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Analysis of international trade patterns of wood-based panels in 15 eastern European and central Asian countries

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A B S T R A C T

Wood-based panels are increasingly important in construction, furniture, interior design, and packaging, yet the drivers of Wood-Based Panel (WBP) trade in Eastern Europe and Central Asia remain insufficiently quantified at the country-panel level. This study provides a focused regional assessment of the determinants of WBP export and import values for 15 Eastern European and Central Asian countries from 2005 to 2020. Pooled ordinary least squares, fixed-effects, and random-effects panel regressions were estimated using GDP per capita, forest coverage, exchange rate, trade policy, and population as explanatory variables. Model selection was guided by Hausman specification tests and overall F-tests. For exports, pooled OLS explains 63.06% of the variation in log export value, while the random-effects model explains 55.97%. GDP per capita and forest coverage are consistently positive and statistically significant export determinants, while the exchange rate has a significant negative coefficient in the pooled and fixed-effects models. For imports, GDP per capita is the most robust determinant, with a positive and highly significant coefficient in all specifications, whereas forest coverage, exchange rate, and population are generally insignificant. Hausman tests favor fixed-effects estimation for both export and import models, confirming that country-specific unobserved heterogeneity is correlated with the regressors. The study contributes by separating export- and import-side determinants for a strategically important but under-studied regional WBP market. The findings suggest that export policies should combine sustainable forest management, stable macroeconomic conditions, and improved processing capacity, whereas import-related policies should focus on domestic demand management, industrial upgrading, and efficient trade facilitation.

Keywords: central Asia, eastern Europe, fixed effects, international trade, panel data, wood-based panels

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1. Introduction

Wood-based panels (WBPs), including plywood, particleboard, medium-density fiberboard (MDF), high-density fiberboard (HDF), and oriented strand board (OSB), are essential inputs for construction, furniture manufacturing, packaging, flooring, and interior applications. Their importance is linked to affordability, structural versatility, and the possibility of using wood residues, recycled fibers, and lower-grade logs in higher-value products (Dukarska, 2023; Gonçalves et al., 2025). Because these products depend simultaneously on forest-resource endowment, processing capacity, market demand, and trade regulation, WBP trade provides a useful empirical setting for examining how natural resources and macroeconomic conditions interact in regional markets.

The global WBP sector has expanded alongside rising demand for engineered wood products, low-carbon building materials, and improved utilization of forest biomass. Countries with abundant forest resources and developed processing industries, such as Russia and several European economies, have increased production and export capacity, whereas economies with growing construction and furniture markets often rely on imports to satisfy domestic demand (Sujová et al., 2016; Zhang et al., 2022; Ivanov et al., 2023). Eastern Europe and Central Asia are therefore particularly relevant because the region contains both forest-rich exporters and smaller economies with different levels of industrial capacity, infrastructure, exchange-rate exposure, and policy openness.

Previous studies have examined forest-products trade, wood-market competitiveness, exchange-rate behavior, and environmental regulations in trade (Buongiorno, 2016; Morland et al., 2018; Saraswati et al., 2023; Sauvage, 2014; Wang et al., 2017). A subset of this literature uses cross-country panel data to model forest-product trade and demand relationships, including comparative-advantage and forest-endowment frameworks (Uusivuori, 2002) and estimates of the income and price elasticities of import demand (Simangunsong & Buongiorno, 2001; Turner & Buongiorno, 2004). However, much of this literature either analyzes aggregate forest-product categories, focuses on large global markets, or relies on gravity-type trade frameworks that do not fully isolate country-specific unobserved characteristics. Existing findings also differ: some studies emphasize income and market size, others stress forest-resource supply, and others identify exchange-rate and policy conditions as key determinants. This variation shows the need for a more focused empirical analysis of WBPs in Eastern Europe and Central Asia.

This study addresses three specific gaps. First, it focuses directly on wood-based panels rather than broad forest-product aggregates. Second, it examines 15 Eastern European and Central Asian countries that share historical trade linkages but differ substantially in forest coverage, industrial structure, exchange-rate conditions, and market size. Third, it compares pooled OLS, fixed-effects, and random-effects models to account for unobserved country characteristics such as logistics systems, institutional quality, industrial history, production technology, and historical trade relationships. By doing so, the study provides a more consistent assessment of how macroeconomic, resource, demographic, and policy factors shape WBP export and import performance.

To address these gaps, this study investigates the determinants of wood-based panel (WBP) trade in 15 Eastern European and Central Asian countries using panel data and comparing pooled ordinary least squares (OLS), fixed-effects, and random-effects models to account for unobserved country-specific characteristics. The analysis focuses on the effects of GDP per capita, exchange rate, trade policy, forest coverage, and population on WBP exports and imports. These variables were selected based on international trade theory and forest-sector literature, where GDP per capita reflects

