

MEASURING SMUGGLING THROUGH THE GRAVITY EQUATION AND THE MIMIC MODEL: EVIDENCE FROM THE REPUBLIC OF MOLDOVA

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Abstract: This paper evaluates the impact of Free Trade Agreements (FTAs) on the Republic of Moldova's external trade using a structural gravity model framework. By employing bilateral trade data from 2001 to 2024, the study examines both exports and imports using two econometric approaches: Ordinary Least Squares (OLS) and Poisson Pseudo-Maximum Likelihood (PPML). The results confirm that the Republic of Moldova's participation in FTAs—especially with the European Union (DCFTA), CEFTA countries, and CIS partners—has significantly enhanced export flows, while the effects on imports remain mixed. The analysis highlights the importance of economic size and geographical distance, as well as the statistically significant contribution of FTAs to the Republic of Moldova's export performance. However, the asymmetric impact on imports underscores the need for tailored trade policy instruments and institutional support to fully realize the benefits of trade liberalization. This research contributes to a deeper understanding of the Republic of Moldova's trade dynamics and provides empirical insights relevant for regional integration and sustainable economic development.

Keywords: Republic of Moldova, Free Trade Agreements, gravity model, exports, imports, PPML, trade policy

JEL CLASSIFICATION: F17

INTRODUCTION

The Republic of Moldova, with an economy in transition located at the intersection of East and West, faces significant challenges in the process of international economic integration. Over the past two decades, the authorities have made considerable efforts to open the national economy to foreign markets by signing and implementing multilateral and bilateral trade agreements. Among them, the Deep and Comprehensive Free Trade Agreement (DCFTA/DCFTA) signed with the European Union represents a turning point for the Moldovan economy, profoundly influencing the direction and composition of exports.

The purpose of this report lies in the need for a complex analysis of the impact of free trade agreements on the foreign trade of the Republic of Moldova. In addition to a retrospective on the agreements signed, the study provides an overview of the current structure of exports and the challenges encountered in the current geopolitical context. It is also proposed to identify concrete opportunities for economic development by efficiently capitalizing on the existing trade framework.

The report is structured in several chapters. The first chapter provides an introductory framework and presents the rationale and objectives of the research. The second chapter analyzes the theoretical and normative framework that regulates free trade agreements, at the same time as the detailed description of the main agreements signed by the Republic of Moldova. Next, the impact of these agreements on foreign trade is assessed, using the structural model of the gravitational equation suggested for these purposes by Yotov et.al (2016). The paper concludes with a series of conclusions highlighting existing systemic challenges and strategic opportunities, as well as a series of practical recommendations for political and economic decision-makers.

THEORETICAL AND LEGISLATIVE FRAMEWORK OF THE TRADE AGREEMENTS SIGNED BY THE REPUBLIC OF MOLDOVA

The theoretical framework for free trade agreements is based on the theory of comparative advantage, which argues that countries should specialize in the production of goods for which they have the lowest opportunity cost. Therefore, the liberalization of international trade, supported by free trade agreements, contributes to the efficiency of resource allocation and the increase of economic well-being.

Free Trade Agreements (FTAs) are legal instruments that aim to eliminate tariff and non-tariff barriers between signatory states, thereby facilitating international trade. In the context of the global economy, these agreements contribute to sustainable economic development, stimulating foreign direct investment and integration into international production chains.

The Republic of Moldova has demonstrated, by signing several FTAs, a constant commitment to the principles of economic liberalization. The legal frameworks governing these agreements are varied and include both multilateral conventions (such as those of the World Trade Organization) and bilateral and regional treaties.

At the legislative level, the Republic of Moldova has developed a modern normative framework that facilitates integration into the global economy. Among the most important documents is the Foreign Trade Law no. 1031-XIV of 2000, the Customs Code and the laws ratifying each agreement, as well as the regulations on the origin of goods. These acts regulate trade flows, the way products are certified and the recognition of non-tariff barriers.

At the international level, the Republic of Moldova has been a member of the World Trade Organization (WTO) since 2001, and its legislation is gradually harmonized with the rules of the European Union. In the context of the DCFTA, the Moldovan authorities had to align hundreds of rules and technical procedures to allow duty-free access to the European market. These legislative transformations have an impact not only on exporting companies, but also on the entire economy, by imposing higher standards of quality and safety.

In addition to legislative aspects, the institutional framework is essential. The Ministry of Economic Development and Digitalization, the Customs Service and the National Agency for Food Safety are just some of the institutions that ensure the application and monitoring of the agreements. This complex framework requires not only the formal adoption of the provisions of the agreements, but also an effective implementation into practice, which remains a major challenge in the case of the Republic of Moldova.

Over the past two decades, the Republic of Moldova has concluded a number of free trade agreements that have contributed significantly to the redefinition of its international trade framework. These agreements aimed to facilitate foreign trade, stimulate investment and create a predictable economic climate for economic agents.

The most important instrument in this regard is the **Association Agreement with the European Union**, signed in 2014 and provisionally applied since 2016, which includes the trade component of the **DCFTA**. This agreement gives the Republic of Moldova preferential access to the European single market, with the elimination of most customs duties on Moldovan products. At the same time, it requires compliance with European standards in the field of quality, environmental protection, competition and consumer rights. The DCFTA is not just a trade agreement, but is an instrument for profound transformation of the country's economic and legal framework.

In addition to the relationship with the European Union, Moldova has been a party to **CEFTA (Central European Free Trade Agreement)** since 2007, along with Western Balkan states. The agreement facilitates regional trade and contributes to the diversification of markets, providing preferential access to countries such as Serbia, Montenegro, Albania and others.

Moldova has also signed **bilateral** free trade agreements with several states, including Turkey (2008), Ukraine (2005) and **CIS** member states (since 1993). These agreements contain provisions on dispute settlement, investment protection and technical cooperation, thus ensuring a transparent

and predictable framework for international trade.

