.688	−0.009	0.159
log_Ural_oil_price	−−	−−	−−	−−	−−	−−	0.022***	0.000
Dispersion parameter	0.00546		0.00311		0.00207		0.00157	
Null deviance	1.122		1.122		1.122		1.122	
Residual deviance	0.712		0.400		0.262		0.198	
Degrees of freedom	131		129		127		126	
BP test (statistic, p-value)	26.197, 0.000		2.646, 0.449		12.822, 0.025		12.436, 0.053	
Shapiro-Wilk test (W, p-value)	0.953, 0.000		0.983, 0.094		0.965, 0.002		0.975, 0.015	

*Notes: * p <0.05, ** p <0.01, *** p <0.001. BP test refers to Breusch-Pagan test for heteroskedasticity.*

The analysis of PPML models (Table 5) demonstrates the ambiguous nature of the relationship between sanctions and trade flows. It is noteworthy that in all the basic models there is a statistically significant positive relationship between sanctions and trade flows (coefficient 0.010, p <0.001 for both imports and exports). However, when the control variables are included, this effect undergoes significant changes - when accounting for the size of economies (GDP), sanctions are beginning to show a significant negative impact on trade. However the inclusion of effective exchange rates makes the coefficient for the import positive(0.007 with p-value <0.001) while adding controls in the model of export negates the significance of the sanctions impact, pointing to the dominant role of macroeconomic factors.

Given the dynamic nature of the analyzed data, it seems advisable to supplement the study with the use of autoregressive distributed lag (ARDL) models. This approach would allow us to take into account the temporal structure of the data.

First of all, the stationarity of the variables needs to be examined to determine the order of integration for each variable included in the model. For this purpose, we have chosen to apply the Augmented Dickey-Fuller (ADF) unit root test. The table below presents a summary of the ADF test results for all variables, both in their levels and in their first differences.

Table 6: Unit Root Test Results (ADF Test)

Variable	Level		1st Difference		Order of Integration
	ADF Statistic	Critical Value (5%)	ADF Statistic	Critical Value (5%)	
Bilateral trade	-2.20	-3.43	-9.47	-2.88	I(1)
Import	-2.80	-3.43	-9.26	-2.88	I(1)
Export	-2.34	-3.43	-9.45	-2.88	I(1)
Ural oil price	-4.09	-2.88	–	–	I(0)
Sanctions	-1.13	-3.43	-7.00	-2.88	I(1)
Effective rate Rus	-4.09	-2.88	–	–	I(0)
Effective rate Tr	-2.35	-3.43	-9.45	-2.88	I(1)
GDP Rus	-4.35	-3.43	–	–	I(0)
GDP Tr	-0.59	-3.43	-9.93	-2.88	I(1)

Most of the variables in our study are first-order integrated I(1), which means that they become stationary after taking the first difference.Two variables are integrated of zero order I(0), that is, they are stationary in levels, these are the variables log(Ural oil price) and log(Effective rate Rus) and log(GDP Rus). Our premise on the application of the ARDL model is confirmed, since the variables have different integration orders and it does not exceed one.

To better capture the dynamics of the variables, we specified a range of lags as arguments in the model. The analysis used the function of building an automatic ARDL model in R, which automatically selects the optimal number of lags for each variable based on the AIC criterion which determined the most appropriate lag structure for each variable, balancing model fit and complexity. The results of this model, including the lag structure, are presented in Table 7. To assess the effectiveness of such a model, tests (Table 8) were conducted on the quality of the model and the properties of the residuals: the Breusch-Godfrey test, the Breusch-Pagan test, the Augmented Dickey-Fuller test, the Jarque-Bera test and CUSUM test.

