Journal of Contemporary Economics (JCE)
Vol. 10, No. 1, 2026

The Dynamics of International Trade Concentration: A Lorenz Curve and Gini Coefficient Analysis of Algeria-EU Trade (2018-2023)

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ARTICLE INFO
Review paper
Received: 25th of August, 2025
Revised: 22nd of November, 2025
Accepted: 03rd of December, 2025
Published: 01st of January 2026
doi:10.7251/JOCE2610001M
UDKxxx

Keywords:
Trade concentration,
Algeria-EU relations, Lorenz curve,
Gini coefficient, import inequality,
export inequality, trade diversification
JEL Classification: C43, F13, O19

ABSTRACT
This comprehensive study examines the structure and evolution of trade relations between Algeria and the European Union from 2018 to 2023 through the lens of inequality measurement tools. Using Lorenz curves and Gini coefficients, we analyze the concentration patterns of both imports and exports across EU member states. Our findings reveal persistently high levels of trade concentration, with extreme inequality in export distribution (Gini coefficients: 0.863-0.896) and very high inequality in import distribution (Gini coefficients: 0.752-0.862). The research identifies significant structural shifts in 2022-2023, particularly the emergence of Bulgaria as a major import partner for Algeria. The study contributes to the understanding of trade concentration dynamics in North African-European relations and offers policy implications for trade diversification strategies.

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1. Introduction

International trade between neighboring regions often exhibits complex patterns of specialization and concentration. Algeria EU trade is a compelling case given historical ties, proximity, and economic complementarity. Algeria, as a key energy exporter, maintains vital economic relations with EU countries, its main trading partner. Understanding trade concentration is vital for policymakers, economists, and business stakeholders.

High concentration can signal vulnerability to external shocks, while diversified trade boosts resilience. This study uses Lorenz curves and Gini coefficients to examine Algeria's trade with the EU from 2018 to 2023. The study period includes major global events such as the COVID-19 pandemic, supply chain disruptions, and energy market shifts, which may have affected Algeria-EU trade. By analyzing both imports and exports, this research provides a bilateral perspective on trade concentration.

Previous studies on Algeria-EU trade have primarily focused on aggregate flows, energy relations, or political dimensions, with limited application of formal inequality measures to analyze trade partner concentration. Recognizing this gap informs the present research, which applies methodological tools traditionally used in income inequality analysis to international trade patterns.

This study addresses a central research question.

To what extent has Algeria's trade with the European Union (EU) been concentrated between 2018 and 2023? To answer this, we investigate four subquestions. How concentrated are Algeria's import and export relationships with EU countries? How have these concentration patterns evolved between 2018 and 2023? What factors explain changes in trade concentration over this period? What are the policy implications of observed trade concentration patterns?

2. Literature Review

2.1. Theoretical Foundations of Trade Concentration

The analysis of trade concentration draws on international trade theory and economic geography. Traditional trade models, such as Ricardo's comparative advantage and Heckscher-Ohlin model, explain specialization patterns but do not directly address the number of trading partners (Dixit & Norman, 1980). New trade theory, developed by Krugman (1979), incorporates economies of scale and product differentiation, which can lead to trade concentration. The concept of trade diversification is well studied in development economics. Imbs and Wacziarg (2003) showed that countries tend to diversify as they develop. They only re-specialize at very high income levels. This U-shaped relationship between specialization and income provides important context for Algeria's trade as an upper-middle-income country.

Algeria-EU trade is strategically important due to historical ties, proximity, and economic complementarities. However, reliance on a few partners exposes Algeria to external risks, such as demand volatility and supply chain disruptions. This study addresses these risks using Lorenz curves and Gini coefficients, which remain uncommon in the Algeria-EU context. Unlike previous studies on aggregate flows or politics, our analysis gives year-by-year concentration patterns for actionable insights on diversification.

This research fills a critical gap in the literature by:

- A methodological approach rarely employed in existing studies is the systematic application of inequality measurement tools (Lorenz curves and Gini coefficients) to Algeria-EU trade data.
- Additionally, by providing a bilateral perspective that separately analyzes import and export concentration, this study reveals asymmetries often overlooked in aggregate analyses, further enhancing the depth of insight compared to previous research.

2.2. Measurement Approaches to Trade Concentration

Trade concentration measurement uses indices like the Herfindahl-Hirschman Index (HHI), Theil index, and Gini coefficient. Michaely (1962) first used the Gini coefficient in trade analysis. Dalginet et al. (2008) later applied it to U.S. imports, showing its effectiveness in capturing changes in trade partner distribution.

