

Article

Croatia's Economic Integration in EU's Regional Supply Chains: Panel Data Quantile Regression

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Abstract: *Background:* Recent global disruptions have exposed the vulnerability of international supply chains, prompting a shift toward regionalization to enhance economic resilience. As a European Union (EU) member, Croatia has an opportunity to strengthen its integration into EU regional value chains (RVCs), fostering economic stability and competitiveness. This study examines Croatia's integration into EU RVCs and its economic impact. *Methods:* Using panel data from the UNCTAD–Eora database (2000–2019), this study applies panel data quantile regression (PDQR) to analyse Croatia's trade relationships with EU Member States. Unlike traditional regression models, PDQR captures variations in trade dynamics across different levels of economic activity, providing a more detailed understanding of Croatia's trade resilience. *Results:* The findings show that Croatia's trade integration strengthens at higher economic quantiles ($\tau = 0.75\text{--}0.85$), reflecting its ability to scale exports during economic expansions. Lower quantiles ($\tau = 0.05\text{--}0.25$) display stable but less dynamic trade patterns, suggesting a need for targeted policy interventions to enhance supply chain resilience. Strong trade linkages with Germany, Austria, Slovenia, Hungary, and Italy highlight Croatia's comparative advantage in high-value trade sectors. *Conclusions:* Croatia's integration into EU RVCs supports economic resilience and competitiveness. These findings provide insights for policymakers to optimize trade participation and mitigate vulnerabilities. By demonstrating the benefits of quantile-based trade analysis, this study advances the discourse on regional economic integration.



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Keywords: Croatia; European Union; economic integration; panel data quantile regression; trade resilience; supply chains

1. Introduction

Global disruptions have exposed supply chain vulnerabilities, driving a shift toward regionalization to enhance resilience. Economic resilience is an economy's ability to absorb shocks, adapt, and maintain stability [1,2]. It includes both absorptive and adaptive capacities, allowing economies to mitigate risks and leverage new opportunities [3]. For smaller economies like Croatia, RVCs strengthen regional trade ties, enhance stability, and reduce reliance on distant markets [4].

As an EU member state, Croatia has a unique opportunity to integrate more deeply into EU regional supply chains, with significant benefits for trade, competitiveness, and economic growth. Croatia's role in RVCs is understudied, as most research focuses on larger EU economies [5–7]. Croatia's location between Central Europe, the Balkans, and the Mediterranean enhances its potential for regional trade and supply chain integration.

This study examines Croatia's EU RVC integration using panel data quantile regression (PDQR). PDQR goes beyond average effects, revealing Croatia's trade resilience across different economic quantiles. Using UNCTAD Eora Multiregional Input–Output Database [8] panel data, this study evaluates whether Croatia's trade relations with key EU partners, including Germany, Austria, Slovenia, Hungary, and Italy, strengthen at higher economic quantiles or remain stable at lower ones.

This study examines whether Croatia is integrated into the EU regional supply chain. This hypothesis examines Croatia's trade resilience within the EU supply chain network, assessing whether regional integration buffers against global shocks and enhances economic stability. By evaluating Croatia's adaptive capacity under different economic conditions, this study provides empirical evidence on the effectiveness of RVC integration efforts. Findings provide policymakers with strategies to strengthen Croatia's RVC role, improve supply chain adaptability, and enhance competitiveness. Given the accelerating shift from globalized to regionalized trade, driven by the COVID-19 pandemic and geopolitical shifts, this research underscores the importance of localized supply networks in ensuring economic resilience and sustainable growth.

This paper is structured as follows: Section 2 reviews the relevant literature; Section 3 outlines the dataset and sources; Section 4 details the methodological approach; Section 5 presents the quantile regression results; Section 6 interprets the findings; and Section 7 concludes with policy recommendations.

2. Literature Review

We analyzed Web of Science articles to assess research on regional supply chain integration. We refined searches using keywords like supply chain management, integration, and regional to refine our search results. We obtained a total of 362 relevant academic articles, with the earliest publications dating back to the early 2000s. The research volume and citations have surged in the past decade, highlighting a growing interest in RVCs (Figure 1).

