EXPORT DIVERSIFICATION IN OPEC COUNTRIES: A PANEL DATA APPROACH

Milan Tomić
Independent Researcher, Bosnia and Herzegovina, milantm93@gmail.com
Srđan Stevandić
Independent Researcher, Bosnia and Herzegovina, srdjanstevandic@gmail.com

Abstract: This study investigates export diversification among OPEC countries, emphasizing its importance for economic resilience and stability. The objective is to assess which factors influence export diversification in OPEC countries. Methodologically, the research analyzes panel data from 2011 to 2022 using the Herfindahl-Hirschman Index (HHI) and the GINI coefficient to measure export diversification. The panel analysis considers GDP per capita, population (market size), FDI, trade openness, education, infrastructure, economic diversification, and the impact of the COVID-19 pandemic. The study employs both pooled and fixed effects (FE) models. The fixed effects model was employed to account for country-specific characteristics that may influence the results and was chosen because the Kruskal-Wallis test indicated statistically significant differences in the medians of HHI and GINI among countries, both for individual observations and average values. The Panel-Corrected Standard Errors (PCSE) model was used to address heteroskedasticity. The Shapiro-Wilk test was initially used to test for normal distribution, and due to its results, the Kruskal-Wallis test was subsequently employed. The results from the PCSE model indicate robust findings, confirming the significant impact of trade openness, economic diversification, and education on export diversification in both models where the dependent variable is HHI and GINI. This study highlights the importance of understanding various economic and infrastructural factors contributing to export diversification, providing valuable insights for policymakers aiming to enhance economic stability and growth in OPEC countries. This research first quantified export diversification indices using HHI and GINI, revealing the countries with the highest and lowest export diversification. The quantification was based on the HS6 classification, which represents the highest level of aggregation in export data, allowing for a detailed analysis of export diversification. According to the HHI, Iraq has the highest market concentration and, thus, the lowest export diversification, while Indonesia shows the highest diversification with the lowest market concentration. On the other hand, the GINI coefficient indicates that Angola has the lowest level of export diversification, whereas Iraq has the highest. Despite using the same dataset, these differing results arise because the HHI measures market concentration across products or countries. At the same time, the GINI coefficient assesses the inequality in export shares, focusing on the distribution of export income among different entities.
Keywords: Export diversification, Herfindahl-Hirschman Index, GINI coefficient, OPEC, Panel data, Covid-19

1. INTRODUCTION

Export diversification refers to the process by which a country broadens the range of products or services it exports or expands its export destinations. It aims to reduce dependence on a limited number of export items or markets, enhancing economic resilience and stability. Diversified exports can mitigate the adverse effects of demand shocks, reduce vulnerability to external economic fluctuations, and foster sustainable economic growth by developing multiple industries and sectors. This process creates job opportunities, reduces unemployment rates, and ensures a more balanced income distribution across various sectors and regions within a country. Export diversification is typically measured using the Herfindahl-Hirschman Index (HHI) and the GINI coefficient (Holiuk et al., 2021; Erkan & Sunay, 2018). A lower HHI value indicates higher diversification, while a higher value signifies higher concentration. The GINI coefficient, ranging from 0 to 1, measures inequality in export shares, with 0 representing perfect equality and 1 indicating maximum inequality. The HHI quantifies market concentration in exports. In contrast, the GINI evaluates income distribution. While the HHI measures the concentration of exports across products or countries, the GINI assesses the distribution of export income among different entities. Therefore, the HHI focuses on the spread of exports, whereas the GINI looks at the equitable distribution of export earnings.

Developing countries have started forming associations of primary product producers and exporters to achieve a better position in the international market and increase their bargaining power. The Organization of the Petroleum Exporting Countries (OPEC) is the best example of such an association. The Organization of the Petroleum Exporting Countries successfully doubled the oil price in the early 20th century and later increased it fourfold, securing higher foreign exchange inflows for its members (Bjelić, 2003). OPEC, founded in 1960, aims to coordinate and unify petroleum policies among member countries. The organization aims to stabilize oil markets and ensure fair and stable prices for oil producers. OPEC consists of 13 member countries holding a significant

portion of the world's oil reserves: Algeria, Angola, Congo, Equatorial Guinea, Gabon, Iran, Iraq, Kuwait, Libya, Nigeria, Saudi Arabia, the United Arab Emirates, and Venezuela.