purchasing power, industrial capacity, and investment potential; forest coverage represents raw-material availability and production potential; exchange rate captures changes in international price competitiveness and import costs; trade policy reflects market access through tariffs, non-tariff measures, customs procedures, and trade facilitation; and population represents domestic demand and labor-market scale. Specifically, the study investigates the effects of GDP per capita and exchange rate on WBP export and import performance, examines how trade policy is associated with WBP trade flows, and evaluates the influence of forest coverage and population on export capacity and import demand. Accordingly, the study addresses three research questions: (i) how do GDP per capita and exchange rate influence WBP exports and imports, (ii) how is trade policy associated with WBP trade flows, and (iii) how do forest coverage and population affect export capacity and import demand? It is hypothesized that GDP per capita positively influences both exports and imports, forest coverage has a stronger positive effect on exports than imports, exchange-rate movements significantly affect export competitiveness, and trade policy has a measurable but context-dependent association with WBP trade. By focusing specifically on WBPs rather than aggregated forest products and by estimating separate export and import models, this study provides a more comprehensive understanding of the macroeconomic, resource, demographic, and policy factors shaping regional WBP trade.

The conceptual framework of this study is grounded in international trade theory and forest-sector economics, which emphasize that macroeconomic conditions, resource availability, and policy environment jointly determine trade flows. In this framework, GDP per capita and exchange rate represent demand capacity and international price competitiveness, respectively, influencing both exports and imports. Forest coverage is expected to mainly support export capacity through raw-material availability, while population reflects domestic demand that may increase import dependence. Trade policy influences trade flows by shaping market access through tariffs, non-tariff measures, and trade facilitation. These relationships form the basis for the empirical export and import models estimated in this study.

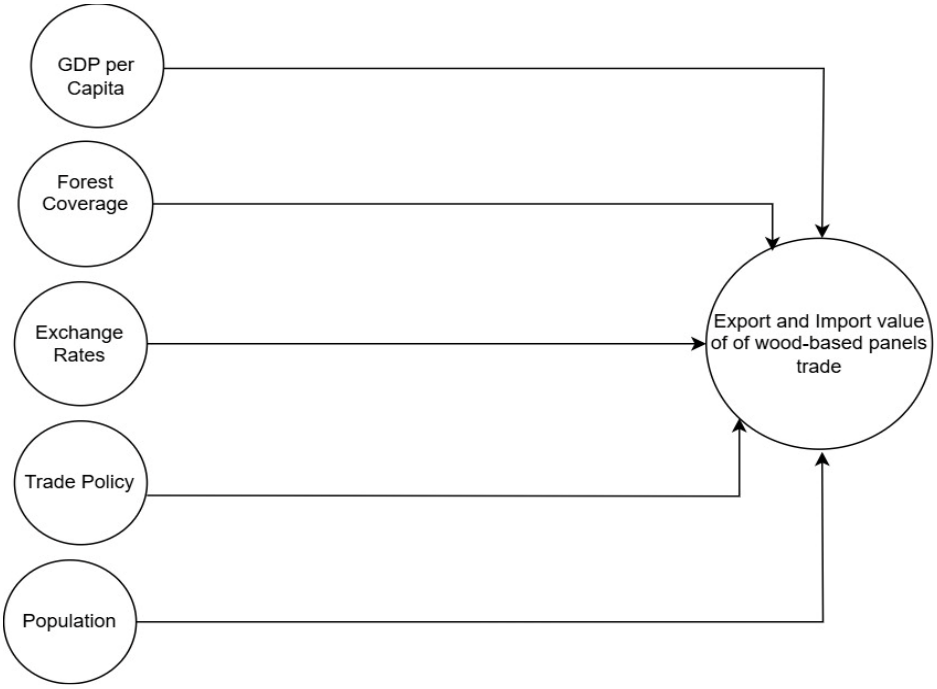


Figure 1. Conceptual framework of the study.

2. Materials and Methods

2.1 Study area and data sources

The analysis covers 15 countries in Eastern Europe and Central Asia: Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, the Republic of Moldova, the Russian Federation, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan. These countries were selected because they form a geographically connected regional market with shared post-socialist trade legacies, strong differences in forest-resource endowment, and varying degrees of industrial development and trade openness. The study period, 2005-2020, was selected according to consistent data availability for WBP trade and macroeconomic indicators across the sample. The endpoint also avoids severe incompleteness in the most recent years and reduces the influence of post-2020 disruptions on the baseline model. Trade and forest variables were compiled mainly from FAO/FAOSTAT, while macroeconomic indicators were obtained from the World Bank, IMF, WTO, and UNCTAD databases.