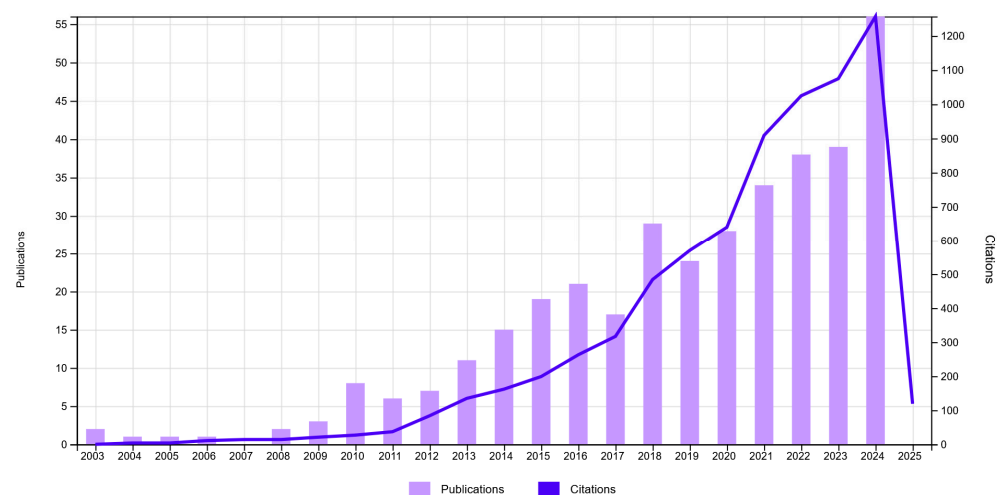


Figure 1. Time distribution of the number of publications and citations for the field of regional supply chain integration. Source: Authors using the WoS web service.

Most studies focus on environmental sciences (64), management (62), and green technology (54). A detailed focus on publications that support the same field of study is made possible by identifying relevant subject areas (Figure 2).



Figure 2. Distribution of subject areas for analyzed articles in the field of regional supply chain integration. Source: Authors using the WoS web service.

During the papers' review process, the chosen articles were rapidly perused to check for any possible discrepancies in their summaries and conclusions. This was carried out in order to maintain the focus of the literature evaluation.

Key topics include supply chain management, integration, innovation, optimization, and sustainability. A heat map has also been created based on the analysis of titles, abstracts, and keywords to better illustrate the key focus areas of research (Figure 3).

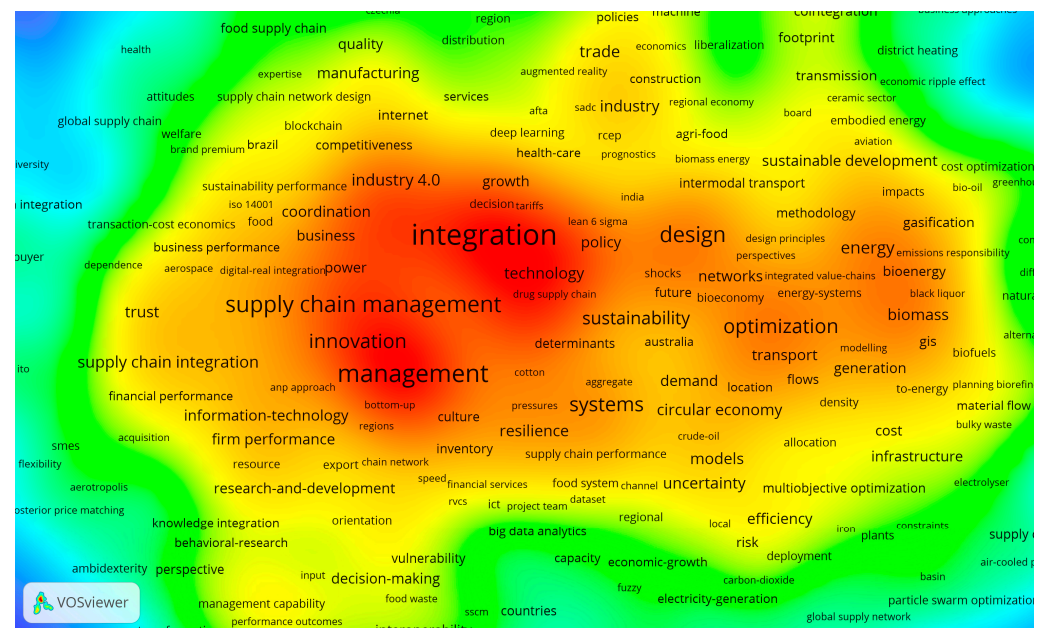


Figure 3. Heat map of keywords showing the frequency of terms related to regional supply chain integration. Warmer colors toward the center indicate higher frequency, highlighting core research themes. Source: Authors (analysis performed using the VOSviewer software ver. 1.6.20).

Although the analysis showed a wide area of research focus, it also revealed that there is an evident lack of research that is comprehensively focused on regional supply chain integration.

Regional supply chains boost efficiency by leveraging local resources, reducing costs, and enhancing resilience. By utilizing local resources and proximity, they optimize supply chain management and logistical performance within a given geographic boundary, promoting economic development and ensuring the efficient delivery of goods and services. A strong transportation infrastructure stabilizes prices, shortens delivery times, and boosts

economic performance [9]. Regional supply chains foster technological innovation and local knowledge transfer, strengthening innovation ecosystems and stimulating business growth [10,11]. The evolution of supply chains requires the continuous adaptation of economic actors, including customs, inland transportation, and maritime shipping companies, as they integrate into increasingly complex logistics networks [12]. Supply chain integration extends beyond traditional roles, requiring active participation in networked logistics systems, particularly in port operations and regional transportation hubs [13,14]. More resilient than global alternatives, regional supply chains allow faster responses to disruptions and reduce vulnerabilities [15]. Supply chain managers play a crucial role in ensuring adaptive recovery strategies [16], though the link between resilience and sustainability remains underexplored [17].