Export diversification is influenced by several factors, including economic development (Agosin et al., 2011; Cadot et al., 2011; Swathi & Sridharan, 2022; Bhaumik et al., 2022), market size, which is usually approximated in analysis with population (Swathi & Sridharan, 2022; Osakwe & Kilolo, 2018), foreign direct investment (Swathi & Sridharan, 2022; Bhaumik et al., 2022; Gamariel et al., 2022), economic diversification (Swathi & Sridharan, 2022; Osakwe & Kilolo, 2018; Ajayi, 2023), infrastructure (Swathi & Sridharan, 2022; Gnangnon, 2020; Cadot et al., 2011; Osakwe & Kilolo, 2018), education (Swathi & Sridharan, 2022; Agosin et al., 2011), trade openness (Agosin et al., 2011; Bhaumik et al., 2022; Basile et al., 2018), and even sudden shocks such as pandemics like COVID-19 (Bhaumik et al., 2022; Lebastard et al., 2023). Higher GDP per capita indicates a more developed economy capable of supporting diverse industries. Larger populations provide a bigger domestic market for testing products before export. FDI brings in capital and technology, fostering industrial growth and competitiveness. Economic diversification reduces reliance on a single commodity, while education and good infrastructure support diverse economic activities. Trade openness allows access to new markets and attracts foreign investment. This study aims to provide insights for policymakers and stakeholders to promote sustainable economic growth and resilience in OPEC nations by analyzing these factors.

Using data from the UN Comtrade database, World Bank, and UNdata from 2011 to 2022, this research analyzes how GDP per capita, population (market size), FDI, trade openness, education levels, internet penetration (infrastructure), and economic diversification influence export diversification in OPEC countries. It includes a synthetic variable for COVID-19 to assess the pandemic's impact on export diversification in 2020 and 2021.

2. MATERIALS AND METHODS

The study first assessed the export diversification of OPEC countries using the Herfindahl-Hirschman Index and the GINI coefficient as measures of export diversification. By evaluating these indices, we identified which countries had the highest and lowest levels of export diversification according to these two indexes. After determining the countries with the highest and lowest export diversification indices, we conducted the Shapiro-Wilk Normality Test for HHI and GINI variables to check for normal distribution. Following this, the Kruskal-Wallis Test was performed to analyze the distributions of HHI and GINI among different countries, both at individual observations and average values.

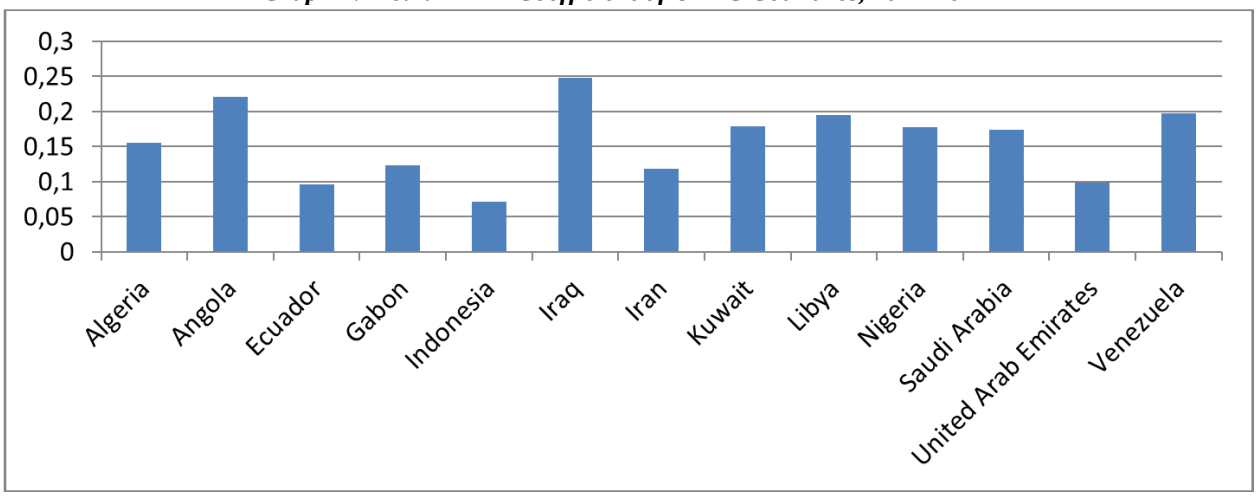
We employed the fixed effects (FE) model for the regression analysis to account for country-specific characteristics that might influence the results. This approach was chosen because the Kruskal-Wallis test indicated significant distribution differences among the countries. The presence of heteroskedasticity was confirmed in both models, necessitating robust standard errors. Consequently, the Panel-Corrected Standard Errors (PCSE) model was utilized to handle heteroskedasticity and provide reliable estimates.