Lorenz curves, created by Lorenz (1905) for income distribution, are now widely used, including in trade analysis. Their visual format helps track changes in distribution over time.

2.3. Algeria-EU Trade Relations

Academic literature on Algeria-EU trade has predominantly focused on energy relations and the political economy of association agreements. Aissaoui (2001) provided a comprehensive analysis of Algeria's hydrocarbon economy and its implications for EU relations. Zoubir (2002) examined the Euro-Mediterranean Partnership and its impact on Algerian trade patterns.

Recent studies reviewed the Algeria-EU Association Agreement. Cherif (2013) analyzed its effects on trade, while Hadj Mohamed (2018) examined its impact on economic diversification. However, they generally relied on aggregate data without analyzing partner concentration (Djamel et al., 2022).

2.4. Methodological Applications in Trade Analysis

The application of inequality measures to trade data has gained traction in recent years. Agosin et al. (2012) used concentration indices to analyze export patterns in developing countries. Benedictis and Tajoli (2011) applied network analysis techniques to study the structure of international trade, revealing high levels of concentration in global trade networks.

Few studies have specifically applied Lorenz curves and Gini coefficients to the dynamics of Algeria-EU trade. This research contributes to the literature by applying these methodological tools to provide new insights into the concentration patterns of Algeria's trade with EU countries.

3. Methodology and Data

3.1. Data Sources and Processing

Annual data from 2018 to 2023, in millions of Algerian Dinars, cover Algeria-EU imports and exports (ONS, 2018-2023). The United Kingdom is excluded from the 2018-2019 data for consistency, even though it was in the EU; it appears separately in export data. Null or '-' values are treated as zero. The countries included in the analysis are: Germany, Austria, Belgium, Bulgaria, Cyprus, Croatia, Denmark, Spain, Estonia, Finland, France, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Czech Republic, Romania, Slovakia, Slovenia, and Sweden.

The 2018-2023 period captures significant global shocks, mainly the COVID-19 pandemic and supply disruptions. This short window highlights the resilience and adaptability of trade structures. Algeria's EU exports, mainly pipeline oil and gas, were mostly unaffected by pandemic-related restrictions, unlike shipments via sea, land, or air. So, the pandemic's impact on outcomes is minimal.

3.2. Lorenz Curve Construction

The Lorenz curve is constructed for each year using the following procedure.

Sorting

Countries are ranked in ascending order based on their trade value (imports or exports).

Cumulative Percentage Calculation

Cumulative percentage of countries: The percentage of total countries represented by each cumulative step. Cumulative percentage of trade: The percentage of total trade value accounted for by countries up to each rank.

Reference Points: The points (0, 0) and (100, 100) are added to complete the curve. The Lorenz curve provides a visual representation of trade concentration. The 45-degree line represents perfect equality, where each country accounts for an equal share of trade. The degree to which the actual curve sags below this line indicates the level of concentration.

3.3. Gini Coefficient Calculation

The Gini coefficient is calculated using the formula:

$$G = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} |x_i - x_j|}{2n^2 \bar{x}}$$

Where:

xi, xj are trade values with individual countries;
n is the number of countries;
x is the mean trade value.

The Gini coefficient ranges from 0 (perfect equality) to 1 (perfect inequality). In this context, a value of 0 would indicate that trade is evenly distributed across all EU countries, while a value of 1 would indicate that all trade is concentrated with a single country.

3.4. Interpretation Framework

The following interpretation framework is used for the Gini coefficients:

0.0-0.2: Perfect equality
0.2-0.4: Low inequality
0.4-0.6: Moderate inequality
0.6-0.8: High inequality
0.8-1.0: Extreme inequality

This classification adapts standard income Gini coefficient interpretations to the trade context.

3.5. Analytical Approach

The analysis proceeds in two stages.

Descriptive analysis

Presentation of Lorenz curves and Gini coefficients for each year from 2018 to 2023, separately for imports and exports.

Comparative analysis

Examination of trends over time and identification of structural breaks or significant changes in concentration patterns. All calculations and visualizations were performed using Python with Pandas for data manipulation and Matplotlib for visualization.