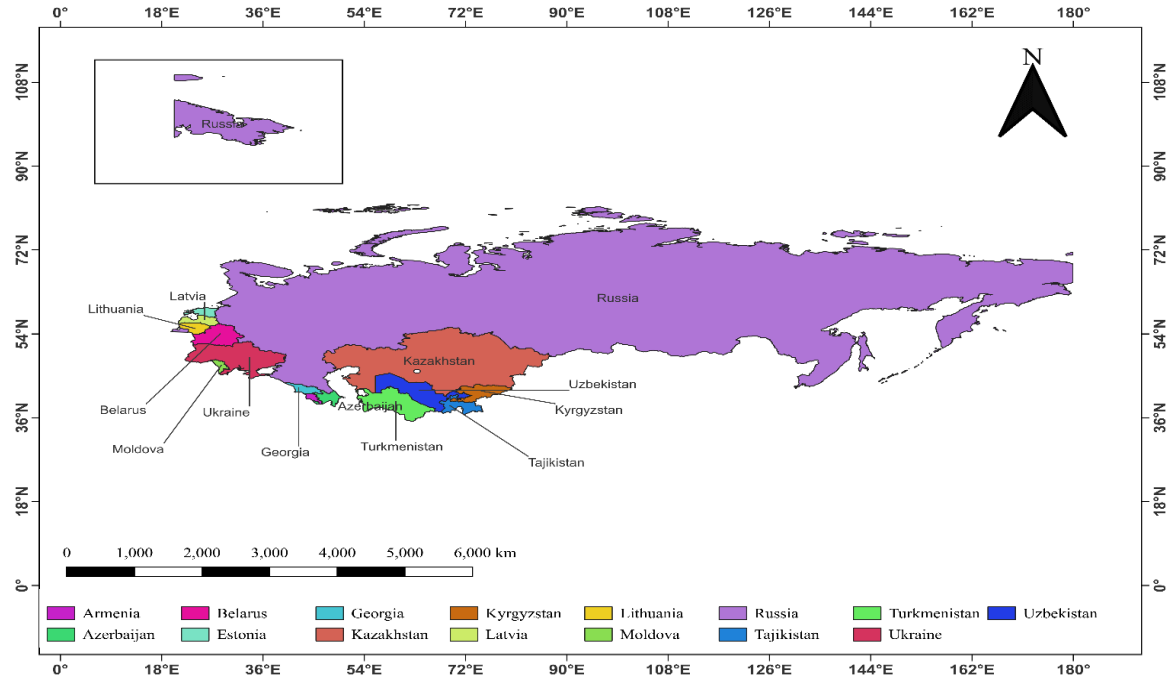


Figure 2. Geographical location of the study countries.

Table 1. Forest and woodland area by country

Country	Forest area (1000 ha)	Forest land (%)
Armenia	328.26	11.53
Azerbaijan	1143.30	13.83
Belarus	8782.10	43.27
Estonia	2438.40	57.04
Georgia	2822.00	40.62
Kazakhstan	3483.92	1.29
Kyrgyzstan	1333.62	6.95
Latvia	3414.66	54.87

Lithuania	2202.67	35.18
Republic of Moldova	386.50	11.72
Russian Federation	815311.60	49.78
Tajikistan	424.80	3.06
Turkmenistan	4127.00	8.78
Ukraine	9696.00	16.73
Uzbekistan	3715.50	8.43

Source: Compiled by the authors from FAOSTAT.

2.2 Variable definitions

The study uses two dependent variables: export value of wood-based panels (EVWBP) and import value of wood-based panels (IVWBP). All variables are transformed into natural logarithms to reduce skewness and allow elasticity-based interpretation of coefficients. Independent variables include GDP per capita (GDP), forest coverage (FC), exchange rate (EXR), trade policy (TP), and population (P). The trade-policy variable is treated as a proxy for the openness or restrictiveness of the policy environment affecting market access, tariff and non-tariff barriers, customs procedures, and trade regulation. Because trade policy is multidimensional, the results for this variable are interpreted cautiously and as associations rather than as the isolated effect of a single policy instrument.

Table 2 Variable definitions and data sources

Variable	Abbreviation	Description	Data source
Export value of wood-based panels	EVWBP	Dependent variable	FAO/FAOSTAT
Import value of wood-based panels	IVWBP	Dependent variable	FAO/FAOSTAT
Gross domestic product per capita	GDP	Economic capacity and income level	World Bank/OECD National Accounts
Forest coverage	FC	Forest-resource availability	FAO/FAOSTAT
Exchange rate	EXR	Currency competitiveness and import-cost channel	World Bank/IMF
Trade policy	TP	Trade openness/restriction and regulatory environment	WTO/UNCTAD
Population	P	Domestic demand and labor-market scale	World Bank

All variables were converted into logarithmic form for regression analysis.

2.3 Econometric model

The empirical analysis estimates separate export and import equations because the determinants of selling panels abroad may differ from those of purchasing panels from foreign suppliers. Export performance is expected to depend more strongly on resource endowment, processing capacity, and price competitiveness, whereas import demand is expected to depend mainly on income, domestic demand, and policy openness. The general panel specification is written as:

$$lnY_it = \alpha_i + \beta 1 lnP_it + \beta 2 lnGDP_it + \beta 3 lnFC_it + \beta 4 lnEXR_it + \beta 5 lnTP_it + \varepsilon_it$$

where Y represents either EVWBP or IVWBP for country i in year t, α_i captures country-specific effects, β denotes the estimated coefficients, and ε_it is the idiosyncratic error term. Pooled OLS assumes common intercepts and homogeneous cross-sectional units. The fixed-effects model allows the intercept to vary by country and therefore controls for time-invariant unobserved heterogeneity, whereas the random-effects model treats country-specific heterogeneity as random and assumes that it is uncorrelated with the regressors (Baltagi, 2005). The Hausman test is therefore central for selecting between fixed and random effects (Hausman, 1978).