The data were sourced from the UN Comtrade database, World Bank, and UNdata, covering the period from 2011 to 2022. The dataset included variables such as GDP per capita, population (as an approximation of market size), FDI, trade openness, education levels, internet penetration (as an approximation of infrastructure), and economic diversification for OPEC countries. Herfindahl-Hirschman Index and GINI indices for export diversification were quantified using the HS6 classification, with data collected from the UN Comtrade database. This system was chosen because it represents the highest level of aggregation in export data. Additionally, the UNdata database provided data on Gross Value Added by Kind of Economic Activity at current prices, which was used to calculate economic diversification for HHI and GINI. A synthetic variable, Covid, was added for the years 2020 and 2021 to examine the impact of the pandemic on export diversification in OPEC countries. The statistical analysis was performed using Stata software.

3. RESULTS

The following section presents the findings on export diversification among OPEC countries, measured using the Herfindahl-Hirschman Index and the GINI coefficient. The data spans from 2011 to 2022 and highlights the countries with the highest and lowest levels of export diversification.

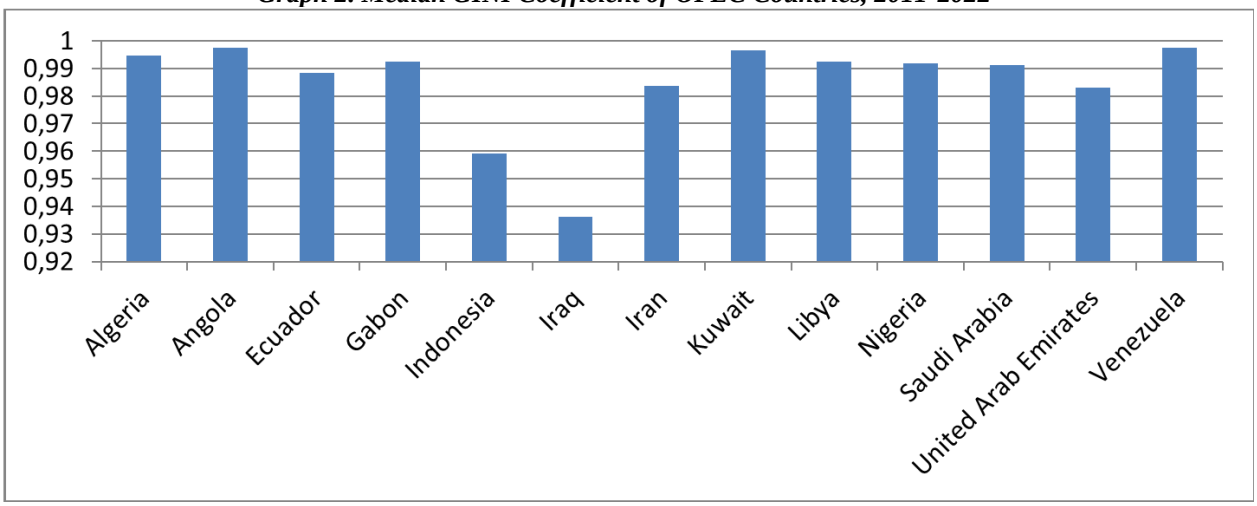
Graph 1. Median HHI Coefficient of OPEC Countries, 2011-2022