Table 7: ARDL Model Estimates

Variable	Estimate	Std. Error	p-value
Intercept	5.078	2.112	0.0177*
L(log_Bilateral_trade, 1)	-0.329	0.061	0.0001***
L(log_Bilateral_trade, 2)	-0.110	0.050	0.028*
L(log_GDP_Ru, 1)	0.064	0.176	0.718
L(log_GDP_Ru, 2)	0.040	0.120	0.300
L(log_GDP_Tr, 1)	0.027	0.059	0.652
L(log_GDP_Tr, 2)	0.020	0.055	0.670
L(log_Sanctions, 1)	0.032	0.023	0.167
L(log_Sanctions, 2)	0.027	0.021	0.090*
L(log_Sanctions, 3)	0.015	0.018	0.012*
L(log_Ural_oil_price, 1)	0.194	0.058	0.001**
L(log_Ural_oil_price, 2)	0.080	0.045	0.070.
L(log_Effective_rate_Rus, 1)	0.172	0.109	0.117
L(log_Effective_rate_Rus, 2)	0.090	0.080	0.280
L(log_Effective_rate_Tr, 1)	-0.128	0.089	0.156
L(log_Effective_rate_Tr, 2)	-0.070	0.070	0.320
d(log_GDP_Tr)	0.337	0.216	0.121
d(log_Sanctions)	0.084	0.048	0.082**
d(log_Effective_rate_Tr)	0.173	0.277	0.534

Table 8: Diagnostic Tests for ARDL Model

Test	Statistic (df)	p-value
Breusch-Godfrey (autocorr.)	2.35 (4)	0.67
Breusch-Pagan (heteroskedast.)	6.53 (13)	0.92
Jarque-Bera (normality)	1.86 (2)	0.40
ADF for residuals (stationarity)	-8.69	< 0.01
CUSUM (structural breaks)	–	No breaks

As expected, sanctions exhibit a statistically significant positive effect on trade flows in both short and long-term horizons. The immediate effect is particularly noteworthy, with a 1% increase in sanctions associated with a 0.084% increase in bilateral trade (p=0.082**). This coefficient for the first difference of sanctions d(log_Sanctions) shows how a change in sanctions in the current period affects trade in the same period, thus reflecting the short-run (immediate) effect. This positive relationship persists in the long run, with the second lag of sanctions being marginally significant (coefficient=0.027, p=0.090*), and the third lag of sanctions being significant (coefficient=0.015, p=0.012*). Additionally, Ural oil price emerges as a significant determinant of bilateral trade (coefficient=0.194, $p < 0.001$**), underscoring the importance of energy markets in the economic relationship between these nations. These findings suggest that Turkey may have positioned itself as an alternative trade partner for Russia under sanctions pressure, effectively creating new trade channels rather than diminishing existing ones.

The results of the diagnostic tests (Table 8) confirm the adequacy of the model: there is no evidence of autocorrelation (Breusch-Godfrey p-value = 0.67), heteroskedasticity (Breusch-Pagan p-value = 0.92), or non-normality of residuals (Jarque-Bera p-value = 0.40). The residuals are stationary (ADF test statistic = -8.69, $p < 0.01$), and the CUSUM test indicates no structural breaks. Thus, the model demonstrates good statistical properties and can be considered reliable for interpretation and further analysis.

4.2. The effect of sanctions on trade on disaggregated data by product category

Having identified the statistically significant impact of sanctions on aggregate import flows, we want to pay special attention to the structure of these flows. This part of the chapter will focus on disaggregated data by product categories. This more detailed analysis will require us to consistently build models for each product group of 99 encodings, however, since there is a possibility of distortion due to a large number of zero flows, we will use the PPML model and try to identify those types of goods that have been and remain more subject to trade restrictions, we will try to identify heterogeneity at the commodity level.

Taking into account the descriptive statistics regarding the analysis of the structures of the import and export portfolio of Russia, we concluded that the most pronounced products in the structure of these ports belong to different hs2 groups, which makes it reasonable and logical to divide the model in question into two, depending on the dependent variable - the first will be with the dependent variable Russian imports from Turkey, the second is Russian exports to Turkey.

Given the nature of the sanctions imposed against Russia, which are often implemented as sectoral measures targeting narrow categories of goods or indirectly affecting trade through the exit of multinational corporations specializing in specific goods, it is natural that some categories of goods experience greater difficulties in trade than others.

To test this hypothesis, we have created a new dataset covering the period from 2019 to 2024, including monthly trade data for 99 different product categories. This set of disaggregated data contains 7,056 observations across 14 variables.

Based on the results of the evaluation of the models, we have identified four main clusters of product categories demonstrating various effects of the sanctions impact on Russian-Turkish trade:

- Group 1: Positive effect on imports and exports
- Group 2: Positive effect on imports, negative effect on exports
- Group 3: Negative effect on imports and exports
- Group 4: Effects only for export
- Group 5: Effects for import only.

Tables 9-11 show the coefficients for the Sanctions variable in models with Import and Export dependent variables.