Regional clusters, where companies collaborate within a geographic area, improve supply chain efficiency, and reduce transaction costs. Trust and cooperation lower internal contract enforcement and monitoring costs [18]. Cluster effects drive economies of scale, boosting competitiveness and sustainability [19]. Domestic market integration, trade volume, and economic development shape regional supply chain sustainability, guiding policy decisions [9,20]. Expanding regional supply chains internationally introduces challenges, including compliance with trade regulations and maintaining global competitiveness [21]. Advances in strategic planning and technology have transformed supply chain models, tackling bottlenecks, digitalization, and sustainability. ICT solutions and advanced logistics enhance efficiency [22,23]. Regional logistics hubs improve supply chain responsiveness and resilience [24], as the competition shifts from individual firms to regional clusters, emphasizing strategic collaboration [18].

GVCs and RVCs shape global production, trade, and policy. Value chains span design to delivery, leveraging geographic dispersion for efficiency. Trade liberalization and technology have fragmented production, with intermediates comprising over half of global imports and 70% of service trade [25]. However, geopolitical tensions and COVID-19 have exposed GVC risks, prompting a shift toward RVCs, which enhance resilience, particularly benefiting smaller EU economies like Croatia. Most research focuses on larger EU economies, leaving Croatia's role underexplored. Studies on its trade with Germany, Austria, and Italy rely on aggregate data or linear models, overlooking trade variability across economic conditions. While Mance et al. [26] examined Croatia's RVC participation and Mance et al. [27] assessed the influencing variables, neither study analyzed the trade dynamics across different value-added quantiles. Capturing this variability informs policies that strengthen economic resilience.

GVCs encompass all the production stages, including design, marketing, and customer service, providing insights into firm strategies and macroeconomic networks [28]. Initially focused on cost efficiency, these networks now address broader concerns such as sustainability and labor standards [29,30]. GVCs are divided into producer-driven chains, dominated by high-tech firms, and buyer-driven chains, typical of labor-intensive industries like textiles [31]. Recent research conceptualizes GVCs as interconnected networks rather than linear chains, reflecting the increasing production complexity [32]. In contrast, RVCs align production and trade within specific economic zones, serving regional rather than global markets [33]. Driven by economic and geopolitical uncertainties, international production networks are becoming increasingly regionalized, with trade clusters concentrated in North America, Asia, and Europe [34]. Within Europe, Germany serves as a hub coordinating extensive intra-EU trade, strengthening localized supply chains and reducing the dependence on distant markets [35]. RVCs also provide clearer insights into economic contributions by emphasizing value-added trade rather than gross flows, avoiding distortions from multiple border crossings. Friesenbichler et al. [36] analyzed the effects of

the EU single market, highlighting asymmetric economic performance among member states due to structural differences, institutional variations, and demand shifts. This study underscores the key implications for EU and national policies, particularly in strengthening RVC efficiency and resilience [36].

For Croatia, transitioning to RVCs presents an opportunity to deepen regional trade integration and enhance economic resilience. Its strategic EU location facilitates stronger ties to interconnected supply chains, improving competitiveness while reducing external vulnerabilities. Recent global disruptions, including COVID-19 and geopolitical tensions, have reinforced the role of robust regional supply chains in ensuring economic stability. The OECD's Towards Balanced Regional Development in Croatia [37] report highlights the importance of multi-level governance and strategic planning to boost competitiveness. However, challenges remain, including sub-national governance fragmentation and the financial sustainability of Regional Development Agencies (RDAs), which play a crucial role in trade facilitation and infrastructure development. Similarly, the World Bank's Country Economic Memorandum for Croatia [38] notes that while Croatia has shown economic resilience, slow productivity gains hinder deeper EU supply chain integration. Weak total factor productivity, labor market inefficiencies, and regional imbalances limit competitiveness, while lower investments in R&D and digital transformation constrain Croatia's ability to compete in higher-value trade sectors. Addressing these challenges is critical for enhancing Croatia's participation in RVCs, promoting sustainable growth, and aligning with EU strategic goals, such as the European Green Deal.

Table 1 succinctly provides current research contributions with used panel data models, case studies, regional focuses, and key findings. In continuation, we represent the contributions of this study.

Table 1. Contributions of current papers and their key findings.