2.4 Model selection and estimation strategy

The analysis proceeds in five steps. First, descriptive statistics are reported to summarize the distribution of the variables. Second, pooled OLS is estimated as a baseline specification. Third, fixed-effects and random-effects models are estimated to account for panel structure. Fourth, Hausman specification tests are used to determine whether fixed effects or random effects are more appropriate. Fifth, diagnostic and robustness checks are considered, including multicollinearity assessment through variance inflation factors, tests for heteroskedasticity and serial correlation, and comparison of coefficient signs across pooled, fixed-effects, and random-effects specifications. If diagnostic tests indicate heteroskedasticity or serial correlation, robust or cluster-robust standard errors should be reported.

2.5 Diagnostic checks and robustness considerations

To strengthen the methodological reliability of the analysis, the diagnostic and robustness assessment was revised using the available Stata outputs reported in the thesis appendices and empirical results. The checks focus on model adequacy, coefficient stability, and model-selection diagnostics across pooled OLS, fixed-effects, and random-effects specifications. The available thesis results report the core panel diagnostics needed for specification choice, including F/Wald significance tests, R-squared values, Hausman tests, observation numbers, and the consistency of coefficient signs and significance across model specifications.

Table 3 Diagnostic and robustness checks considered in the panel regression analysis

Diagnostic / robustness check	Reported thesis-based results	Interpretation
Pooled OLS overall fit	Export: N = 212; F(5,206) = 70.33; Prob > F = 0.0000; R-squared = 0.6306; adjusted R-squared = 0.6216. Import: N = 230; F(5,224) = 29.22; Prob > F = 0.0000; R-squared = 0.3948; adjusted R-squared = 0.3813.	Both baseline models are statistically significant, but the import model has lower explanatory power than the export model.
Fixed-effects within fit	Export: N = 212; countries = 15; within R-squared = 0.2398. Import: N = 238; countries = 15; within R-squared = 0.2570.	The within R-squared values show moderate within-country explanatory power, suggesting that additional time-varying factors may also influence trade.
Random-effects overall fit	Export: N = 212; Wald chi2(5) = 62.24; Prob > chi2 = 0.0000; overall R-squared = 0.5597; rho = 0.7221. Import: N = 230; Wald chi2(5) =	The random-effects models are jointly significant, but the rho values indicate important country-level heterogeneity.

	54.92; Prob > chi2 = 0.0000; overall R-squared = 0.3790; rho = 0.4212.	
Hausman specification test	Export: chi-square = 63.05; p-value = 0.0000. Import: chi-square = 11.58; p-value = 0.0410.	The null hypothesis of random-effects consistency is rejected for both models; fixed effects are preferred.
Coefficient-stability check	Export: GDP and forest coverage are positive in the main specifications; exchange rate is negative in pooled OLS and fixed effects; trade policy changes sign across specifications. Import: GDP remains positive and highly significant across pooled OLS, fixed-effects, and random-effects models.	The substantive conclusions are robust for GDP-driven imports and resource/economic export determinants, while trade-policy effects should be interpreted cautiously.

Overall, the diagnostic evidence supports the use of fixed-effects estimation as the preferred specification. The Hausman tests reject the random-effects assumption for both export and import equations, while the significant F/Wald statistics confirm that the explanatory variables jointly improve model fit. The robustness comparison also shows that GDP is the most stable determinant of imports, whereas GDP and forest coverage are the most consistent export-side determinants. Because the thesis output does not report separate VIF, Wooldridge serial-correlation, or modified Wald heteroskedasticity statistics, the robustness discussion is based on the reported model-comparison diagnostics and coefficient stability across specifications.