Table 9: Categories with significant sanctions effect

Code	Category	Import	Export
Group 1: Positive effect on both Import and Export			
19	Preparations of cereals, flour or starch or milk	0.031.	1.082.
20	Preparations of vegetables, fruits or other parts of plants	0.058**	0.443***
76	Aluminium and articles thereof	0.091***	0.016*
Group 2: Positive effect on Import, Negative on Export			
21	Miscellaneous edible preparations	0.031*	-0.177***
33	Essential oils and resinoids, perfumery, cosmetic or toilet prep.	0.043***	-0.039.
71	Precious stones, precious metals, pearls and articles thereof	0.209*	-0.251**

Table 10: Categories with significant sanctions effect

Code	Category	Import	Export
Group 3: Negative effect on both Import and Export			
40	Rubber and articles thereof	-0.001.	-0.032*
83	Miscellaneous articles of base metal	-0.011.	-0.188**
Group 4: Effects on Export only			
44	Wood and articles of wood, wood charcoal		0.049***
87	Vehicles (other than railway or tramway rolling stock), parts thereof		-0.073*

The first group (Table 9) of product categories is of particular interest, as it demonstrates steady growth in both import and export flows between Russia and Turkey, despite the sanctions pressure. It includes category of products of vegetables, fruits and other plant parts, where imports from Turkey to Russia increased (coefficient 0.06**), and exports from Russia to Turkey also increased (0.44***) due to Turkey's traditional role as a significant supplier of processed foods to the Russian market. The sanctions led to an intensification of trade relations: Russia increased imports of Turkish products as part of its import substitution policy after restricting supplies from Western countries, and Turkey became an important re-export hub for Russian products, which explains the increase in exports. At the same time, an embargo is in effect in Russia , prohibiting the import of products from countries that have imposed sanctions against Russia, including vegetables and fruits from the United States, the EU, Canada, Australia and Norway, which additionally stimulates the expansion of trade with Turkey. In the second group, there is an asymmetric impact of sanctions: imports from Turkey are growing, while exports from Russia to Turkey are declining. Category 33 - essential oils, perfumes, cosmetics and toilet products - demonstrates a significant increase in imports (0.04***), due to the withdrawal of Western cosmetic brands from the Russian market after the start of a special military operation and the emergence of new brands from Turkey, Korea and Iran. Category 71 - precious stones,

Table 11: Group 5: Effects of sanctions on Import only

Code	Category	Import
22	Beverages, spirits and vinegar	0.262***
27	Mineral fuels, mineral oils and products of their distillation	0.075***
32	Tanning and dyeing extracts, fillers and stoppings, inks	0.060***
34	Soap, organic surface-active agents, washing preparations etc.	0.049***
37	Photographic and cinematographic goods	2.255**
38	Miscellaneous chemical products	0.408***
45	Cork and articles of cork	1.531***
49	Printed books, newspapers, pictures and other printed products	0.103*
52	Cotton, cotton yarn and cotton textiles	0.266.
61	Knitted and crocheted goods and articles thereof	0.050**
62	Non-knitted and crocheted goods and articles thereof	0.076***
64	Footwear, gaiters and similar articles	0.099**
67	Prepared feathers and down, artificial flowers, articles of human hair	0.438*
68	Articles of stone, plaster, cement, asbestos or mica	0.043***
74	Copper and articles thereof	0.039**
84	Boilers, machinery and mechanical appliances, parts thereof	0.222***
85	Electrical machinery and equipment, parts thereof	0.319***
90	Optical, photographic, cinematographic, measuring instruments	0.728***
95	Toys, games and sports requisites, parts thereof	0.130***

metals, pearls and products made from them - also shows an increase in imports (0.21*), due to the replacement of Western luxury brands with Turkish products, and a sharp decline in exports (-0.25**) due to the ban of the EU and G7 countries on the import of Russian gold and diamonds, as well as sanctions against ALROSA The EU has also banned the export of luxury goods, including pearls, diamonds, and gold and silver jewelry.

Among the product categories that have demonstrated the most pronounced vulnerability to sanctions, which is manifested in negative coefficients for both import and export flows: rubber and articles therefore, miscellaneous articles of base metal (Table 10).