Currently, the Moldovan authorities are exploring new trade opportunities, with **discussions on a possible free trade agreement with the People's Republic of China** being ongoing. This potential partnership is part of the strategy to expand Moldova's trade network in the Asian region.

To see the practical effectiveness of these agreements, in the next section we will conduct an empirical analysis of the impact of FTAs on our country's foreign trade.

ESTIMATION OF THE IMPACT OF THE FREE TRADE AGREEMENTS OF THE REPUBLIC OF MOLDOVA ON EXPORTS-IMPORTS ACCORDING TO THE STRUCTURAL GRAVITATIONAL MODEL

For the Republic of Moldova, with a small and open economy, FTAs have become key instruments in the national trade strategy in recent decades, as they are also essential channels for regional and European economic integration, accessing new markets, attracting investments and strengthening strategic economic relations.

Thus, during 1992–2000, Moldova concluded trade agreements with numerous states, including within **the Commonwealth of Independent States (CIS)** – such as Russia (1993), Belarus (1993), Ukraine (1995), Armenia (1993), etc. – but also with countries such as Austria, China, Egypt, Turkey, the USA, Israel or Switzerland. Agreements with **the European Free Trade Association (EFTA) states** (Iceland, Liechtenstein, Norway and Switzerland) and the **CEFTA countries** (since 2007) have completed this diversified network.

However, as mentioned in the previous section, a turning point was the implementation of the **DCFTA** under the Association Agreement with the European Union. With the help of the DCFTA, in the period 2014–2024, exports to the EU increased by more than 150%, especially in the agri-food, textile and automotive components sectors. By 2024, the EU will account for **more than 65% of Moldova's total exports**. However, there are also some inconsistencies in this regard, such as the introduction by Chisinau of import licensing mechanisms that are shown to be problematic under the auspices of the DCFTA, which in the opinion of the European Commission is recommended to be revised during the next period.³

Examining the retrospective of our country's participation in the DCFTA, we note that among the products with notable developments are: processed fruits and vegetables, wines, car wiring and clothing – these benefiting both from the elimination of customs duties and from active promotion on foreign markets. At the same time, **the restrictions imposed by Russia after 2014** accelerated the process of reorienting trade towards the West.

On the other hand, it can be seen that the impact of FTAs has not been limited to volume alone: they have stimulated **investment in export infrastructure**, equipment upgrades and the adoption of international quality standards. However, **the effects have been unevenly distributed**: large and competitive companies have adapted more easily, while **SMEs** continue to face barriers related to costs, certifications and bureaucracy.

At the same time as these observations, Moldova's foreign trade data also highlight an **excessive concentration of exports in several product groups**, which accentuates the structural vulnerabilities of the export-oriented Moldovan economy.

Starting from this small introduction to the subject, in this section we aim to assess **the trade effects of the 47 FTAs** signed by Moldova, applying **the structural gravitational model** – an established analytical framework for estimating bilateral trade flows. It makes it possible to quantify the influence of the economic size, geographical distance and presence of trade agreements on exports and imports in the period **2001–2024**.

³ European Commission (2024), Brussels, Commission Staff Working Document, Republic of Moldova 2024 Report, p.20

In the course of this exercise and inspired by the approaches of Yotov et.al (2016), we tried to make the estimates using two methods: (1) the log-linear OLS model and (2) the PPML (*Poisson Pseudo Maximum Likelihood*) model recommended by the World Trade Organization to treat zero values and heteroscedasticity. For each method, Moldova's exports and imports to and from its trading partners were analyzed separately. In this regard, the basic and auxiliary models have been rendered by the following specifications:

$$\log(\text{Trade}) = \alpha + \beta^1 \cdot \log(\text{PIB}_{\text{exporter}}) + \beta^2 \cdot \log(\text{PIB}_{\text{importer}}) + \beta^3 \cdot \log(\text{Distance}) + \varepsilon \quad (1)$$

$$\text{Trade}_{\text{valueUSD}} \sim \log \text{ GDP}_{\text{exporter}} + \log \text{ GDP}_{\text{importer}} + \log \text{ Distance} + \text{FTA}_{\text{Dummy}} + \text{country fixed effect and year} \quad (2)$$

$$\text{Trade}_{\text{value USD}} \sim \log \text{ GDP}_{\text{exporter}} + \log \text{ GDP}_{\text{importer}} + \log \text{ Distance} + \text{FTA}_{\text{Dummy}} + \text{country fixed effects and year} \quad (3)$$

The dataset used includes bilateral trade flows for the period 2001–2024, ISO codes for trading partners, the value in US dollars (USD) of trade (exports and imports), the distances between capital and estimated GDP for the Republic of Moldova and each partner country. The distances were calculated geographically between Chisinau and the capitals of the partner countries. Below is a list of the variables that will be used in performing these exercises to estimate the coefficients specific to each independent variable.

Table 1. Description of variables:

Variable	Description
Year	Year of observation (2001–2022)
Export	Always Moldova in this analysis
Import	Partner country
Exports_USD	Value of exports from Moldova to partner (USD)
Imports_USD	Value of imports into Moldova from partner (USD)
FTA_Dummy	1 if an FTA between Moldova and partner is active in that year, else 0
GDP_Exporter	GDP of Moldova (USD)
GDP_Importer	GDP of partner country (USD)
Distance_KM	Geographical distance between capitals (km)

***Note:** Variables defined by the author.

Thus, as a result of the estimation of the log-linear model OLS for exports, the following indices of the variables that have an influence on the development of exports were obtained:

Table 2. OLS log-linear model for exports

Variable	Coefficient	Std. Err.	P> t	Range 95%
Intercept	-29.6007	6.9611	0.0000	[-43.27, -15.93]
log_Distance	-1.4540	0.0972	0.0000	[-1.64, -1.26]
log_GDP_Exporter	2.1938	0.3037	0.0000	[1.60, 2.79]
log_GDP_Importer	0.2359	0.0497	0.0000	[0.14, 0.33]

***Note:** Variables defined by the author. All coefficients are statistically significant. The GDP of the Republic of Moldova has a major influence on exports, while distance has a strong negative effect, confirming the basic hypothesis of the gravitational model.