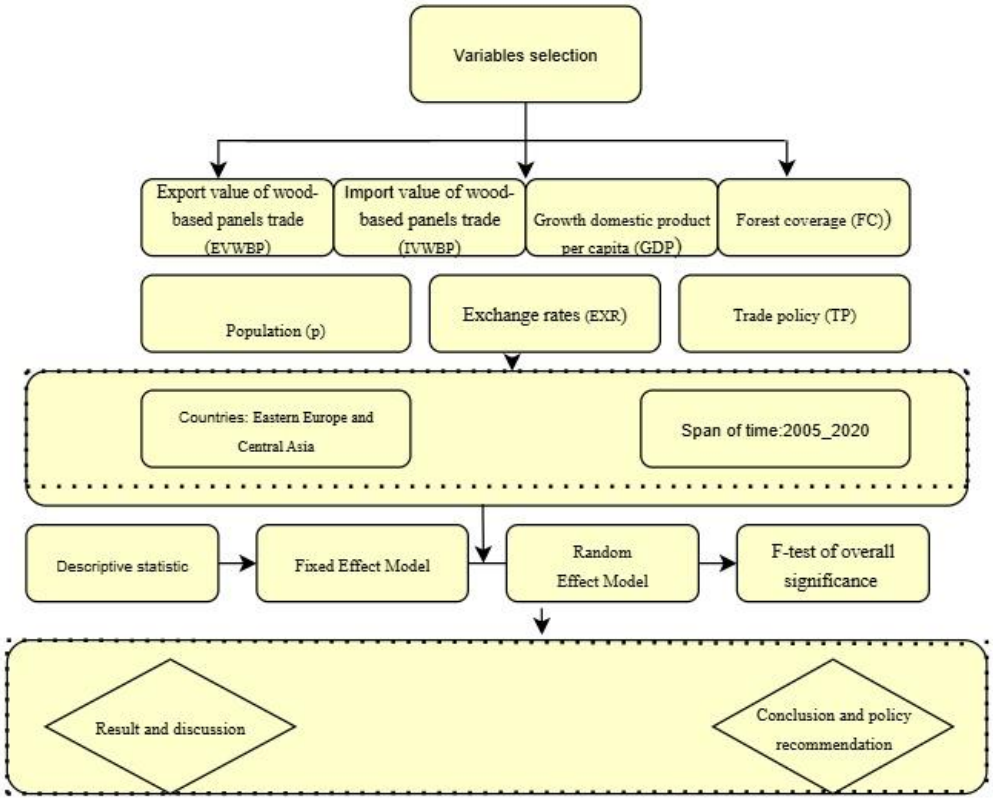


Figure 3. Analytical roadmap of the study.

3. Empirical results

3.1 Descriptive statistics

Table 4. Summary of descriptive statistics

Variable	Obs.	Mean	Std. dev.	Min.	Max.
log_EVWBP	216	15.4365	3.8238	6.9078	21.4495
log_IVWBP	234	17.9147	1.6620	9.9988	20.5543
log_P	240	15.8111	1.4007	7.9643	18.7974
log_GDP	240	24.2814	1.3976	22.1671	28.0105
log_FC	240	2.7026	1.1026	0.1310	4.0438
log_EXR	240	2.7910	2.6844	-1.2112	9.3445
log_TP	236	1.2301	1.2249	-1.2040	2.8034

Source: Computed by the authors using Stata. EVWBP = export value; IVWBP = import value.

The descriptive statistics show that export values vary more widely than import values. The standard deviation of log_EVWBP is 3.8238, compared with 1.6620 for log_IVWBP, indicating stronger cross-country and temporal heterogeneity in exports. This pattern is consistent with the uneven distribution of forest resources and processing capacity across the sample. GDP, forest coverage, exchange rate, and trade-policy variables also show notable variation, supporting the use of panel techniques that account for country-specific differences rather than relying only on pooled cross-sectional variation.

3.2 Pooled OLS results

Table 5 Pooled OLS export regression results (dependent variable: log_EVWBP)

Variable	Coefficient	Std. err.	t	p-value	95% confidence interval
log_P	-0.1981	0.1712	-1.16	0.249	-0.5355 to 0.1394
log_GDP	1.6223***	0.1788	9.07	0.000	1.2697 to 1.9748
log_FC	1.4794***	0.1787	8.28	0.000	1.1271 to 1.8317
log_EXR	-0.2403**	0.0755	-3.18	0.002	-0.3891 to -0.0914
log_TP	-0.3131*	0.1524	-2.05	0.041	-0.6135 to -0.0127
Constant	-23.9976***	2.9881	-8.03	0.000	-29.8888 to -18.1065

Number of observations = 212; F(5,206) = 70.33; Prob > F = 0.0000; R-squared = 0.6306; adjusted R-squared = 0.6216.
Significance: * p<0.05, ** p<0.01, *** p<0.001.

Table 6. Pooled OLS import regression results (dependent variable: log_IVWBP)

Variable	Coefficient	Std. err.	t	p-value	95% confidence interval
log_P	-0.0763	0.0940	-0.81	0.418	-0.2617 to 0.1090
log_GDP	0.8728***	0.0969	9.01	0.000	0.6818 to 1.0638
log_FC	-0.0521	0.0972	-0.54	0.592	-0.2438 to 0.1395
log_EXR	-0.0148	0.0381	-0.39	0.697	-0.0899 to 0.0602
log_TP	-0.2761***	0.0828	-3.33	0.001	-0.4393 to -0.1128
Constant	-1.6008	1.6255	-0.98	0.326	-4.8041 to 1.6025

Number of observations = 230; F(5,224) = 29.22; Prob > F = 0.0000; R-squared = 0.3948; adjusted R-squared = 0.3813. Significance: * p<0.05, ** p<0.01, *** p<0.001.

The pooled OLS export model indicates that a 1% increase in GDP per capita is associated with an estimated 1.62% increase in export value, while a 1% increase in forest coverage is associated with an estimated 1.48% increase in export value, holding other variables constant. The negative exchange-rate coefficient suggests that currency movements affect export competitiveness through price channels. For imports, the GDP coefficient indicates that a 1% increase in GDP per capita is associated with an estimated 0.87% increase in import value. These baseline elasticities show that the statistically significant variables also have meaningful economic importance.

3.3 Fixed-effects results

Table 7. Fixed-effects export regression results (dependent variable: log_EVWBP)

Variable	Coefficient	p-value	Interpretation
log_P	0.1178	0.437	Not significant
log_GDP	1.3804*	0.050	Positive and marginally significant
log_FC	19.9522***	0.001	Positive and highly significant
log_EXR	-0.1539*	0.048	Negative and significant
log_TP	0.4096*	0.018	Positive and significant
Constant	-75.4040***	0.000	Significant

Number of observations = 212; number of countries = 15; within R-squared = 0.2398. Significance: * p<=0.05, ** p<0.01, *** p<0.001.