Source: Author's Calculation

The graph 1. depicts the median Herfindahl-Hirschman Index for each OPEC country from 2011 to 2022. According to the graph, Iraq has the highest market concentration, with a median HHI of approximately 0.2487, indicating the lowest export diversification. In contrast, Indonesia has the highest export diversification, with a median HHI of approximately 0.0709, indicating the lowest market concentration for the examined years.

Graph 2. Median GINI Coefficient of OPEC Countries, 2011-2022



Source: Author's Calculation

The graph 2. depicts the median GINI coefficient for each OPEC country from 2011 to 2022. According to the graph, Angola has the lowest level of export diversification, with a median GINI coefficient of approximately 0.9976. In contrast, Iraq has the highest level of export diversification, with a median GINI coefficient of approximately 0.93605, indicating the most diversified exports among the examined countries.

The graphs above provide a visual summary of the median Herfindahl-Hirschman Index and GINI coefficient of export diversification for OPEC countries from 2011 to 2022, highlighting the countries with the highest and lowest levels of export diversification. However, to ensure the robustness and validity of these visual observations, detailed statistical analyses are essential. The following tables present the results of the Shapiro-Wilk normality test and the Kruskal-Wallis test, which provide a deeper statistical understanding of the data.

Table 1. Results of Shapiro-Wilk Normality Test for of HHI and GINI Variables

HHI					
Variable	**Obs**	**W**	**V**	**z**	**Prob>z**
HHI	123	0.952	4.694	3.469	0.000
GINI					
Variable	**Obs**	W	V	z	**Prob>z**
Gini	123	0.385	60.339	9.198	0.000

Source: Author's Calculation

The results of the Shapiro-Wilk test for normality for the HHI and Gini coefficient variable distributions indicate that these variables do not meet the assumptions of an approximate normal distribution. The W statistic for the HHI variable is 0.952, while the p-value is 0.000, which is less than 0.05. Similarly, the GINI coefficient's W statistic is 0.385 with a p-value of 0.000. Therefore, we can reject the null hypothesis of normal distribution. The null hypothesis (H0) of the Shapiro-Wilk test is that the variables meet the assumptions of an approximate normal distribution, while the alternative hypothesis (H1) is that the examined variables do not meet these assumptions. Based on the test results, we reject the null hypothesis and accept the alternative hypothesis, indicating that the data for these variables are not normally distributed. Furthermore, these results suggest the need for non-parametric statistical methods for further analysis. One such method is the Kruskal-Wallis test, which determines if there are statistically significant differences in the distributions of the Herfindahl-Hirschman Index and GINI coefficient among different countries. The Kruskal-Wallis test is appropriate because it does not assume a normal data distribution and uses ranked data to assess whether the medians of multiple groups differ. This makes it suitable for analyzing the HHI and GINI variables, given the non-normality indicated by the Shapiro-Wilk test.

Table 2. Kruskal-Wallis Test Results for HHI and GINI Variables, 2011-2022

			HHI		**GINI**	
Country	**Obs Each Country**	**Obs Average**	**Rank Sum Each Country**	**Rank Sum Average**	**Rank Sum Each Country**	**Rank Sum Average**
Algeria	7	12	489.00	1086.00	685.50	1518.00
Angola	12	12	1322.00	1662.00	958.50	78.00
Ecuador	12	12	428.50	222.00	609.00	798.00
Gabon	11	12	650.00	654.00	910.00	1374.00
Indonesia	12	12	90.00	78.00	184.00	366.00
Iraq	6	12	723.00	1806.00	59.00	222.00
Iran	10	12	438.00	510.00	339.00	510.00
Kuwait	11	12	659.50	798.00	1182.50	1806.00
Libya	4	12	399.00	1374.00	312.50	1230.00
Nigeria	12	12	813.50	942.00	887.50	1086.00
Saudi Arabia	11	12	870.00	1230.00	742.50	942.00
United Arab Emirates	12	12	435.50	366.00	455.50	654.00
Venezuela	3	12	308.00	1518.00	300.50	1662.00