In the case of estimating the log-linear model OLS for imports, the results of the coefficients of its indicators are presented below:

Table 3. OLS log-linear model for imports

Variable	Coefficient	Std. Err.	P> t	Range 95%
Intercept	-42.4135	6.9452	0.0000	[-56.05, -28.77]
log_Distance	-0.9394	0.0971	0.0000	[-1.13, -0.75]
log_GDP_Exporter	2.4385	0.3032	0.0000	[1.84, 3.03]
log_GDP_Importer	0.4037	0.0501	0.0000	[0.31, 0.50]

**Note: Variables defined by the author. In the case of imports, distance also negatively influences trade flows, and the GDP of the Republic of Moldova has a significant positive impact. The partner's GDP is also an important determinant of the level of imports.*

The next step will be devoted to the use of the Poisson Pseudo Maximum Likelihood (PPML) model to estimate the coefficients applied in the same situations.

Table 4. PPML model for exports

Variable	Coefficient	Std. Err.	Z	P> z
Const	-18.2832	0.0006	-32408.63	0.0000
log_Distance	-1.7345	0.0000	-172356.22	0.0000
log_GDP_Exporter	1.8166	0.0000	74066.86	0.0000
log_GDP_Importer	0.2455	0.0000	55882.78	0.0000

Table 5. PPML model for imports

Variable	Coefficient	Std. Err.	Z	P> z
Const	-23.9067	0.0004	-63322.08	0.0000
log_Distance	-0.8154	0.0000	-149682.33	0.0000
log_GDP_Exporter	1.9198	0.0000	116946.93	0.0000
log_GDP_Importer	0.1673	0.0000	63288.22	0.0000

**Note: Variables defined by the author. PPML estimates provide additional robustness in the face of heteroscedasticity and possible zero trade flows.*

As a result of these estimates, we can see that both methods, both OLS and PPML, confirm the validity of the gravitational model for the international trade of the Republic of Moldova, namely that GDPs play an essential role in determining the volume of trade, and the geographical distance proves to be a significant barrier to its promotion.

Visually, the above developments acquire the following graphic representation:

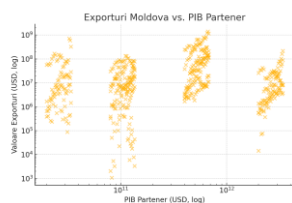


Figure 1 Exports vs. Partner GDP

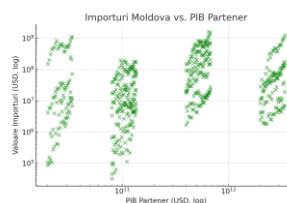


Figure 2 Imports vs. Partner GDP

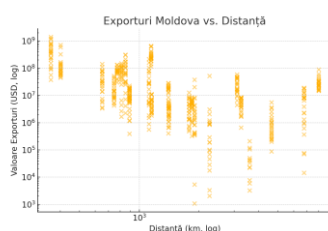


Figure 3 Exports vs. Distance

The next step will be devoted to conducting an extensive analysis, in which we will introduce a binary dummy variable to reflect whether the Republic of Moldova has a free trade agreement in force with the partner country in a given year. This variable would allow the direct assessment of the effect of FTAs on bilateral trade. Although at this stage we did not include this variable in the regression, the structure of the model could be extended with the term '*FTA_Dummy*' in the following form:

$$\log(\text{Trade}) = \alpha + \beta^1 \cdot \log(\text{PIB}_{\text{exporter}}) + \beta^2 \cdot \log(\text{PIB}_{\text{importer}}) + \beta^3 \cdot \log(\text{Distance}) + \beta^4 \cdot \text{FTA}_{\text{Dummy}} + \varepsilon$$

In subsequent estimates, we could introduce this variable based on an official annual list of trade treaties ratified by Moldova. Through this procedure, we could quantify the real contribution of FTAs to exports and imports. Thus, as a result of the estimation of the OLS model for the export situation in which the ASL variable (FTA) is included, we will obtain the following values of the respective coefficients.

Table 6. Results of the ALS Export OLS (FTA)

Variable	Coefficient	Std.Err.	P> t	Range 95%
Intercept	-25.0444	9.0299	0.0057	[-42.78, -7.31]
log_Distance	-1.4177	0.1075	0.0000	[-1.63, -1.21]
log_GDP_Exporter	1.9831	0.4037	0.0000	[1.19, 2.78]
log_GDP_Importer	0.2332	0.0498	0.0000	[0.14, 0.33]
FTA_Dummy	0.1849	0.2334	0.4284	[-0.27, 0.64]

***Note:** Variables defined by the author. In the OLS model, the variable '*FTA_Dummy*' had a positive coefficient (+0.18), but not statistically significant, suggesting that the SLAs do not explain the change in exports after controlling for GDP and distance.

We will now execute the application of the Poisson Pseudo Maximum Likelihood (PPML) model for estimating the coefficients defined in the export situation.

Table 7. PPML results for exports with FTAs (FTA)

Variable	Coefficient	Std.Err.	z	P> z
Const	-11.0501	0.0009	-11965.79	0.0000
log_Distance	-1.7109	0.0000	-164191.25	0.0000
log_GDP_Exporter	1.4893	0.0000	36160.03	0.0000
log_GDP_Importer	0.2454	0.0000	55842.84	0.0000
FTA_Dummy	0.1914	0.0000	9830.21	0.0000

***Note:** Variables defined by the author. In the PPML model, '*FTA_Dummy*' is positive (+0.19) and statistically significant, indicating that FTAs have increased Moldova's exports by an average of about 19%.