A category was also identified, which is characterized by the presence of statistically significant effects only for export flows, in the absence of a significant impact on imports. These include wood and products made from it, charcoal (imports: no data available, exports: 0.049***)-the supply of sawn timber from Russia to Turkey was indeed increased. Category 87: Means of land transport, other than railway or tramway rolling stock (import: export: -0.073*).This negative response can be attributed to the European Union's fourth sanctions package, which specifically prohibited the import of vehicles valued over €50,000 into Russia. This targeted restriction substantially disrupted established automotive supply chains and trade flows, reflecting how sector-specific sanctions can effectively impede trade in strategic goods.

Mineral fuels, machinery and mechanical equipment, electrical equipment, as well as optical

and measuring instruments are strategically important sectors of the economy and are characterized by relatively high demand elasticity values. This need is due to the need to circumvent sanctions, which confirms our initial assumption, made at the beginning of the research, that these product groups will show the greatest effect in the face of external restrictions(Table 11).

Special attention should be paid to the textile industry, in particular knitwear(code 61) and non-knitwear(code 62), which are expected to experience an increase in demand due to the withdrawal of many foreign companies from this sector. This phenomenon is caused by the reallocation of production capacity and increased domestic production in response to external challenges. In addition, specialized goods such as photographic and cinematographic products (code 37), many of which are classified as dual-use goods and can be used in the defense sector, also show significant dynamics. In the chemical industry, growth is observed in the segment of various chemical products (code 38), which is associated with the need to replace imported components and develop domestic production. Similarly, the cork and cork products industry (code 45) received an additional boost after the introduction of EU sanctions that restricted the supply of wine corks from Spain and Portugal, which created favorable conditions for the development of domestic production in this niche.

4.3. Moderating effects

An additional research hypothesis of the present work was aimed at identifying the moderating effect of macroeconomic factors on the sanctions impact. The inclusion of these factors as control variables is based on the assumption that they influence the dependent variable and contribute to explaining the variation of the independent variable, which is of primary interest for this study. In other words, it is suggested that the effectiveness of sanctions is to some extent determined by the dynamics of exchange rates and fluctuations in oil prices. As part of the construction of regression models, an attempt was made to empirically verify the intensity of this effect and the direction of its impact, in particular, to determine whether the factors under consideration enhance the impact of trade restrictions or, conversely, contribute to their leveling.

According to economic intuition, sanctions mechanisms final influence does not function in isolation, but interact with other economic variables, modifying the nature of their impact on trade flows. On the one hand, increased oil prices can provide the economy with additional resources to help overcome the negative effects of sanctions, on the other hand, fluctuations in exchange rates can both intensify and weaken the impact of sanctions on international trade flows. When empirically testing hypotheses about the presence of moderating effects, it is necessary to take into account the statistical properties of the analyzed variables. At the initial stage of the study, the possibility of using a distributed lag autoregression model ARDL was considered. However, in the process of forming interaction terms between time series of different integration orders, a fundamental methodological problem arises - it is the uncertainty about the order of integration of the resulting interaction variable. The interaction between a variable stationary in levels I(0) (in our case, exchange rates) and a variable stationary in the first differences I(1) (sanctions variable) forms a mixed stochastic process, the statistical characteristics of which are difficult to correctly interpret within the framework of the ARDL methodology. Therefore, it is more reasonable to use the Poisson Pseudo Maximum Likelihood model to verify the hypothesis.

The results of econometric modeling (Table 12 and 13) demonstrate that oil price quotations significantly moderate the relationship between sanctions and trade flows in both the import and export models. It is noteworthy that the sanctions regime as a whole is associated with the expansion of trade, but as oil prices increase, this effect weakens. One of the explanations is based on the fact that in conditions of high energy prices, the Russian economy accumulates additional financial resources that can be directed to the intensification of domestic production and the implementation of import substitution, which in turn leads to a decrease in demand for certain categories of imported goods. At the same time, increased oil export revenues may partially offset

the negative impact of the sanctions regime on total exports, making the effect of sanctions less pronounced.