HHI			**Gini**		
Each Country	chi-squared 93.158 with 12 d.f.	probability 0.000	**Each Country**	chi-squared 83.902 with 12 d.f.	probability 0.000
Average	chi-squared 154.089 with 12 d.f.	probability 0.000	**Average**	chi-squared 154.089 with 12 d.f.	probability 0.000

Source: Author's Calculation

The Kruskal-Wallis test results for the HHI and GINI variables from 2011-2022 indicate significant differences in their distributions among different countries. This non-parametric test was chosen due to the non-normal distribution

of the data, as shown by the Shapiro-Wilk test (see Table 1). The test assesses whether the medians of these variables differ significantly across countries. For HHI, the test statistic for individual observations is 93.158 with a p-value of 0.000, and for average values, the test statistic is 154.089 with a p-value of 0.0001, both with 12 degrees of freedom. For GINI, the test statistic for individual observations is 83.902 with a p-value of 0.000. For average values, the test statistic is 154.089, with a p-value of 0.000 and 12 degrees of freedom. In all cases, the p-value is less than 0.05, leading to the rejection of the null hypothesis. This indicates statistically significant differences in the medians of HHI and GINI among countries, both for individual observations and average values.

Based on the results of the Kruskal-Wallis test, we conclude that the variables HHI and GINI have different distributions among different countries, both at the individual observations level and at the average values level.

The regression results for the Herfindahl-Hirschman Index and GINI coefficient variables are presented in the table below, using both pooled and fixed-effects (FE) models. The fixed-effects model was employed to account for country-specific characteristics that may influence the results.

Table 3. Regression Results for HHI and GINI Variables

Variable	Pooled HHI	Pooled Gini	FE HHI	FE Gini	PCSE HHI	PCSE GINI
GDPper capita	.173 (.130)	.003 (.003)	.581 (.357)	.011 (.008)	.173 (.117)	.003 (.003)
Population	-.040 (.056)	**-.005***** **(.001)**	**-1.161*** **(.656)**	.010 (.013)	-.040 (.054	**-.005***** **(.001)**
FDI	-.046 (.037)	**-.002**** **(.001)**	-.003 (.028)	.0004 (.0007)	-.046 (.043)	**-.002*** **(.001)**
Opennes	**-.408*** **(.203)**	**-.009*** **(.005)**	-.027 (.160)	-.002 (.004)	**-.408**** **(.154)**	**-.008**** **(.004)**
Div. of economy HHI/Gini	**.725***** **(.221)**	**.009**** **(.003)**	**.499**** **(.247)**	**.020***** **(.006)**	**.725***** **(.200)**	**.009***** **(.003)**
Education	**1.213**** **(.538)**	.024 (.015)	-.342 (.347)	.010 (.008)	**1.213**** **(.502)**	**.024*** **(.013)**
Internet	-.084 (.117)	-.0007 (.002)	-.071 (.093)	.00005 (.002)	-.084 (.091)	-.0007 (.003)
Covid	-.081 (.101)	-.001 (.002)	-.038 (.055)	-.002 (.001)	-.081 (.070)	-.001 (.002)
Obs.	65	65	65	65	65	
MODEL SIG.	F(8, 56)= 9.42 Prob > F = 0.000	F(8, 56)= 21.49 Prob > F = 0.000	F(8,48)= 5.60 Prob > F = 0.000	F(8,48)= 2.90 Prob > F = 0.010	Wald chi2(8) 90.35 Prob > F = 0.000	Wald chi2(8) 182.54 Prob > F =0.000
COEF. OF DETERMINATION	R^2 = 0.573 R^2_{adj}= 0.512	R^2 = 0.754 R^2_{adj}= 0.719	within = 0.482 between = 0.130 overall = 0.257	within = 0.326 between = 0.122 overall = 0.027	R^2 = 0.573	R^2 = 0.754