Study	Model Type	Case Study	Regional Focus	Key Findings
Mance et al. (2023), in: <i>Economies</i> (MDPI). [26]	Panel FMOLS, EGLS; Dumitrescu–Hurlin Causality, Impulse Response Functions	Croatia and EU Trading Partners	CEEC RVCs	The VA of Croatian exports is statistically related to the VA of exports from the main EU trading partners: Croatian RVCs are robust and structured around regional production centres.
Mance et al. (2023), in: <i>Ekonomski Vjesnik</i> . [27]	Panel GMM (Arellano–Bond Estimator), Spearman Rank Correlation	CEECs	RVCs and ICT Integration	ICT adoption positively correlates with efficiency, logistics performance, and cost-effectiveness in regional value chains.
Li et al. (2023), in: <i>Sustainability</i> (MDPI). [39]	Non-linear Model and Spatial Spill over Effects with Panel Data	Chinese Cities	GVCs	The non-linear impact of GVC participation on regional economic growth in China. A U-shaped relationship and technological innovation as a mediating factor.
Taguchi & Lar (2024), in: <i>Economies</i> (MDPI). [40]	Panel Vector Auto-Regressive (PVAR) Model	Emerging and Developing Asian Economies	Servicification in GVCs	Investigated how services integrate into GVCs in Asia, highlighting reciprocal interactions between business services and manufacturing.
Sada & Ikeda (2021), preprint on arXiv. [41]	Network Science Methods	Global	RVCs	Detected regional communities (Europe and the Pacific Rim) in international value-added networks and evaluated economic integration using network science methods.
This Study	Panel Data Quantile Regression (PDQR)	Croatia	EU RVCs	Captures heterogeneous trade effects across different economic conditions, showing trade integration shifts across economic cycles.

Source: own representation.

This study contributes to the existing literature on GVCs/RVCs by introducing:

- The use of panel data quantile regression (PDQR) in the RVC analysis: in contrast to previous studies that used linear panel models (FMOLS, GMM, PVAR), this study uses PDQR to capture the heterogeneous effects of trade integration at different economic levels.
- Trade integration across business cycles shows how Croatia's trade integration shifts between low and high economic quantiles, highlighting structural resilience and vulnerability.
- A value-added trade analysis, which differentiates trade patterns between economic quantiles and provides a nuanced view of Croatia's role in the EU's RVCs.
- Policy-driven insights on trade resilience: the study goes beyond correlations by linking quantile-specific insights with policy recommendations on diversification, infrastructure, and supply chain resilience.
- Integration intensity with key EU partners, which identifies differences in Croatia's trade relations with Austria, Germany, Slovenia, and Hungary.
- A regional trade competitiveness policy, which proposes measures for trade diversification, infrastructure, and sectoral investment.

3. Data

The data used in this study are from the UNCTAD–Eora Multi-Regional Input–Output [8] database, which covers the period from 2000 to 2019. The data are from the multi-regional input–output table created as part of the EORA project. The calculation of the data to measure trade in value added follows the generally accepted procedure described in Koopman et al. [5] as depicted in Table 2.

Table 2. Example of a UNCTAD–Eora Global Value Chain (GVC) basic input–output table.

	Final Demand		Gross Output
	Country A	Country B	
Country A	Final use by A of its own domestic output	Final use by B of exports from A	Gross output of A
Country B	Final use by A of exports from B	Final use by B of its own domestic output	Gross output of B
Value added	Value added of A	Value added of B	
Gross input	Gross output of A	Gross output of B	

Source: own representation as in [26] based on [8].

The MRIO database allows for the decomposition of gross trade flows into value-added contributions, which enables a better understanding of the actual economic impact of trade relations. This approach mitigates distortions caused by the repeated cross-border movement of intermediate goods. This database provides detailed input–output tables that capture trade flows and value-added contributions between countries and sectors. It is particularly suitable for analyzing value-added trade relationships within global and regional value chains. The inclusion of all 27 EU member states ensures comprehensive coverage of Croatia's trade dynamics within the European Union. By focusing on value-added measures, the study highlights the direct contributions of Croatian trade with important EU partners, such as Austria, Germany, Hungary, and Slovenia.

Key variables in the dataset include bilateral trade flows, value-added shares of exports and imports, as well as macroeconomic indicators, such as GDP and sectoral trade shares.

To ensure the integrity of the data, missing values in the UNCTAD–Eora MRIO dataset were handled using linear interpolation for individual gaps, while longer missing periods were excluded to avoid bias. Outliers were assessed using a distributional analysis to ensure that they did not bias the quantile regression estimates. Key variables include bilateral trade flows, value-added shares, and macroeconomic indicators, such as GDP and sectoral trade shares, which were selected to capture Croatia’s trade relations and broader economic integration into regional value chains.

These variables form the basis for assessing Croatia’s integration into regional value chains and understanding the structural drivers of its trade relations. The longitudinal nature of the data enables an analysis of the trade dynamics over two decades and provides valuable insights into the development of Croatia’s economic integration in the EU.