The interaction between sanctions measures and the exchange rate of the Russian ruble in the import model deserves special attention. The positive coefficient (0.548) indicates that with the strengthening of the national currency of the Russian Federation, the negative impact of sanctions on imports from the Republic of Turkey weakens. While the effective exchange rate of Turkey has not demonstrated a statistically significant deterrent effect, the effective exchange rate of the Russian Federation has proved to be a significant factor. In the specification of the import model, it is observed that the interaction of the exchange rate and the sanctions regime is characterized by a coefficient of 0.55 at a 10% level of statistical significance. Based on the results obtained, it can be assumed that as the ruble strengthens, the destructive effect of import sanctions weakens. In other words, with the strengthening of the national currency, Russian economic agents acquire more rubles for each unit of foreign currency, which helps reduce the ruble value of imported goods from Turkey and increases their availability to Russian consumers. This phenomenon can be interpreted from the perspective that the strengthening of the national currency increases the purchasing power of Russian importers, partially leveling the barriers created by sanctions restrictions. At the same time, a similar moderating effect (0.476) is also observed in the export model, but it does not reach the threshold of statistical significance at generally accepted levels.

Table 12: Moderating Effects in the Import Model

Variable	**Model 1**	**Model 2**	**Model 3**
Intercept	22.678***	21.559*	36.354***
log(Sanctions)	0.646***	0.436	-2.305.
log(GDP Russia)	-0.417.	-0.257	0.045
log(GDP Turkey)	0.069	0.126	0.068
log(Effective Rate Russia)	0.432*	0.496*	-3.259
log(Effective Rate Turkey)	-1.070***	-0.740	-0.845**
log(Oil Price)	0.038**	-0.000	0.001
log(Sanctions) : log(Oil Price)	-0.006***	—	—
log(Sanctions) : log(Effective Rate Turkey)	—	-0.055	—
log(Sanctions) : log(Effective Rate Russia)	—	—	0.548**

Table 13: Moderating Effects in the Export Model

Variable	**Model 1**	**Model 2**	**Model 3**
Intercept	24.154***	13.735	36.185***
log(Sanctions)	0.482***	1.527	-2.164*
log(GDP Russia)	-0.982***	-0.714***	-0.573**
log(GDP Turkey)	0.247**	0.382***	0.266**
log(Effective Rate Russia)	1.118***	1.182***	-2.089
log(Effective Rate Turkey)	-0.610***	1.500	-0.388.
log(Oil Price)	0.045***	0.006***	0.008***
log(Sanctions) : log(Oil Price)	-0.005***	—	—
log(Sanctions) : log(Effective Rate Turkey)	—	-0.351	—
log(Sanctions) : log(Effective Rate Russia)	—	—	0.476

5. Conclusion and discussion

5.1. Conclusion

The aim of this research was to analyze the transformation of bilateral trade between Russia and Turkey under the impact of economic sanctions imposed in connection with the geopolitical conflict that began in 2022. The study examines how the large-scale and unprecedented restrictions imposed on the Russian economy have affected the structure and volumes of trade between the two countries, as well as specific product categories. The research focused on the following key question: how have economic sanctions changed bilateral trade relations between Russia and Turkey? To answer this question using the gravity model, three main hypotheses were formulated and tested.

The first and primary hypothesis postulated that sanctions have had a positive impact on trade between Turkey and Russia. It was assumed that Turkey has gained significant benefits from the restrictions imposed on Russia by becoming an alternative trading partner. To test the proposed hypotheses, three different specifications of the gravity model were used in the study:

1. Ordinary Least Squares method
2. Poisson Pseudo Maximum Likelihood method
3. Autoregressive Distributed Lag model

The PPML method was chosen as the main specification because it most adequately reflects the essence of the gravity model and takes into account the peculiarities of trade flow data, such as the presence of zero values and heteroscedasticity. Simultaneously, the ARDL model was applied for a deeper analysis of the dynamics of trade relations, taking into account the temporal structure of the data. Due to its ability to model short-term and long-term effects, ARDL significantly better describes the nature of time series and allows for the identification of more subtle mechanisms of the influence of sanctions and macroeconomic factors on trade.

Based on the results of empirical analysis, the following models were obtained, reflecting the impact of sanctions and macroeconomic factors on bilateral trade between Russia and Turkey:

Final ARDL model equation

This model demonstrates that changes in sanctions and macroeconomic indicators, such as oil prices, have a significant impact on the dynamics of bilateral trade.

$$\begin{aligned}\Delta \log(\text{Bilateral trade})_t = 5.078 \\ &- 0.329 \times \log(\text{Bilateral trade})_{t-1} \\ &- 0.110 \times \log(\text{Bilateral trade})_{t-2} \\ &+ 0.027 \times \log(\text{Sanctions})_{t-2} \\ &+ 0.015 \times \log(\text{Sanctions})_{t-3} \\ &+ 0.194 \times \log(\text{Ural oil price})_{t-1} \\ &+ 0.080 \times \log(\text{Ural oil price})_{t-2} \\ &+ 0.084 \times \Delta \log(\text{Sanctions})_t \\ &+ \varepsilon_t\end{aligned} \tag{5}$$