4. Results and Discussion

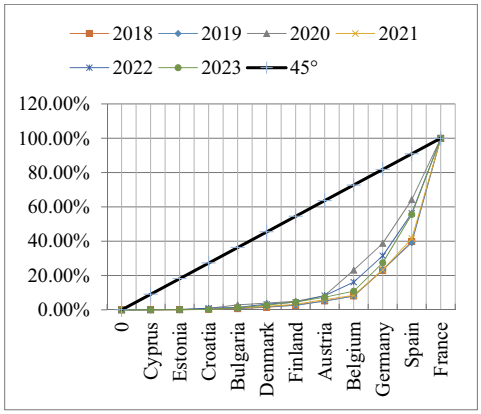
4.1. Import Concentration Analysis

4.1.1 Lorenz Curve Visualization

The following Lorenz curves (Figure 1) illustrate the concentration of Algeria's imports from EU countries.

Figure 1

Lorenz curves illustrate the concentration of Algeria's imports from EU countries



Notes. Authors own elaboration.

4.1.2. Gini Coefficient Analysis

The calculated Gini coefficients for import concentration are as follows.

Table 1

Gini coefficients for import

Year	*Gini Coefficient*	*Interpretation*
2018	0.782	Very High Inequality
2019	0.788	Very High Inequality
2020	0.752	Very High Inequality
2021	0.786	Very High Inequality
2022	0.862	Extreme Inequality
2023	0.848	Extreme Inequality

Notes. Authors own elaboration.

4.1.3. Discussion of Import Concentration Patterns

The analysis reveals consistently high concentration in Algeria's imports from EU countries throughout the 2018-2023 period. All years show Gini coefficients above 0.75, indicating very high to extreme inequality in import distribution. The Lorenz curves show significant sag below the line of equality, confirming the visual representation of concentration.

In all years, the bottom 70% of countries account for less than 15% of total imports, while the top 10-20% of countries account for the majority of imports. A notable pattern emerged in 2020, with the Gini coefficient decreasing to 0.752, suggesting a slight diversification of import sources. This may be attributed to pandemic-related disruptions in global supply chains, which forced Algerian importers to seek alternative sources within the EU.

The most striking development occurs in 2022-2023, when the Gini coefficients spike to extreme levels of inequality (0.862 and 0.848, respectively). This surge is primarily driven by the dramatic increase in imports from Bulgaria, which grew from approximately 16 billion DZD in 2021 to 98 billion DZD in 2022—a more than sixfold increase.

This shift significantly altered the import concentration pattern, making Bulgaria a major import partner alongside traditional leaders France and Germany. France and Germany consistently remain the dominant import sources throughout the period, typically accounting for 60-70% of Algeria's imports from the EU. This reflects historical ties, economic complementarities, and established trade relationships.

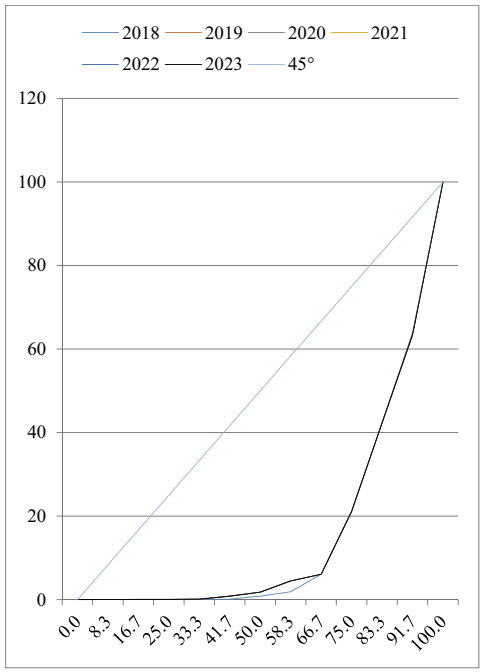
In contrast, countries like Cyprus, Croatia, and Estonia consistently account for less than 0.5% of total imports, highlighting nascent relationships with certain EU economies on the path to greater prominence in Algeria's import landscape.

4.2. Export Concentration Analysis

4.2.1. Lorenz Curve Visualization

The following figure illustrates Lorenz curves concentration of Algeria's exports to EU countries.

Figure 2
Lorenz curves illustrate the concentration of Algeria's exports to EU countries



Notes. Authors own elaboration.

4.2.2. Gini Coefficient Analysis

The calculated Gini coefficients for export concentration are presented in Table 2.

Table 2
Gini coefficients for export

YEAR	GINI COEFFICIENT	INTERPRETATION
2018	0.892	Extreme Inequality
2019	0.882	Extreme Inequality
2020	0.863	Extreme Inequality
2021	0.878	Extreme Inequality
2022	0.896	Extreme Inequality
2023	0.894	Extreme Inequality

Notes. Authors own elaboration.