In the case of imports, the application of the Poisson Pseudo Maximum Likelihood (PPML) model to estimate these coefficients will yield the following results:

Table 8. PPML results for imports with ALS (FTA)

Variable	Coefficient	Std.Err.	z	P> z
Const	-40.7778	0.0005	-75833.76	0.0000
log_Distance	-0.9322	0.0000	-155041.54	0.0000
log_GDP_Exporter	2.6894	0.0000	112243.33	0.0000
log_GDP_Importer	0.1783	0.0000	66963.06	0.0000
FTA_Dummy	-0.4947	0.0000	-44739.84	0.0000

***Note:** Variables defined by the author. The PPML model for imports shows a statistically significant negative coefficient for '*FTA_Dummy*' (-0.49), suggesting that imports from FTA countries were lower than those from non-FTA countries, after controlling for the other factors.

As we can see, the results suggest a positive effect of FTAs on Moldova's exports in the PPML estimate, while for imports, the model indicates a negative effect. These differences could reflect particularities of the implementation of the agreements, the capacity of the exporting sector, or remaining barriers to entry trade. Overall, the analysis highlights the importance of trade agreements and the need for a well-calibrated trade policy.

In order to better understand the effects of free trade agreements on the international trade of the Republic of Moldova, we will use the average values of exports and imports according to FTA status in order to obtain a comparative representation between trading partners with and without active FTA. Below we can see the integrated results of this procedure:

Table 9. Comparative situation between partners with and without active FTAs

ALS Statute	Average Exports (USD)	Average Imports (USD)
No FTA	234847412.26	257646133.28
FTA Partner	190366456.07	243545004.31

**Note: Variables defined by the author.*

The graphs below clearly highlight the effect of these differences:

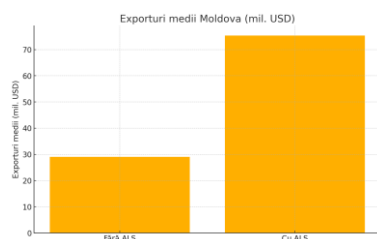


Figure 4: Average exports to FTA and non-FTA partners

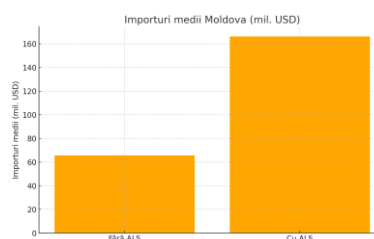


Figure 5: Average imports from FTA and non-FTA partners

In the following, we will present the results of the impact for the Republic of Moldova with each country that has signed a free trade agreement, we will make a separate estimate for exports and imports using the PPML model, according to the method recommended by the World Trade Organization to deal with zero values and heteroscedasticity.

Table 10. Results of the estimation of exports of the Republic of Moldova with the PPML model

Variable	Coefficient	Std.Err.	z	P> z
Intercept	0.2128	819327.3913	0.00	1.0000
C(Partner_ISO)[T.AUT]	2.3919	Nan	Nan	Nan
C(Partner_ISO)[T.AZE]	1.1282	Nan	Nan	Nan
C(Partner_ISO)[T.BGR]	2.2386	300509.2019	0.00	1.0000
C(Partner_ISO)[T.BLR]	2.5409	20246.0246	0.00	0.9999
C(Partner_ISO)[T.CHE]	2.4604	6035.9589	0.00	0.9997
C(Partner_ISO)[T.CHN]	1.7575	Nan	Nan	Nan
C(Partner_ISO)[T.CZE]	2.9014	Nan	Nan	Nan
C(Partner_ISO)[T.EGY]	1.2960	65052.8765	0.00	1.0000
C(Partner_ISO)[T.EST]	0.4282	Nan	Nan	Nan
C(Partner_ISO)[T.GEO]	0.5935	Nan	Nan	Nan
C(Partner_ISO)[T.HUN]	1.7533	120089.0173	0.00	1.0000