We are aware of certain limitations that are inherent in the UNCTAD–Eora Global Value Chain (GVC) database. While it provides a comprehensive multiregional input–output (MRIO) framework for analyzing trade flows and value-added contributions, the database relies on national input–output tables and aggregate data sources that can overlook specific trade dynamics at the firm level. In addition, the database does not fully capture informal trade flows or recent structural shifts in regional value chains, especially those that occurred after 2018 due to geopolitical and pandemic-related disruptions [42]. These limitations should be considered when interpreting the results. Future studies could benefit from the inclusion of alternative datasets or company-level trade data to obtain a more detailed analysis.

4. Methods

This study builds on the previous work by Mance et al. [26] that analyzed Croatia’s integration into regional value chains (RVCs) using advanced econometric techniques. The earlier study used dynamic panel methods, including first differencing to account for non-stationarity, Dumitrescu–Hurlin panel non-causality tests to examine bilateral causal relationships, and a panel EGLS with fixed effects and cross-sectional SUR adjustments to control for heterogeneity and cross-sectional dependence. By extending the analysis to quantile regression, this paper complements these results by showing how trade dynamics vary under different economic conditions. Since in this paper we used the same dataset as in the previous one, for purposes of brevity, most of the tests will not be repeated here. Thus, we proceed immediately to the explanation of the quantile regression.

The quantile regression model assumes the following relationship for a given quantile τ where $0 < \tau < 1$:

$$\text{Quant}_{\tau}(y_{it}|x_{it}) = x_{it}\beta(\tau); t = 1, \dots, T; i = 1, \dots, I \quad (1)$$

where $\text{Quant}_{\tau}(y_{it}|x_{it})$ represents the conditional quantile function, y_{it} is the dependent variable, x_{it} is the vector of the independent variables, and $\beta(\tau)$ represents the quantile-specific coefficients. This formulation captures how changes in x_{it} influence different quantiles of y_{it} , enabling a detailed exploration of the heterogeneous effects.

For the panel data, quantile regression extends to incorporate unobserved heterogeneity. The model can include idiosyncratic effects α_i as follows:

$$\text{Quant}_{\tau}(y_{it}|x_{it}, \alpha_i) = x_{it}\beta(\tau) + \alpha_i; t = 1, \dots, T; i = 1, \dots, I \quad (2)$$

Estimating this model poses challenges, particularly in accounting for the incidental parameter problem when I (cross-sectional unit) is large and T (time period) is small. This issue can be addressed by leveraging partial effects and treating time-specific intercepts,

which improves estimation consistency. Quantile regression is also computationally robust, as it minimizes the following objective function:

$$\min_{\beta} \sum_i^I \sum_t^T \rho_{\tau}(y_{it} - x_{it}\beta); t = 1, \dots, T; i = 1, \dots, I \quad (3)$$

where $\rho_{\tau}(u) = u \cdot (\tau - I(u < 0))$ is the control function. This approach ensures that deviations from the predicted quantile are weighted differently depending on their sign, allowing for the precise estimation of quantile-specific coefficients [43].

Quantile regression provides a robust framework for analyzing complex trade relationships by overcoming the limitations of traditional linear regression. Unlike ordinary least squares (OLS), which estimates the conditional mean effects, quantile regression captures variations across different economic conditions and provides a more comprehensive assessment of trade integration. As Wooldridge [43] explains, this approach extends the traditional panel data analysis by accounting for heteroscedasticity and providing a detailed look at the conditional distribution of the dependent variable. It is particularly valuable for economic research as it identifies non-linear dynamics and influential factors at different points in the distribution.

In this study, quantile regression is applied to assess Croatia's trade integration under different economic conditions and value-added structures. The lower quantiles ($\tau = 0.05$ – 0.25) reflect trade behavior during downturns, while the upper quantiles ($\tau = 0.75$ – 0.95) capture trade behavior during upturns. In contrast to OLS, which focuses on average effects and possibly overlooks trade asymmetries, this approach shows that Croatia maintains stable trade relations in the lower quantiles but experiences greater integration in the higher quantiles, especially with key EU partners such as Germany, Austria, and Slovenia. This suggests that the resilience of Croatian trade increases during economic growth, highlighting the need for policies that stabilize trade during downturns.

In addition to economic fluctuations, this study also examines trade integration based on value-added structures. Low quantiles indicate trade characterized by low value-added activities where Croatia relies on imported inputs and assembly processes. In contrast, higher quantiles reflect high value-added trade and signal deeper integration into EU supply chains through specialized intermediate goods and services. By distinguishing between dynamic (expansion vs. contraction) and structural (low- vs. high value-added trade) quantile effects, this analysis provides a more detailed understanding of Croatian trade patterns. The results emphasize the importance of policies that increase domestic value-added content, promote trade diversification, and improve resilience in times of economic downturn.