4.2.3. Discussion of Export Concentration Patterns

The export concentration analysis reveals even more extreme inequality than observed in imports, with Gini coefficients consistently above 0.85 throughout the entire period. This indicates that Algeria's exports to the EU are highly concentrated among a very small number of destination countries.

The Lorenz curves for exports show a more pronounced sag below the line of equality than those for imports. In all years, the bottom 80% of countries account for less than 5% of total exports, while the top 2-3 countries account for the vast majority. Italy, France, and Spain emerge as the dominant destinations for Algerian exports throughout the period. These three countries typically account for 70-85% of Algeria's total exports to the EU, reflecting Algeria's energy-focused exports and existing infrastructure connections. The year 2020 shows a slight decrease in concentration (Gini coefficient of 0.863), which may be attributed to pandemic related disruptions in energy markets and logistics. However, the concentration quickly rebounded in subsequent years, reaching peak levels in 2022-2023.

Notably, many EU countries receive negligible amounts of Algerian exports. Countries like Slovakia, Luxembourg, Estonia, and Hungary consistently account for less than 0.1% of total exports, highlighting the extreme concentration of Algeria's export Year Gini Coefficient Interpretation 2018 0.892 Extreme Inequality 2019 0.882 Extreme Inequality 2020 0.863 Extreme Inequality 2021 0.878 Extreme Inequality 2022 0.896 Extreme Inequality 2023 0.894 Extreme Inequality relationships.

The persistently extreme concentration in exports reflects Algeria's specialized export structure, dominated by hydrocarbons. Energy products typically require specific infrastructure and established trade relationships, leading to concentration among a few partners with the necessary facilities and commercial relationships.

4.3. Comparative Analysis: Imports vs. Exports

The comparison between import and export concentration reveals interesting asymmetries in Algeria-EU trade relations.

Level of Concentration

Exports show consistently higher concentration than imports throughout the period. This reflects Algeria's specialized export basket (primarily hydrocarbons) versus more diversified import needs.

Stability Patterns

Import concentration shows more variability, particularly with the dramatic shift in 2022-2023 due to Bulgaria's emergence. Export concentration remains consistently extreme, with only minor fluctuations.

Key Partners

The dominant import partners (France and Germany) differ from the dominant export partners (Italy, France, and Spain).

Policy Implications

The high concentration of exports, which are primarily supplied via pipelines to a limited number of partners such as Italy and Spain, creates significant exposure to risks from demand fluctuations in these key markets.

Diversifying export routes by increasing the use of liquefied natural gas (LNG) tankers could reduce this reliance, enhance flexibility, and improve access to a broader range of markets, thereby mitigating the risks posed by demand volatility in any single country.

5. Conclusion and implications

This study has applied Lorenz curves and Gini coefficients to analyze the concentration of Algeria's trade with EU countries from 2018 to 2023. The key findings are:

- Both imports and exports show high to extreme levels of concentration throughout the period, with exports being more concentrated than imports.
- Import concentration showed significant variability, with a notable decrease in 2020, followed by a sharp increase in 2022- 2023, driven primarily by Bulgaria's emergence as a major import partner.

- Export concentration remained consistently extreme, with minor fluctuations around very high levels (Gini coefficients: 0.863-0.896).
- France and Germany are the most important suppliers of imports to Algeria from the EU, while Italy, France, and Spain are the most important destinations for Algeria's exports to the EU. S
- everal emerging EU markets are still on a growth trajectory in their economic relations with Algeria, accounting for modest shares of total bilateral trade.

Our findings both align with and extend the existing literature on trade patterns. The persistently extreme concentration in Algeria's exports strongly corroborates Aissaoui's (2001) historical analysis of the structural dominance of hydrocarbons in Algeria's economy and trade relations. Results provide empirical validation for the theoretical framework of Imbs and Wacziarg (2003); as an upper-middle-income country, Algeria's extreme specialization contradicts the expected diversification path, an effect that locks energy-exporting nations into specialized trade structures.

The identified asymmetry—where exports are more concentrated than imports—echoes findings in studies of other resource dependent economies (e.g., Agosin et al., 2012), reinforcing the notion that export concentration is inherently higher in countries with a narrow commodity-based export basket.

This study reveals a nuance not deeply explored in earlier work on Algeria-EU relations: the significant volatility in import concentration. The dramatic rise of Bulgaria as a key partner in 2022-2023 is a finding absent from earlier studies, such as Cherif (2013). The dramatic rise of Bulgaria as a key partner in 2022-2023 is a finding absent from earlier studies, such as Cherif (2013). Given the high concentration level, strategies should diversify both import sources and export destinations within the EU to reduce vulnerability to shocks in specific countries.