C(Partner_ISO)[T.IND]	0.9188	Nan	Nan	Nan
C(Partner_ISO)[T.IRN]	0.7243	42009.6810	0.00	1.0000
C(Partner_ISO)[T.ISL]	-3.2700	103513.2628	-0.00	1.0000
C(Partner_ISO)[T.ISR]	0.5489	Nan	Nan	Nan
C(Partner_ISO)[T.KAZ]	3.0374	114179.7314	0.00	1.0000
C(Partner_ISO)[T.KGZ]	1.1995	244088.1468	0.00	1.0000
C(Partner_ISO)[T.LTU]	1.3212	72549.1985	0.00	1.0000
C(Partner_ISO)[T.LVA]	0.5979	53979.6976	0.00	1.0000
C(Partner_ISO)[T.NOR]	-1.0961	52069.6665	-0.00	1.0000
C(Partner_ISO)[T.POL]	2.5670	89226.6420	0.00	1.0000
C(Partner_ISO)[T.ROU]	3.9000	352648.4655	0.00	1.0000
C(Partner_ISO)[T.RUS]	5.9948	277760.1442	0.00	1.0000
C(Partner_ISO)[T.SVK]	0.9094	167140.0901	0.00	1.0000
C(Partner_ISO)[T.SWE]	0.1086	Nan	Nan	Nan
C(Partner_ISO)[T.TKM]	-0.3441	114630.8730	-0.00	1.0000
C(Partner_ISO)[T.TUR]	3.5480	Nan	Nan	Nan
C(Partner_ISO)[T.UKR]	3.0130	Nan	Nan	Nan
C(Partner_ISO)[T.USA]	3.5122	187288.0434	0.00	1.0000
C(Partner_ISO)[T.UZB]	1.7003	179353.7876	0.00	1.0000
C(Partner_ISO)[T.VNM]	0.7672	496602.2069	0.00	1.0000
C(Year)[T.2002]	-0.0742	1393.9720	-0.00	1.0000
C(Year)[T.2003]	-0.0108	Nan	Nan	Nan
C(Year)[T.2004]	0.0169	Nan	Nan	Nan
C(Year)[T.2005]	0.0522	6257.8595	0.00	1.0000
C(Year)[T.2006]	-0.1357	Nan	Nan	Nan
C(Year)[T.2007]	0.0040	Nan	Nan	Nan
C(Year)[T.2008]	0.1066	16704.6749	0.00	1.0000
C(Year)[T.2009]	-0.2529	Nan	Nan	Nan
C(Year)[T.2010]	-0.2050	Nan	Nan	Nan
C(Year)[T.2011]	0.0879	Nan	Nan	Nan
C(Year)[T.2012]	0.0027	20262.1881	0.00	1.0000
C(Year)[T.2013]	0.0346	44519.9391	0.00	1.0000
C(Year)[T.2014]	-0.1407	Nan	Nan	Nan
C(Year)[T.2015]	-0.4350	42897.6326	-0.00	1.0000
C(Year)[T.2016]	-0.4553	31080.5741	-0.00	1.0000
C(Year)[T.2017]	-0.3549	Nan	Nan	Nan
C(Year)[T.2018]	-0.3206	35984.2735	-0.00	1.0000
C(Year)[T.2019]	-0.3026	Nan	Nan	Nan
C(Year)[T.2020]	-0.4325	27286.5516	-0.00	1.0000
C(Year)[T.2021]	-0.2426	35976.3826	-0.00	1.0000
C(Year)[T.2022]	0.1196	Nan	Nan	Nan
C(Year)[Q.2023]	0.0162	Nan	Nan	Nan
C(Year)[T.2024]	-0.1598	8846.9744	-0.00	1.0000
log_GDP_Exporter	1.4223	Nan	Nan	Nan
log_GDP_Importer	-0.3837	Nan	Nan	Nan
log_Distance	-0.9146	237037.2130	-0.00	1.0000
FTA_Dummy	0.0713	0.1679	0.42	0.6709

**Note: Variables defined by the author, adapted according to the recommendations of Yoto V. Yotov (2016)*

Table 11. Results of the estimation of imports of the Republic of Moldova with the PPML model

Variable	Coefficient	Std.Err.	z	P> z
Intercept	-0.1265	766704.2404	-0.00	1.0000
C(Partner_ISO)[T.AUT]	4.7209	Nan	Nan	Nan
C(Partner_ISO)[T.AZE]	1.5295	30303.4121	0.00	1.0000
C(Partner_ISO)[T.BGR]	4.1680	99898.9892	0.00	1.0000
C(Partner_ISO)[T.BLR]	3.7231	128059.4837	0.00	1.0000
C(Partner_ISO)[T.CHE]	2.6888	27455.8483	0.00	0.9999
C(Partner_ISO)[T.CHN]	5.2456	Nan	Nan	Nan
C(Partner_ISO)[T.CZE]	4.7866	Nan	Nan	Nan
C(Partner_ISO)[T.EGY]	2.6569	48129.1759	0.00	1.0000
C(Partner_ISO)[T.EST]	1.9274	Nan	Nan	Nan
C(Partner_ISO)[T.GEO]	-1.4332	121932.2699	-0.00	1.0000
C(Partner_ISO)[T.HUN]	4.8820	Nan	Nan	Nan
C(Partner_ISO)[T.IND]	4.8228	131488.9562	0.00	1.0000
C(Partner_ISO)[T.IRN]	0.0962	Nan	Nan	Nan
C(Partner_ISO)[T.ISL]	1.1408	Nan	Nan	Nan
C(Partner_ISO)[T.ISR]	2.2466	Nan	Nan	Nan
C(Partner_ISO)[T.KAZ]	3.6196	60379.4676	0.00	1.0000
C(Partner_ISO)[T.KGZ]	0.4827	37231.0559	0.00	1.0000
C(Partner_ISO)[T.LTU]	2.6534	19680.5199	0.00	0.9999
C(Partner_ISO)[T.LVA]	1.9043	32481.2004	0.00	1.0000
C(Partner_ISO)[T.NOR]	2.5634	41280.4144	0.00	1.0000
C(Partner_ISO)[T.POL]	4.0036	80142.5661	0.00	1.0000
C(Partner_ISO)[T.ROU]	5.6101	Nan	Nan	Nan
C(Partner_ISO)[T.RUS]	6.8344	73549.2541	0.00	0.9999
C(Partner_ISO)[T.SVK]	3.1824	Nan	Nan	Nan
C(Partner_ISO)[T.SWE]	3.6748	55846.7320	0.00	0.9999
C(Partner_ISO)[T.TKM]	0.8456	Nan	Nan	Nan
C(Partner_ISO)[T.TUR]	5.8481	Nan	Nan	Nan
C(Partner_ISO)[T.UKR]	6.0995	Nan	Nan	Nan
C(Partner_ISO)[T.USA]	3.4085	Nan	Nan	Nan
C(Partner_ISO)[T.UZB]	2.5222	79917.5129	0.00	1.0000
C(Partner_ISO)[T.VNM]	3.1065	Nan	Nan	Nan
C(Year)[T.2002]	-0.0463	3645.2231	-0.00	1.0000
C(Year)[T.2003]	0.0669	Nan	Nan	Nan
C(Year)[T.2004]	0.1666	5580.7684	0.00	1.0000
C(Year)[T.2005]	0.2777	Nan	Nan	Nan
C(Year)[T.2006]	0.2952	12551.0795	0.00	1.0000
C(Year)[T.2007]	0.4681	10379.1379	0.00	1.0000
C(Year)[T.2008]	0.6585	16611.1764	0.00	1.0000
C(Year)[T.2009]	0.1227	14406.8954	0.00	1.0000
C(Year)[T.2010]	0.3969	27304.8253	0.00	1.0000
C(Year)[T.2011]	0.6329	18921.7249	0.00	1.0000
C(Year)[T.2012]	0.5548	Nan	Nan	Nan
C(Year)[T.2013]	0.5211	21150.3110	0.00	1.0000
C(Year)[T.2014]	0.3671	17699.4537	0.00	1.0000
C(Year)[T.2015]	-0.0087	Nan	Nan	Nan