Table 8. Fixed-effects import regression results (dependent variable: log_IVWBP)

Variable	Coefficient	p-value	Interpretation
log_P	-0.0787	0.473	Not significant
log_GDP	2.4777***	0.000	Positive and highly significant
log_FC	4.2805	0.302	Not significant
log_EXR	-0.0401	0.393	Not significant
log_TP	0.1371	0.247	Not significant
Constant	-52.5600***	0.000	Significant

Number of observations = 238; number of countries = 15; within R-squared = 0.2570. Significance: * p<=0.05, ** p<0.01, *** p<0.001.

After controlling for country-specific time-invariant heterogeneity, forest coverage remains a strong positive determinant of exports, while exchange rate remains negative and significant. GDP is marginally significant in the export model, suggesting that within-country changes in economic capacity may support exports but that much of the GDP-export relationship is also captured by persistent country characteristics. The relatively large fixed-effects coefficient for forest coverage should be interpreted cautiously because forest coverage changes slowly over time; in a fixed-effects model, limited within-country variation can magnify coefficient size. Therefore, the coefficient indicates the direction and importance of forest-resource availability, but it should not be interpreted as a simple short-run causal elasticity. In the import model, GDP is the only robust significant determinant, indicating that import demand is mainly income-driven once country-specific factors are controlled.

3.4 Random-effects results

Table 9. Random-effects export regression results (dependent variable: log_EVWBP)

Variable	Coefficient	Std. err.	z	p-value	95% confidence interval
log_P	0.0538	0.1510	0.36	0.722	-0.2421 to 0.3496
log_GDP	1.8642***	0.3550	5.25	0.000	1.1685 to 2.5599
log_FC	2.0112***	0.5733	3.51	0.000	0.8875 to 3.1348
log_EXR	-0.1194	0.0736	-1.62	0.105	-0.2636 to 0.0249
log_TP	0.3439*	0.1710	2.01	0.044	0.0088 to 0.6790
Constant	-36.4676***	8.4534	-4.31	0.000	-53.0360 to -19.8992

Number of observations = 212; number of countries = 15; Wald chi2(5) = 62.24; Prob > chi2 = 0.0000; within R-squared = 0.2022; between R-squared = 0.6309; overall R-squared = 0.5597; rho = 0.7221. Significance: * p<0.05, ** p<0.01, *** p<0.001.

Table 10. Random-effects import regression results (dependent variable: log_IVWBP)

Variable	Coefficient	Std. err.	z	p-value	95% confidence interval
log_P	-0.1822	0.1067	-1.71	0.088	-0.3913 to 0.0269
log_GDP	1.2634***	0.1797	7.03	0.000	0.9112 to 1.6157
log_FC	-0.1245	0.2390	-0.52	0.602	-0.5929 to 0.3439
log_EXR	-0.0694	0.0433	-1.60	0.109	-0.1544 to 0.0155
log_TP	-0.1284	0.1132	-1.13	0.257	-0.3502 to 0.0935
Constant	-9.2296*	4.0548	-2.28	0.023	-17.1769 to -1.2823

Number of observations = 230; number of countries = 15; Wald chi2(5) = 54.92; Prob > chi2 = 0.0000; within R-squared = 0.2108; between R-squared = 0.5900; overall R-squared = 0.3790; rho = 0.4212. Significance: * p<0.05, ** p<0.01, *** p<0.001.

The random-effects results are broadly consistent with the pooled OLS export model for GDP and forest coverage. GDP and forest coverage remain positive and highly significant for exports, while trade policy is positive and significant. In the import model, GDP remains positive and highly significant, but other variables are not statistically significant. The difference between fixed- and random-effects estimates suggests that unobserved country characteristics are important and should not be ignored; this is later confirmed by the Hausman tests.

3.5 Model selection and overall significance

Table 11. Hausman specification test results

Model	Chi-square	p-value	Decision
Export model	63.05	0.0000	Reject random-effects consistency; fixed effects preferred
Import model	11.58	0.0410	Reject random-effects consistency; fixed effects preferred

The null hypothesis is that the difference in coefficients is not systematic. Because both p-values are below 0.05, fixed-effects estimation is preferred for both export and import equations.

Table 12. Overall model significance tests

Model	F-statistic	Prob > F	R-squared	Decision
Export full model	70.33	0.0000	0.6306	Overall model is statistically significant
Import full model	29.22	0.0000	0.3948	Overall model is statistically significant

The F-tests confirm that the explanatory variables jointly improve model fit. R-squared values should be interpreted as explanatory power rather than causal completeness.

The Hausman tests favor fixed effects for both export and import models. This means that unobserved country-specific factors are systematically correlated with the regressors, making the fixed-effects estimator more appropriate than the random-effects estimator. The significant F-tests confirm that the full models are statistically meaningful. However, the lower within R-squared values in fixed-effects models indicate that some time-varying determinants of trade are not captured in the current specification. These may include logistics costs, institutional quality, production technology, trade agreements, geopolitical shocks, energy costs, sanctions, and changes in global demand. Therefore, the results should be interpreted as robust associations within the available specification, not as complete causal explanations.