The interpretation of this equation according to our research question is as follows. The long-term effect of sanctions is estimated by the coefficients 0.027 and 0.015 for the second and third lags of log(Sanctions), respectively. This means that a 1% increase in the count of sanctions imposed two or three periods ago is associated with approximately a 0.027% and 0.015% increase in bilateral trade on average in the long term. The short-term effect of sanctions is expressed by the coefficient 0.084 for the change $\Delta \log(\text{Sanctions}_t)$, meaning that a 1% increase in sanctions' count in the current period is associated with an average 0.084% increase in bilateral trade volume.

Final PPML equation

The model has the following form:

$$\begin{aligned}\text{Bilateral Trade}_t = \exp\Big[\, 2.669 \\ &+ 0.034 \times \log(\text{Sanctions}_t) \\ &+ 0.007 \times \log(\text{GDP\_Ru}_t) \\ &+ 0.017 \times \log(\text{GDP\_Tr}_t) \\ &+ 0.057 \times \log(\text{Ural\_oil\_price}_t) \\ &\Big] + \epsilon_{RT,t}\end{aligned} \tag{6}$$

The coefficient 0.034 for $\log(\text{Sanctions}_t)$ means that with a 1% increase in sanctions, the expected volume of Russian-Turkish trade increases by approximately 3.4%. This convincingly confirms the hypothesis that sanctions stimulate the growth of trade between the two countries.

Conclusion on the main hypothesis:

Based on the constructed ARDL and PPNL model, the hypothesis about the positive impact of sanctions on bilateral trade between Russia and Turkey is not rejected. The obtained coefficients show a statistically significant and positive impact of sanctions both in the short term and long term. This confirms that the imposed restrictions contributed to the growth of trade between the countries, which corresponds to the expectations set in the study.

The second hypothesis of the study suggested that the impact of sanctions on Russian-Turkish trade varies significantly depending on the product category, with the most pronounced effects manifesting in sectors previously subject to restrictions by Western countries. This assumption is based on the fact that sanctions typically have a sectoral nature and are directed at specific groups of goods, or have an indirect impact through the withdrawal of multinational corporations specializing in specific products from the market. To test this hypothesis, a new expanded dataset was formed, and the PPML model was used for the correct processing of a large number of zero observations. During the analysis, separate models were constructed for Russian imports from Turkey and Russian exports to Turkey. This approach is due to the fact that the structure of commodity flows between the countries differs significantly, as well as the varying degree of sensitivity to external restrictions.

The results of the analysis convincingly confirm that the impact of sanctions on Russian-Turkish trade has a pronounced differentiated character depending on the product group. The most noticeable positive effect is observed in sectors where restrictions from Western countries were previously in place - for example, in the categories of mineral fuels, machinery and equipment, electrical engineering, and optical devices. In these industries, sanctions effectively stimulated the growth of trade between Russia and Turkey through the reorientation of flows and the replacement of Western suppliers. At the same time, negative or asymmetric effects have been identified for a number of categories: for example, the export of precious metals and vehicles from Russia to Turkey has significantly decreased, while imports of cosmetics and textiles, on the contrary, have significantly increased against the backdrop of the withdrawal of some foreign brands.

Conclusion on the second hypothesis:

The impact of sanctions on bilateral trade between Russia and Turkey varies depending on product categories indeed. Particularly noticeable growth is observed in groups of goods that were previously subject to Western restrictions, such as high-tech equipment, machinery, and dual-use items. This indicates that sanctions contributed to the redistribution of trade flows and the development of alternative supply channels precisely in those sectors where the greatest restrictions arose. Thus, the second hypothesis is not rejected and is confirmed by the research data.

Testing the third hypothesis - identifying the moderating influence of macroeconomic factors on the effect of sanctions - has important applied significance both for understanding the mechanisms of transformation of patterns of bilateral trade and for developing effective state policy. Understanding how exactly these factors strengthen or weaken sanctions restrictions allows the state to more accurately predict the consequences of sanctions and adapt its economic strategy.