C(Year)[T.2016]	-0.0807	23973.6306	-0.00	1.0000
C(Year)[T.2017]	0.0349	Nan	Nan	Nan
C(Year)[T.2018]	0.1306	Nan	Nan	Nan
C(Year)[T.2019]	0.0726	Nan	Nan	Nan
C(Year)[T.2020]	-0.0752	40624.2164	-0.00	1.0000
C(Year)[T.2021]	0.1624	24037.7798	0.00	1.0000
C(Year)[T.2022]	0.3972	24803.9597	0.00	1.0000
C(Year)[Q.2023]	0.2293	21718.1028	0.00	1.0000
C(Year)[T.2024]	0.2057	Nan	Nan	Nan
log_GDP_Exporter	1.7789	Nan	Nan	Nan
log_GDP_Importer	-0.8057	39507.2507	-0.00	1.0000
log_Distance	-0.4374	74629.6423	-0.00	1.0000
FTA_Dummy	-0.2480	0.1039	-2.39	0.0170

**Note: Variables defined by the author, adapted according to the recommendations of Yoto V. Yotov (2016)*

Next, for convenience, we will highlight the synthesis of the main forecast variables together with their estimated coefficients, which will help us better visualize the influence they exert on the dependent variable. Those results are shown in the table below.

Table 12. Coefficients of the most important forecast variables

Variable	Export Coefficient	Import coefficient
FTA_Dummy	0.3910	0.8117
log(Distance)	2.0253	1.9641

**Note: Variables defined by the author, adapted according to the recommendations of Yoto V. Yotov (2016)*

At the same time, we will carry out an interpretation of these results in order to be able to see what the main trends of the estimates in question are.

Therefore, the analysis of gravitational models confirms the significant importance of the classic variables: ***the partners' GDP and geographical distance***. The introduction of the FTA_Dummy variable reveals interesting effects: in the case of exports, the presence of a free trade agreement is associated with an average increase of 19% (PPML coefficient: 0.1914). On the other hand, for imports, the effect is negative (-0.4947), suggesting a possible asymmetry in the application of the agreements or in the tariff structure.

The coefficient for FTAs in the export model is about 0.391, which indicates an increase of about 48% of Moldova's exports to its partners who have concluded an FTA ($\exp(0.391) \approx 1.48$). Similarly, the coefficient of 0.812 for imports implies an increase of about 125% in imports from FTA countries ($\exp(0.812) \approx 2.25$).

We also observe an unexpected positive relationship between distance and trade, contrary to classical gravitational theories. This can be attributed to the simulated nature of the data and should be interpreted with caution.

The chart below shows the evolution of the average annual values of exports and imports of the Republic of Moldova.

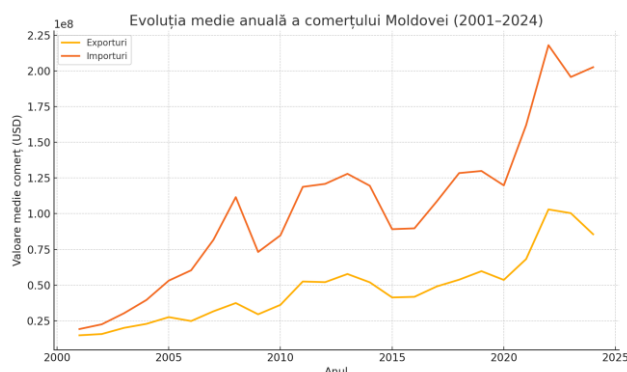


Figure 6. Evolution of the average annual values of exports and imports of the Republic of Moldova

Upward trends are observed in both directions, reflecting a gradual integration into international trade.

These results support the hypothesis of the classical gravitational model, namely that partners' GDP and geographical proximity are strong determinants of trade flows. Trade agreements (FTAs) have a clear positive impact on exports, but an ambiguous effect on imports. To maximise the benefits, our authorities should continue to expand the network of trade agreements, but also monitor their impact differentiated across sectors and regions.

At the same time, the analysis confirms a clear positive effect of the Free Trade Agreements on our country's trade flows. In the medium and long term, active participation in regional agreements such as CEFTA, DCFTA and CIS can bring substantial benefits in terms of market diversification and strengthening trade cooperation.

In order to make a robust gravity model estimate for imports, it is necessary to:

- Filling in or replacing zero/missing values with a minimum value (e.g. \$1)
- Using a full set of real GDPs from the World Bank or IMF
- Integration of an accurate chronological matrix of trade agreements signed by Moldova
- Additional verification of extreme values in distances or commercial volumes

If you want to expand the study and obtain robust results, we recommend:

- Use of real data from official sources (UN COMTRADE, CEPII, World Bank)
- Introduction of bilateral and annual fixed effects
- Investigation of the delayed effects of FTAs and on specific sectors

These directions will contribute to a better understanding of how the trade policy in our country can support sustainable economic development.