3.6 Robustness interpretation

The robustness assessment compares the pooled OLS, fixed-effects, and random-effects specifications. For exports, the pooled OLS model explains 63.06% of the variation in log export value, while the random-effects model explains 55.97%; both are jointly significant. For imports, the pooled OLS and random-effects models explain 39.48% and 37.90% of the variation, respectively. The fixed-effects within R-squared values are lower, 0.2398 for exports and 0.2570 for imports, which is expected because the fixed-effects estimator uses only within-country variation after controlling for time-invariant country characteristics. The Hausman tests support fixed effects for both export and import equations, confirming that unobserved country-specific factors are correlated with the regressors and should be controlled.

Across specifications, GDP remains the most reliable import determinant, with positive and highly significant coefficients in pooled OLS, fixed-effects, and random-effects models. On the export side, GDP and forest coverage remain positive in the main specifications, indicating that economic capacity and resource availability are central to export performance. Exchange rate is negative in the pooled OLS and fixed-effects export models, while trade policy changes sign across specifications; therefore, the trade-policy coefficient should be interpreted as context-dependent rather than as a uniform causal effect.

4. Discussion

4.1 Export determinants

The export results show that WBP export performance is mainly determined by economic scale, forest-resource availability, and exchange-rate conditions. GDP is positive and significant in the pooled OLS and random-effects models and marginally significant in the fixed-effects model. This implies that economically stronger countries are better positioned to produce and export WBPs because they can support industrial investment, processing capacity, transport infrastructure, and export-oriented firms. This finding is consistent with Buongiorno (2016) and Morland et al. (2018), who emphasize the role of income, market scale, and competitiveness in forest-product trade. The slightly weaker GDP effect under fixed effects suggests that part of the GDP-export relationship reflects persistent national characteristics rather than only year-to-year changes.

Forest coverage is the most consistent export-side resource variable. Its positive and significant coefficient across export models indicates that countries with larger forest endowments have stronger raw-material availability and therefore greater potential for WBP production and export. This finding agrees with studies showing that forest-resource supply supports forest-product competitiveness (Saraswati et al., 2023; Coelho Junior et al., 2023) and with panel evidence that forest endowment is a significant determinant of net forest-product trade (Uusivuori, 2002). However, forest coverage alone is not sufficient. Resource-rich countries can convert forests into export value only when harvesting, processing, logistics, certification, and sustainability standards are effectively managed. This is why country-specific effects are important in the present study.

Exchange rate has a significant negative coefficient in the pooled OLS and fixed-effects export models. This suggests that exchange-rate movements affect export competitiveness through price channels. Depending on the definition of the exchange-rate variable, a negative coefficient may indicate that currency appreciation reduces export competitiveness or that depreciation improves foreign-market affordability. This result is consistent with Wang et al. (2017), who reported that

exchange-rate fluctuations influence pricing behavior among wood-based panel exporters. The finding also implies that exporters in the region are sensitive to macroeconomic instability and currency volatility.

Trade policy shows mixed signs across models, which indicates that its effect is context-dependent. In the pooled model, the coefficient is negative, while in the fixed- and random-effects export models it is positive. This difference may reflect the broad nature of the trade-policy proxy. Trade policy can include both restrictive elements, such as tariffs and non-tariff barriers, and facilitative elements, such as preferential agreements, customs simplification, export promotion, or regulatory harmonization. Therefore, the results should be interpreted cautiously and should motivate future research using more disaggregated policy indicators.

4.2 Import determinants

GDP is the most robust determinant of WBP imports. It is positive and highly significant in pooled OLS, fixed-effects, and random-effects models. This indicates that as countries become economically stronger, their demand for imported panels increases. Higher GDP can stimulate construction, housing, furniture production, renovation activities, and downstream manufacturing, all of which increase demand for WBPs. Unlike exports, imports are less dependent on domestic forest-resource availability because they are driven primarily by purchasing power and domestic demand. This result is consistent with demand-side interpretations in forest-products trade models (Morland et al., 2018; Nepal et al., 2021) and with panel-data evidence that import demand for forest products, including wood-based panels, is elastic with respect to income (Turner & Buongiorno, 2004).

Trade policy is negative and significant only in the pooled OLS import model. This suggests that restrictive trade policies may reduce import values when cross-country differences are not fully controlled. However, the coefficient becomes insignificant in fixed- and random-effects models, indicating that policy effects may be absorbed by country-specific characteristics or may not vary enough over time to be strongly identified within countries. This result also highlights the limitation of using a broad trade-policy proxy rather than precise measures such as tariff rates, non-tariff measures, customs delays, trade-agreement participation, or regulatory quality.