Risk Management

The high concentration of exports, particularly in the energy sector, directed towards a limited number of markets, represents a significant risk to economic stability. To mitigate this exposure, it is essential to diversify export destinations and develop new products. A strategic shift towards greater use of LNG carriers and oil tankers would reduce reliance on fixed pipeline infrastructure, enhance logistical flexibility, and provide access to a broader range of global markets. This approach would strengthen Algeria's resilience against fluctuations in demand from any single economy.

Strategic Diversification

Algeria should proactively leverage the evolving dynamics within the European Union to its advantage. By strategically leveraging its Association Agreement, it can prioritize and cultivate new trade partnerships with emerging Eastern European economies, such as Slovenia, Croatia, and Poland. This forward-looking approach aims to build resilient economic ties with growing markets ahead of potential shifts in the EU's internal structure, thereby future-proofing its export economy and reducing its risk profile.

Sectoral Policies

Industrial and investment policies should encourage diversification both within and beyond the energy sector to reduce export concentration.

Limitations and suggestions for future research

This study has some limitations. Primarily, its emphasis on the country-partner level limits the analysis of product composition and firm dynamics behind the observed concentration. While exploring product diversity in Algeria may be challenging, focusing on the variations in product concentration in more diversified economies, such as intra-EU trade, could yield valuable insights. Future research should aim to disaggregate data by SITC or HS code categories to provide more precise recommendations for sectoral diversification policies. Additionally, although the Gini coefficient is a widely recognized measure of inequality, it does not effectively capture extreme variations in the distribution. Future studies should consider using alternative metrics, such as the Theil index or Palma ratio, to achieve a deeper understanding of inequality and its broader implications.

Author Contributions: Conceptualization, D. M., T. M., and N. B.; methodology, D.M., T. M., and N. B.; software, -; validation, D. M., T.M., and N.B.; formal analysis, D. M., T.M., and N.B.; investigation, D.M., T. M., and N.B.; resources, D. M., T. M., and N.B.; data curation, D.M., T.M., and N.B.; writing—original draft preparation, D.M., T.M., and N.B.; writing—review and editing, D. M., T. M., and N.B.; visualization, D. M., T. M., and N. B.; supervision, D. M., T. M., and N. B. All authors have read and agreed to the published version of the manuscript. Add information!!

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable. The study uses aggregated, publicly available macroeconomic data and involves no human participants or personally identifiable information.

Informed Consent Statement: Not applicable.

Data Availability Statement: The raw trade data supporting the conclusions of this article are publicly available from the Algerian Office for National Statistics (ONS) in its annual reports on foreign trade (see Section 3.1). The aggregated dataset and calculations used for the Lorenz curves and Gini coefficients in this study are available from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declare no conflicts of interest.

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Biography

Mezouaghi Djilali, PhD, is a Professor lecturer at the Faculty of Economic, Commercial and Management Sciences, University of Ahmed Zabana Relizane, Algeria. His research agenda centers on the quantitative analysis of international trade and financial flows. By employing advanced econometric techniques, time-series modeling, and mathematical statistics, he investigates patterns of trade concentration, the impact of financial integration, and the formulation of evidence-based economic policies.

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Динамика концентрације међународне трговине: анализа Лоренцове криве и Гини коефицијента трговине Алжира и ЕУ (2018–2023)

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насеље Боурмадија, Релизан, Алжир

Кључне ријечи:
Концентрација трговине,
односи Алжир–ЕУ,
Лоренцова крива,
Гини коефицијент,
неједнакост увоза,
неједнакост извоза,
диверсификација трговине

JEL класификација: C43, F13, O19

САЖЕТАК

Ова свеобухватна студија испитује структуру и еволуцију трговинских односа између Алжира и Европске уније у периоду од 2018. до 2023. године кроз призму алата за мјерење неједнакости. Користећи Лоренцове криве и Гини коефицијенте, анализирамо обрасце концентрације увоза и извоза по државама чланицама ЕУ. Наши налази указују на упорно висок ниво концентрације трговине, са изразито високим степеном неједнакости у дистрибуцији извоза (Гини коефицијенти: 0,863–0,896) и веома високом неједнакошћу у дистрибуцији увоза (Гини коефицијенти: 0,752–0,862). Истраживање идентификује значајне структурне промјене у периоду 2022–2023, посебно појаву Бугарске као важног увозног партнера Алжира. Студија доприноси разумјевању динамике концентрације трговине у односима Сјеверна Африка – Европа и нуди смјернице за креирање политика усмјерених на диверсификацију трговине.