To ensure robustness, several pre-processing steps were carried out before applying the quantile regression. First, all the variables were first differenced to control for unobserved heterogeneity and non-stationarity. This transformation mitigates the problem of the unit root, improves the reliability of the estimates, and reduces the bias due to the omitted variables. By focusing on changes rather than absolute levels, the analysis isolates dynamic trade responses and provides clearer insights into how variations in key factors affect Croatia's integration into the EU RVCs.

A key challenge in applying quantile regression to panel data is to account for unobserved heterogeneity, especially time-invariant country-specific effects. While fixed and random effects models are standard in panel regression, quantile regression requires alternative techniques to account for bias. In this study, an estimator that controls for unobserved heterogeneity ensures the robustness of the regression coefficients across the quantiles. The choice of quantile regression is particularly important given the asymmetric nature of business cycles. Trade patterns differ significantly between the expansion and contraction

phases, with stronger trade integration in higher quantiles ($\tau = 0.75\text{--}0.85$) during economic growth and more stable but less dynamic trade in lower quantiles ($\tau = 0.05\text{--}0.25$) during downturns. In addition, this method is less sensitive to outliers and skewed distributions that are common in trade data due to external shocks, supply chain disruptions, and sectoral fluctuations. By identifying asymmetric effects under different economic conditions, quantile regression provides valuable insights for policy makers to identify vulnerabilities and develop targeted trade strategies.

The methodological process follows a structured series of statistical tests and transformations. Unit root tests, including the Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests, were performed to determine stationarity. When non-stationarity was detected, differencing was performed to stabilize the mean and variance over time. Multicollinearity between the explanatory variables was examined using the variance inflation factor (VIF) to avoid estimation errors. The Breusch–Pagan and Jarque–Bera tests were performed to assess the heteroscedasticity and non-normality of the error distributions and to clarify the reasons for using quantile regression instead of OLS.

This study uses quantile regression to assess Croatia’s intra-EU trade linkages and their impact on economic resilience, providing actionable insights for policy makers. The results underline the need for targeted interventions to strengthen Croatia’s position in regional value chains and improve its adaptability to economic fluctuations. Deepening Croatia’s integration into EU supply chains contributes to a more resilient regional economy—a goal shared by other EU Member States facing similar challenges.

By capturing trade patterns under different economic conditions, quantile regression provides a comprehensive analysis of Croatia’s trade integration. This approach enables policy makers to take measures that mitigate risks in the lower trade quantiles while optimizing opportunities in the higher quantiles to strengthen Croatia’s role in the EU’s evolving trade network.

Logarithmic transformations were deliberately avoided, as they have their limitations when dealing with first-differentiated data. The presence of negative values, often resulting from trade reversals, makes the logarithmic transformation undefined and requires the addition of an arbitrary constant, which can lead to bias in the estimation. Furthermore, the application of logarithms to first-differenced data increases the noise for small changes, leading to unreliable estimates. In addition, the interpretation of the logged coefficients becomes less intuitive as it incorporates the elasticity of change, which may not be consistent with the practical policy needs. Given the characteristics of the dataset, logarithmic transformations would unnecessarily increase complexity without improving analytical precision.

5. Results

This study uses quantile regression to assess Croatia’s integration into EU regional value chains in order to provide a detailed assessment of trade dynamics under different economic conditions. The results indicate strong trade linkages with Austria, Germany, Hungary, and Slovenia, especially at higher quantiles, suggesting deeper integration in times of economic expansion. Conversely, weaker or statistically insignificant relationships with countries such as Finland and Estonia illustrate the concentration of Croatian trade relations on its most important partners.

The ADF test assessed for unit roots using two specifications: with constant (non-zero mean, no trend), and with constant and trend (deterministic trends).

At the form level, most trade-related variables were non-stationary (p -values > 0.05), so differencing was necessary to achieve stationarity in all EU Member States. The “With Constant (Intercept Only)” model was used to identify possible shifts due to economic

shocks or policy changes and played the role of the structural break test at the level. The UNCTAD–Eora MRIO database contained no missing data for the EU Member States and only small individual gaps in other countries of the world, which were compensated for using linear interpolation. This ensures that the PDQR estimates remain robust and unbiased and accurately reflect Croatia’s integration into EU regional supply chains.

Table 3 summarizes the full ADF test results.

Table 3. Augmented Dickey–Fuller stationarity tests before and after first differencing.