*Note: Standard errors are given in parentheses. Asterisks indicate the level of significance: *** significance level at 1%, ** significance level at 5%, * significance level at 10%.*
Source: Author's Calculation

In the models, the logged version of the variables was used to stabilize variance, reduce the impact of outliers, and achieve a more linear relationship. No evidence of first-order autocorrelation indicates that residual errors are not autocorrelated. Heteroskedasticity is confirmed in both models, necessitating robust standard errors. The Panel-Corrected Standard Errors (PCSE) model was utilized for this purpose, providing robust standard errors crucial for reliable estimates. To ensure that multicollinearity does not adversely affect the regression results, the Variance Inflation Factor (VIF) was calculated, with all variables having a VIF below the threshold of concern (mean VIF = 5.93). According to José Dias Curto and José Castro Pinto (2010), a VIF below 10 is considered acceptable, indicating no harmful multicollinearity. The modified Wald test for groupwise heteroskedasticity showed significant results, indicating heteroskedasticity: for HHI, the chi-squared statistic is 2317.46 (p-value 0.000), and for GINI, the chi-squared statistic is 258.68 (p-value 0.000). The Wooldridge test for autocorrelation showed no significant autocorrelation: for HHI, the F statistic is 3.217 (p-value 0.123), and for GINI, the F statistic is 1.202 (p-value

0.315). The Pesaran (2015) test for cross-sectional dependence showed no significant dependence: for HHI, the CD statistic is -0.264 (p-value 0.791), and for GINI, the CD statistic is 0.215 (p-value 0.830). Due to heteroskedasticity, the PCSE model was employed to provide more reliable standard errors, ensuring robust and valid results despite heteroskedasticity.

Table 3. presents the regression results for the HHI and GINI variables using pooled, fixed effects (FE), and panel-corrected standard errors (PCSE) models. The Herfindahl-Hirschman Index and GINI coefficient are used as approximations for export diversification. Several variables show significant effects across the different models, indicating their consistent impact on export diversification. Notably, Population, FDI, Openness, Education, and Diversification of the economy are highlighted. The negative coefficient for FDI is significant in the pooled and PCSE models for GINI, suggesting that increased FDI contributes to higher export diversification. The negative coefficient for Openness is significant in both the pooled and PCSE models, indicating that greater economic openness is associated with increased export diversification. The positive and significant coefficient for Diversification of the economy across all models underscores its consistent impact, suggesting that increased economic diversification leads to decreased export diversification in OPEC countries. The positive and significant coefficient for Education in the pooled and PCSE models indicates that higher levels of education are associated with increased export concentration. A synthetic variable was included in the model to examine the impact of COVID-19 in 2020 and 2021 on export diversification in OPEC countries, and it was found to be statistically insignificant in all models.

These findings underscore the complex relationships between different factors and export diversification. The PCSE model is particularly crucial as it provides robust standard errors, corrects heteroskedasticity, and ensures the reliability of these results. This approach allows for more accurate inferences, highlighting the significant and varied impacts of the examined variables on export diversification. Trade openness, economy diversification, and education variables show consistent signs and significance across both PCSE models. Specifically:

- Openness: Greater openness of trade leads to increased export diversification. More open trade policies allow OPEC countries to access a broader range of markets and trading partners, promoting export diversification. These countries can better integrate into the global market by opening up their economies.
- Diversification of economy: An increase in economic diversification leads to a decrease in export diversification. This apparent paradox may occur because, in OPEC countries, diversification efforts within the oil sector can dominate, reducing the emphasis on diversifying into non-oil sectors.
- Education: Higher levels of education are associated with increased export diversification, but in the context of OPEC countries, more excellent education may lead to decreased export diversification because the highest revenues are derived from oil. Like essential agricultural and food products, oil is a unique commodity that will always be in demand worldwide.