This hypothesis is based on a deep understanding that sanctions do not operate in isolation but interact with other key economic variables, creating a complex and multifaceted effect on the economy and trade relations. The results of the analysis showed that an increase in oil prices reduces the stimulating effect of sanctions on trade while Russian ruble weakens the negative impact of sanctions on Russian imports from Turkey.

Conclusion on the third hypothesis:

Empirical analysis confirmed the presence of significant moderating effects of macroeconomic factors on the impact of sanctions in Russian-Turkish trade. The rise in oil prices weakens the positive effect of sanctions on trade, which is explained by the increase in financial resources of the Russian economy and the strengthening of import substitution. The strengthening of the Russian ruble reduces the negative impact of sanctions on imports from Turkey, increasing the availability of Turkish goods for Russian consumers. Thus, the third hypothesis is not rejected: macroeconomic variables significantly affect the effectiveness of sanctions and should be taken into account when analyzing trade relations under sanctions pressure.

To summarize all of the above, the conducted research has allowed for a comprehensive analysis of how the large-scale economic sanctions imposed against Russia after 2022 have transformed bilateral trade relations with Turkey. The findings demonstrate that sanctions did not diminish trade flows but rather have significantly stimulated the growth of trade between Russia and Turkey. This phenomenon, paradoxical at first glance, is explained by the fact that under external pressure, Turkey has occupied a unique strategic niche in international trade, acting as an effective "window" for imports and an alternative channel for the supply of those goods for which access was restricted. This effect is convincingly confirmed by both short-term and long-term estimates, which indicates a deep restructuring of trade flows and significant adaptive capabilities of the Russian economy. Overall, the results of the study do not only empirically confirm the proposed hypotheses but also significantly expand the understanding of the nature of sanctions shocks in the modern world economy.

Russian-Turkish trade relations under sanctions become a clear example of how geopolitical restrictions can not only destroy habitual connections but also create new economic opportunities, stimulating innovative forms of cooperation and adaptive strategies. The increasing trade volumes and diversification in certain sectors underscore Turkey's crucial role as a supportive intermediary, helping both countries navigate the economic challenges posed by sanctions. This evolving partnership reflects a deepening friendship and mutual reliance, highlighting the importance of further developing and strengthening trade ties to foster resilience and shared prosperity in an uncertain global environment.

5.2. Discussion

The conducted research, despite the significance of the results obtained, reveals a number of methodological limitations, overcoming which can significantly enrich the scientific understanding of the mechanism of economical restrictions. The prevailing gravity model, which focuses on bilateral cooperation between Russia and Turkey, needs to significantly expand its geographical coverage in order to form a holistic picture of the transformation of global trade flows under the influence of the sanctions regime. It is advisable to incorporate a wider range of market players into the analytical framework, including initiating countries (USA, EU, UK, Canada, Japan, Australia, etc.); post-Soviet countries(Kazakhstan, Belarus, Armenia, Azerbaijan); new priority areas of Russian foreign trade reorientation (China, India, UAE, Southeast Asia). Such a diversification of the research sample will allow not only to identify the effects of substitution and redirection of trade flows, but also to conduct a comparative analysis of the effectiveness of the sanctions regime depending on the institutional and structural characteristics of trading partners.

Additionally, an urgent methodological problem is the insufficient detail of the variable reflecting the impact of sanctions. To overcome this limitation, it is necessary to develop a multidimensional classification of sanctions measures that takes into account:

- Type of sanctions restriction (sectoral sanctions, personal restrictions, technological embargoes adn etc)
- Industry specifics of the sanctions impact with details according to HS codes
- The jurisdictional features of the sanctions regimes of various states and their imposition

And last but not least, for a deeper understanding of the nature of Russian-Turkish trade and the role of Turkey in current foreign trade relations, it would be extremely useful to have access to data from the Customs Service that allows us to distinguish the origin of goods. In particular, it is important to determine which goods are actually produced in Turkey, and which are actually European or other foreign goods imported through Turkey as part of parallel imports. This would make it possible to understand whether the direct partnership between Russia and Turkey is strengthening at the level of real commodity exchange, or whether Turkey is acting as an intermediary through which European and other sanctioned goods are re-exported to the Russian market. This differentiation of the origin of goods is critical for assessing the sustainability and nature of trade relations, as well as for developing a more accurate economic and foreign policy strategy.

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