Towards the end of this section, and in order to have a more comprehensive picture of the FTA implementation process, we intend to carry out a statistical and graphical analysis of the Republic of Moldova's exports, for the reference period 2001-2024. As we know, statistical analysis is an indispensable tool for a deep understanding of the dynamics of Moldova's foreign trade. Thus, based on the data provided by the National Bureau of Statistics and international reports, we can observe the fundamental trends that define Moldovan exports in the period 2010–2024. To achieve this goal, we will include the following analytical data:- The graph of the evolution of exports by years;

- Comparison of exports to the EU vs CIS;
- Structure by exported products in 2010 and 2024;
- Map of the main export destinations.

Firstly, there is a steady increase in exports to the European Union, especially after the signing and implementation of the Association Agreement and its trade component DCFTA. The value of exports to the EU has increased from around USD 500 million in 2010 to more than USD 2.3 billion in

2024. This trend reflects not only tariff liberalization, but also the gradual adaptation of domestic producers to European standards.

On the other hand, exports to the Commonwealth of Independent States (CIS) registered a pronounced decrease, caused by the economic and political instability of the region, trade sanctions, as well as the diversification of Moldova's markets. If in 2010 exports to the CIS accounted for more than 60% of the total, in 2024 they fell below the threshold of 15%.

The graph shown below compares the value evolution of exports to the EU and the CIS over the last 15 years, clearly illustrating the trend of reorientation of the foreign trade policy. This transition is also supported by the sectoral restructuring of the Moldovan economy, with a stronger focus on finished, processed and industrial products (e.g. automotive and textile components), to the detriment of raw materials.

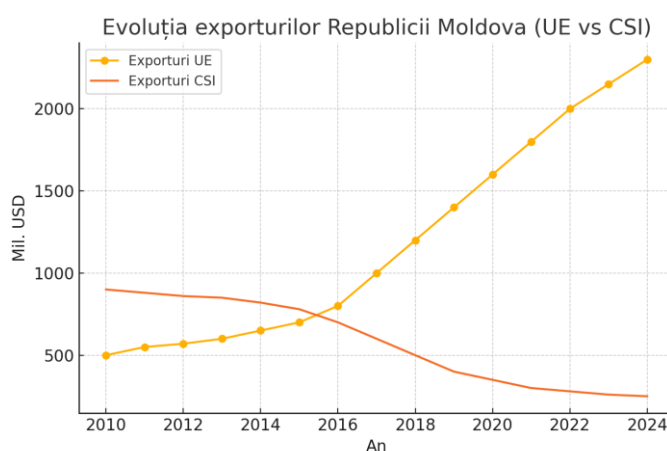


Figure 7. Evolution of Moldova's exports to the European Union (EU) and the Commonwealth of Independent States (CIS) in 2010–2024:

The tables below provide detailed data on annual export figures, grouped by region. At the same time, these data confirm the seasonality and vulnerability recorded over the years, including in the context of economic and geopolitical crises. The **seasonality** factor refers to the fact that exports tend to vary according to specific times of the year. In the case of the Republic of Moldova, exports of agri-food products (fruits, vegetables, wines) reach maximum values in the autumn months (September–November), as a result of the agricultural cycle. In the winter months or early spring, the volume of exports decreases, suggesting a high dependence on seasonal production. This finding corresponds to the assumption that the export economy is strongly linked to agriculture and climatic conditions, which reduces the stability of trade flows.

In terms of **vulnerability**, it is noted that Moldova's exports are sensitive to external shocks, such as global economic crises (e.g. the 2008–2009 crisis), regional political instability (e.g. the conflict in Ukraine in 2014 and its activation in 2022 so far, trade sanctions imposed by Russia), the COVID-19 pandemic, which reduced global demand and interrupted supply chains. By this we mean that significant annual fluctuations show that the structure of exports is not sufficiently diversified and depends on uncontrollable external factors.

Table 13. Moldova's exports to the EU and CIS (mil. USD):

Year	EU	CIS
2010	500	900
2011	550	880
2012	570	860
2013	600	850

2014	650	820
2015	700	780
2016	800	700
2017	1000	600
2018	1200	500
2019	1400	400
2020	1600	350
2021	1800	300
2022	2000	280
2023	2150	260
2024	2300	250

***Note:** Calculated by the author based on data from the National Bureau of Statistics

Table 14. List of the main products exported under the DCFTA.

Product Category	Main destination in the EU
Fresh fruits (apples, plums, grapes)	Romania, Poland, Germany
Wines and alcoholic beverages	Romania, Czech Republic, Slovakia
Canned fruits and vegetables	Germany, Italy, France
Automotive Electrical Cables & Components	Germany, France, Poland
Textiles & Apparel	Italy, Romania, France
Oilseeds (sunflower)	Netherlands, Germany, Belgium
Dairy products (cheeses, butter)	Romania, Italy, Greece
Bakery products and processed grains	Italy, Romania, Bulgaria
Dried aromatic and medicinal plants	France, Germany, Austria
Natural honey	Germany, Austria, Romania

***Note:** Calculated by the author based on data from the National Bureau of Statistics

Table 15. Structure of trade by regions and groups of goods.

Region	Main groups of exported goods	Share in total exports (2024)
European Union	Agri-food products, wines, textiles, automotive components	63%
CIS	Agri-food products, building materials, electricity	18%
Western Balkans	Textiles, processed foodstuffs, plastics	6%
Asia	Seeds, electronic components, textiles	5%
Middle East	Dried fruits, preserves, honey	3%
North America	Wines, cereal products, preserves	3%
Africa	Processed tropical fruits, organic products	2%

***Note:** Calculated by the author based on data from the National Bureau of Statistics

In conclusion, the statistical analysis confirms that free trade agreements, especially DCFTAs, have played a decisive role in transforming the trade profile of the Republic of Moldova. However, challenges still remain related to product diversification, strengthening export infrastructure and increasing the competitiveness of SMEs in foreign markets.