	At Level				At First Difference			
	With Constant		With Constant and Trend		With Constant		With Constant and Trend	
	t-Statistic	Prob.	t-Statistic	Prob.	t-Statistic	Prob.	t-Statistic	Prob.
Croatia	0.3475	0.4049	0.7528	0.2665	0.0010	0.0000	0.0028	0.0002
Austria	0.4611	0.0634	0.7491	0.9395	0.0005	0.0000	0.0014	0.0099
Belgium	0.4280	0.0676	0.8052	0.8798	0.0003	0.0000	0.0007	0.0042
Bulgaria	0.4194	0.3770	0.8327	0.7956	0.0013	0.0003	0.0032	0.0006
Cyprus	0.3604	0.3161	0.8252	0.4043	0.0014	0.0000	0.0031	0.0067
Czech Republic	0.5940	0.2473	0.5679	0.4768	0.0005	0.0000	0.0025	0.0060
Denmark	0.4203	0.2873	0.7231	0.9523	0.0002	0.0000	0.0007	0.0038
Estonia	0.4738	0.3872	0.7595	0.7731	0.0012	0.0002	0.0251	0.0066
Finland	0.4243	0.3132	0.6416	0.9570	0.0002	0.0002	0.0007	0.0132
France	0.4733	0.0940	0.6769	0.3618	0.0002	0.0001	0.0008	0.0004
Germany	0.5538	0.2055	0.5355	0.3674	0.0002	0.0000	0.0009	0.0002
Greece	0.4605	0.1603	0.5690	0.0526	0.0002	0.0000	0.0010	0.0003
Hungary	0.5129	0.3382	0.6645	0.9514	0.0003	0.0002	0.0011	0.0414
Ireland	0.4623	0.3454	0.9399	0.8855	0.0072	0.0014	0.0087	0.0208
Italy	0.4143	0.4692	0.7238	0.2551	0.0007	0.0000	0.0020	0.0003
Latvia	0.4526	0.3061	0.8060	0.8418	0.0016	0.0005	0.0250	0.0094
Lithuania	0.5694	0.3325	0.5354	0.6203	0.0003	0.0000	0.0196	0.0072
Luxembourg	0.4751	0.3988	0.9374	0.8120	0.0112	0.0010	0.0192	0.0023
Malta	0.3139	0.0457	0.7319	0.0441	0.0004	0.0146	0.0135	0.0659
Netherlands	0.4243	0.4098	0.7572	0.9827	0.0002	0.0001	0.0007	0.0058
Poland	0.6598	0.3446	0.3686	0.9001	0.0002	0.0011	0.0012	0.0179
Portugal	0.4913	0.0205	0.6199	0.0188	0.0001	0.0000	0.0146	0.0002
Romania	0.4758	0.2859	0.6956	0.9797	0.0004	0.0000	0.0013	0.0297
Slovakia	0.6886	0.3300	0.3698	0.8819	0.0003	0.0010	0.0018	0.0243
Slovenia	0.5840	0.4572	0.5777	0.2306	0.0003	0.0000	0.0014	0.0089
Spain	0.4935	0.1365	0.7305	0.2349	0.0005	0.0001	0.0014	0.0003
Sweden	0.5323	0.3395	0.6078	0.9419	0.0004	0.0001	0.0015	0.0266

Sample (adjusted): 2001–2019. Lag length based on SIC. Probability based on one-sided *p*-values. Null hypothesis: the variable has a unit root.

The quantile regression model estimated with EViews 13 shows statistically significant correlations between Croatia’s export value added and its most important EU trading partners. Slovenia has consistently strong trade links across all quantiles, while weaker links with some countries indicate limited participation in the supply chain. Statistically insignificant coefficients were greyed out in the tables with results.

Table 4 shows the quantile regression analysis of Croatian value-added exports with a focus on the lower economic quantiles ($\tau = 0.05$ to $\tau = 0.25$) and trade dynamics with 24 EU Member States. At lower quantiles ($\tau = 0.05$ – 0.25), trade linkages remain stable but less dynamic, highlighting potential structural limitations in weaker economic conditions. The results show significant coefficients for all trading partners, indicating a strong correlation between their VA imports and Croatia’s VA exports. Slovenia consistently has the highest coefficients across all quantiles, highlighting its key role in Croatia’s regional supply chains. Other notable partners are Austria, Hungary, and Italy, which have strong trade relations, while Latvia, Lithuania, and Portugal have lower coefficients, reflecting limited economic interaction. Interestingly, Germany and France have moderate coefficients, indicating Croatia’s regionally oriented integration, where geographical proximity is an important factor for trade relations.

Table 4. Quantile regression of Croatia’s VA as a dependent variable from Tau = 0.05 to Tau = 0.25.