Forest coverage, exchange rate, and population do not show robust statistical significance in the import equations. The insignificant forest-coverage coefficient may indicate that domestic forest resources do not directly determine import demand once GDP and country effects are controlled. Some forest-rich countries may still import specialized panels due to quality, design, or industrial requirements, while forest-poor countries may rely on substitutes or domestic processing based on imported raw materials. Population is also insignificant, suggesting that import demand is more strongly related to income and industrial activity than to demographic size alone.

4.3 Model limitations and robustness

The Hausman tests clearly support fixed effects, confirming that unobserved country-specific characteristics matter. Nevertheless, the modest within R-squared values show that the models do not capture all time-varying drivers of WBP trade. Important omitted factors may include infrastructure quality, transport costs, energy prices, domestic production capacity, firm-level competitiveness, institutional quality, sanctions, regional conflicts, global price shocks, and changes in environmental standards. Diagnostic tests for multicollinearity, heteroskedasticity, and serial correlation should

therefore be reported with the final estimation output, and robust or cluster-robust standard errors should be used when required.

Another limitation concerns the trade-policy variable. Because trade policy is multidimensional, a single proxy may not fully capture tariffs, quotas, non-tariff barriers, customs procedures, export incentives, trade agreements, and regulatory quality. Future studies should use disaggregated policy measures and product-level trade data. In addition, the period 2005-2020 includes major economic and geopolitical changes; future research could use dynamic panel models, structural-break tests, or interaction terms to examine whether determinants differ before and after major regional shocks. Robustness checks using alternative policy indicators, lagged explanatory variables, or exclusion of influential countries such as the Russian Federation would further strengthen the reliability of the results.

5. Conclusion and policy implications

This study examined the determinants of wood-based panel export and import values in 15 Eastern European and Central Asian countries from 2005 to 2020. The main contribution of the study is its focused treatment of WBPs as a distinct forest-product category and its comparison of export and import determinants using panel-data models that account for country-specific heterogeneity. The first objective was to evaluate economic factors. The results show that GDP is a key determinant of both exports and imports, while exchange rate significantly affects export performance in the pooled and fixed-effects models. The second objective was to assess trade policy. Trade policy has a significant association with exports and imports in some specifications, but its sign and significance vary across models, indicating that policy effects are complex and context-specific. The third objective was to examine resource and demographic factors. Forest coverage strongly supports exports, whereas population is not a robust determinant of either exports or imports.

The Hausman tests support the use of fixed-effects models for both export and import equations. This confirms that country-specific unobserved heterogeneity is important and that ignoring it may lead to biased results. Overall, exports are shaped by economic capacity, forest-resource availability, and exchange-rate competitiveness, while imports are mainly driven by GDP and domestic demand conditions. These conclusions are directly based on the empirical findings and should be interpreted within the limitations of the available variables and time period.

5.1 Policy implications

First, sustainable forest management should be treated as a trade-development strategy. Since forest coverage positively affects exports, governments should strengthen reforestation, responsible harvesting, certification systems, legality verification, and forest monitoring. These actions can improve raw-material security while maintaining environmental sustainability and access to environmentally sensitive export markets.

Second, macroeconomic stability is important for export competitiveness. The significant exchange-rate effect shows that currency volatility can influence WBP export performance. Policymakers should support stable macroeconomic conditions, reduce transaction costs for exporters, improve access to trade finance, and provide information services that help firms manage exchange-rate risk.

Third, trade policies should be simplified and targeted. Customs procedures, excessive tariffs, non-tariff barriers, and regulatory uncertainty can reduce trade efficiency. Governments should improve

trade facilitation, harmonize standards, negotiate market-access arrangements, and distinguish between policies that restrict inefficient trade and policies that support sustainable export growth.

Fourth, countries should strengthen domestic processing capacity. GDP-driven import demand suggests that economic growth increases demand for WBPs. Investments in domestic manufacturing, technology upgrading, energy efficiency, quality certification, and workforce development can reduce excessive import dependence while improving export potential. Industry stakeholders should also focus on higher-value panels, improved design standards, and reliable supply-chain management.

Future research should use more disaggregated product-level data, dynamic panel models, and detailed trade-policy indicators. Incorporating variables such as logistics performance, institutional quality, energy costs, sanctions, trade agreements, industrial capacity, exchange-rate volatility, and global price indices could improve explanatory power. Firm-level or regional-level data would also help identify how microeconomic competitiveness translates into national trade performance. Additional robustness checks, including alternative time periods, exclusion of dominant exporters, and lagged-variable specifications, are recommended to test the stability of the findings.

Author Contributions

Conceptualization, S.A.H.; methodology, S.A.H.; software, S.A.H. and S.M.K.M.; validation, S.M.K.M., and A.R.B.; formal analysis, S.A.H.; investigation, S.A.H. and A.R.B.; resources, S.A.H. and S.M.K.M.; data curation, S.M.K.M., A.R.B., and S.A.H.; writing—original draft preparation, S.A.H.; writing—review and editing, S.M.K.M., A.R.B., and S.A.H.; visualization, A.R.B. and A.R.; supervision, S.A.H.; project administration, S.A.H. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Conflict of Interest

The authors declare no conflict of interest.

Artificial Intelligence (AI) Use Statement

The authors declare that no artificial intelligence tools were used in the research, analysis, writing, or preparation of this manuscript.

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