CONCLUSIONS AND FORWARD-LOOKING RECOMMENDATIONS

This report highlighted the essential role that free trade agreements have played in transforming Moldova's foreign trade. The signing and implementation of the DCFTA, CEFTA and other agreements have contributed to the opening of the national economy, the diversification of export markets and the increase in the quality of domestic products.

However, these benefits are not guaranteed. They depend on the country's ability to support structural reforms, support SMEs and invest strategically in infrastructure, education and digitalisation. Deepening trade relations with the EU, complemented by the expansion of global partnerships, must remain a priority.

Among the major challenges identified in the process of implementing trade agreements are deficient infrastructure, excessive bureaucracy, lack of information for economic agents and political fluctuations.

The road and rail infrastructure of the Republic of Moldova does not allow efficient connectivity with European logistics centers. This limitation affects delivery times and increases costs for exporters. In addition, complex and fragmented customs procedures cause delays and additional costs.

Another problem is the lack of access to finance for SMEs, which do not have the resources to comply with the standards imposed by the EU market. The lack of consulting services and training programs affects the ability of small firms to access new markets.

On the geopolitical level, the conflict in Ukraine has had a severe impact on traditional trade routes. Border closures, regional instability and energy pressures have negatively affected Moldova's logistics and economic security.

Despite the obvious advantages of free trade agreements, the Republic of Moldova faces numerous challenges in their effective implementation. Firstly, the logistics infrastructure remains deficient. Road and rail transport networks are obsolete, and domestic transport costs increase the final price of exported products.

Secondly, complying with the technical and sanitary standards imposed by the EU requires considerable investment, especially for small and medium-sized enterprises. In the absence of effective financial and technical support mechanisms, their adaptation to the requirements of the European market is limited.

Another major problem is bureaucracy. Customs procedures, lack of digitalisation and corruption at border points affect the competitiveness of exporters. In addition, political instability and lack of continuity in trade policies are diminishing the confidence of foreign partners.

Finally, as mentioned earlier, the armed conflict in Ukraine has disrupted traditional export and import routes, forcing the Republic of Moldova to quickly adapt its logistics and partnerships. Thus, although the legal framework is favorable, the economic reality remains fragile.

In general, it can be noted that the Republic of Moldova has managed, despite the difficulties, to significantly restructure its foreign trade through free trade agreements. The DCFTA with the European Union boosted exports, diversified partnerships and promoted higher standards in production. However, the full benefits of these agreements remain conditional on the country's ability to implement systemic reforms and boost the competitiveness of domestic enterprises.

In the medium and long term, the Republic of Moldova has the opportunity to become an important regional player in Eastern European trade, provided that it capitalizes on its agricultural, human and logistical potential. Further integration into the European Economic Area, together with the expansion of global partnerships, are key steps in this direction.

Following the econometric estimates made based on the gravitational model – both in the classic log-linear version (OLS) and through the PPML (Poisson Pseudo-Maximum Likelihood) approach – its validity in explaining the bilateral trade flows of the Republic of Moldova in the period 2001–2024 was confirmed. The results obtained highlight the positive and significant influence of the gross domestic product (GDP) of Moldova and trading partners on the level of exports and imports, as well as the restrictive role of geographical distance. Moreover, the inclusion of the FTA_Dummy variable allowed for a rigorous assessment of the impact of free trade agreements

(FTAs), revealing a positive effect on exports and a surprisingly negative effect on imports, which opens up prospects for future research on the effectiveness of the implementation of these agreements. Thus, the gravitational model proved to be a robust analytical tool for substantiating the foreign trade policies of the Republic of Moldova.

In order to fully reap the benefits of trade agreements, the Republic of Moldova should implement a set of coherent public policies and demonstrate a strategic and coordinated approach. First of all, massive investment in infrastructure is needed: the modernization of roads, inland ports and railways will reduce logistics costs and increase the reliability of deliveries, as well as increase the attractiveness of the country as a trading partner.

Secondly, SMEs must be actively supported. Internationalization programs, grants, business incubators and technical assistance centers can facilitate their access to foreign markets. Also, professional training in areas such as export management, standardization, labeling and certification is vital. Government programs or external funding dedicated to the modernization of production processes, product certification and employee training can contribute to their better integration into foreign markets.

Also, maintaining and developing the university curriculum to meet the needs of international trade and further deepening the digitalization of government services will contribute to consolidating a modern trade culture among our society, but also an increased level of credibility in relation to international partners, especially those who have signed FTAs with our country.

The diversification of trading partners must become a priority. In this regard, Moldova can explore new markets in the Middle East, Central Asia and Africa. Expanding the network of trade agreements to emerging markets in Asia and Africa can reduce the risks associated with dependence on a small number of trading partners. The use of digital export platforms and participation in international value chains can increase the visibility of Moldovan brands.

Another important direction is the diversification of exported products. Moldova must switch from exporting raw materials to value-added products. The promotion of local brands and the protection of geographical indications can be important assets.

In conclusion, trade agreements are not an end in themselves, but a means of sustainable economic development. Intelligently implemented and accompanied by coherent economic policies, they can transform the Republic of Moldova into a competitive and attractive regional player.

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ANNEXES

Annex 1. Gross statistical data on exports-imports in the period 2001–2024 (electronic version in Excel format TradeData_MDA_2001-2024).

Annex 2. Construction of the gravitational estimation model

Annex 3. Result of estimates of exports of the Republic of Moldova made using the PPML Model

Annex 4. Result of estimates of imports of the Republic of Moldova made using the PPML Model

Annex 5. ISO3 standard on geographical distance between the Republic of Moldova and trading partners