5. CONCLUSIONS

This study examines export diversification in OPEC countries, highlighting its role in enhancing economic resilience and stability. Export diversification mitigates demand shocks, reduces vulnerability to external fluctuations, and promotes sustainable growth by developing various industries. It also creates jobs, reduces unemployment, and balances income distribution. Using the Herfindahl-Hirschman Index and the GINI coefficient, the research analyzed data from 2011 to 2022, considering GDP per capita, population, FDI, trade openness, education, infrastructure, and economic diversification. A synthetic variable for COVID-19 was included to assess its impact in 2020 and 2021. The study first assessed which country has the highest and lowest export diversification based on HHI and GINI indices. According to the data, Iraq has the lowest export diversification, while Indonesia has the highest, according to HHI. Regarding the GINI coefficient, Angola has the lowest export diversification, while Iraq has the highest. Although both indices measure export diversification, HHI emphasizes export concentration, while the GINI coefficient measures overall inequality. This can lead to different results for the same data, as each metric approaches export concentration and distribution differently.

The study found significant relationships between three factors and export diversification, which are constant in all two models. The Panel-Corrected Standard Errors (PCSE) model provided robust results. Key findings include that greater trade openness increases diversification, while economic diversification within the oil sector may increase export concentration. Higher education levels are generally linked to increased export diversification. However, in OPEC countries, this may lead to decreased diversification due to the dominant revenue from oil, a unique and consistently demanded commodity. These insights are valuable for policymakers and stakeholders aiming to reduce reliance on limited export items or markets, enhancing economic stability and growth prospects in OPEC countries. Understanding these dynamics aids in developing strategies for sustainable economic growth and resilience.

REFERENCES

Agosin, M. R., Alvarez, R., & Bravo-Ortega, C. (2012). Determinants of export diversification around the world: 1962–2000. The World Economy, 35(3), 295-315.

Ajayi, K. J. (2023). Impact of Export Diversification on Economic Growth in Sub-Saharan Africa (SSA). South Asian Journal of Social Studies and Economics, 20(3), 289-299.

Basile, R., Parteka, A., & Pittiglio, R. (2018). Export diversification and economic development: a dynamic spatial data analysis. Review of International Economics, 26(3), 634-650.

Bjelić, P. (2003). Ekonomika međunarodnih odnosa. Prometej: Beograd.

Cadot, O., Carrère, C., & Strauss-Kahn, V. (2011). Export diversification: what's behind the hump?. Review of Economics and Statistics, 93(2), 590-605.

Curto, J. D., & Pinto, J. C. (2011). The corrected vif (cvif). Journal of Applied Statistics, 38(7), 1499-1507.

Erkan, B., & Sunay, Z. F. (2018). Russia's market and product-based export diversification. Journal of Life Economics, 5(3), 43-60.

Gamariel, G., Bomani, M., Musikavanhu, L., & Juana, J. (2022). Foreign direct investment and export diversification in developing countries. Risk Governance & Control: Financial Markets & Institutions, 12(1).

Gnangnon, S. K. (2020). Effect of the internet on services export diversification. Journal of Economic Integration, 35(3), 519-558.

Holiuk, V. Y., Kovalchuk, B. S., & Anh, T. T. N. (2021). Export diversification impact on economic growth. Бізнес, Інновації, Менеджмент: Проблеми та Перспективи, 132-133.

Lebastard, L., Matani, M., & Serafini, R. (2023). GVC exporter performance during the COVID-19 pandemic: the role of supply bottlenecks.

Nguyen, C. P., & Su, T. D. (2022). Export dynamics and income inequality: New evidence on export quality. Social Indicators Research, 163(3), 1063-1113.

Osakwe, P. N., & Kilolo, J. M. (2018, October). What drives export diversification? New evidence from a panel of developing countries. In United Nation Conference on Trade and Development.

Swathi. M, & Sridharan, P. (2022). Determinants of export diversification: Evidence from fractional logit estimation model. Foreign Trade Review, 57(2), 160-177.