Country	Coef. Tau = 0.05	Coef. Tau = 0.1	Coef. Tau = 0.15	Coef. Tau = 0.2	Coef. Tau = 0.25
D(Austria)	0.001607	0.001606	0.001590	0.001585	0.001575
D(Belgium)	0.000215	0.000195	0.000186	0.000186	0.000193
D(Bulgaria)	0.000893	0.000531	0.000435	0.000448	0.000440
D(Cyprus)	0.003744	0.001003	0.000433	0.000348	0.000305
D(Czech Republic)	0.000623	0.000557	0.000538	0.000716	0.000772
D(Denmark)	0.000239	0.000216	0.000212	0.000206	0.000207
D(Estonia)	0.001230	0.000307	0.000149	0.000126	0.000115
D(Finland)	0.000158	0.000147	0.000133	0.000129	0.000140
D(France)	0.000151	0.000148	0.000141	0.000139	0.000156
D(Germany)	0.000348	0.000357	0.000388	0.000385	0.000389
D(Greece)	0.000763	0.000674	0.000566	0.000618	0.000612
D(Hungary)	0.001582	0.001487	0.001466	0.001460	0.001456
D(Ireland)	0.000229	0.000141	0.000161	0.000155	0.000188
D(Italy)	0.000865	0.000862	0.000933	0.000930	0.000946
D(Latvia)	0.000870	0.000205	0.000135	9.72×10^{-5}	8.38×10^{-5}
D(Lithuania)	0.000907	0.000247	0.000174	0.000155	0.000146
D(Luxembourg)	0.000860	0.000325	0.000224	0.000203	0.000192
D(Malta)	0.004804	0.001232	0.000825	0.000904	0.000931
D(Netherlands)	0.000167	0.000155	0.000149	0.000184	0.000180
D(Poland)	0.000348	0.000266	0.000245	0.000246	0.000240
D(Portugal)	0.000191	6.82×10^{-5}	4.54×10^{-5}	4.01×10^{-5}	3.67×10^{-5}
D(Romania)	0.000344	0.000265	0.000205	0.000217	0.000209
D(Slovakia)	0.001267	0.001051	0.001018	0.001010	0.001045
D(Slovenia)	0.010474	0.010636	0.010571	0.010557	0.011085
D(Spain)	0.000150	0.000127	0.000119	0.000123	0.000120
D(Sweden)	0.000224	0.000190	0.000181	0.000178	0.000174
Pseudo R-squared	0.187522	0.184090	0.189150	0.195003	0.200646
Adjusted R-squared	0.181595	0.178138	0.183235	0.189130	0.194815
Prob(Quasi-LR stat)	0.000000	0.000000	0.000000	0.000000	0.000000

Sample (adjusted): 2001–2019. Included observations: 3591 after adjustments. Huber sandwich standard errors and covariance. Sparsity method: Kernel (Epanechnikov) using residuals.

The pseudo R-squared values (from 0.1875 at $\tau = 0.05$ to 0.2006 at $\tau = 0.25$) confirm the explanatory power of the model, supported by significant quasi-likelihood ratio statistics. These results underline Croatia’s robust trade relations, which ensure continuous integration into the EU supply chain even in times of economic downturn. The policy implications recommend further strengthening of regional partnerships, especially with key neighbors such as Slovenia and Austria, to improve supply chain resilience and economic stability.

Table 5 provides an insight into the interdependence of Croatian trade with VA at the median quantiles ($\tau = 0.3$ to $\tau = 0.5$), reflecting trade dynamics under moderately favorable economic conditions. The statistical significance of the coefficients remains high for most countries, although a slight variation in significance indicates a possible reduction in the strength of the relationships or the occurrence of non-linearities. Slovenia continues to have the highest coefficients across all quantiles, highlighting its crucial role in Croatia’s trade network, with coefficients of up to 0.011785 at $\tau = 0.5$. Austria, Hungary, and Italy also exhibit robust positive coefficients, further underlining their importance as key partners for Croatia’s regional integration. In contrast, more distant economies such as Latvia, Lithuania, and Portugal show consistently low coefficients, indicating a limited contribution to Croatia’s VA exports. The pseudo R-squared values range between 0.205871 and 0.225338, indicating a stable fit of the model and its ability to explain a considerable part of the variance of Croatia’s VA exports. These results highlight Croatia’s strong and resilient integration into EU value chains, particularly with neighboring and strategically important countries, even under average economic conditions. The results underline the need for a continued policy focus on promoting regional trade linkages in order to further improve economic stability.

Table 5. Quantile regression of Croatia's VA as a dependent variable from Tau = 0.3 to Tau = 0.5.

Country	Coef. Tau = 0.3	Coef. Tau = 0.35	Coef. Tau = 0.4	Coef. Tau = 0.45	Coef. Tau = 0.5
D(Austria)	0.001571	0.001607	0.001593	0.001585	0.001784
D(Belgium)	0.000190	0.000194	0.000203	0.000210	0.000205
D(Bulgaria)	0.000437	0.000440	0.000434	0.000429	0.000423
D(Cyprus)	0.000308	0.000300	0.000294	0.000287	0.000281
D(Czech Republic)	0.000768	0.000759	0.000822	0.000847	0.000870
D(Denmark)	0.000204	0.000200	0.000197	0.000193	0.000263
D(Estonia)	0.000109	0.000122	0.000116	0.000113	0.000108
D(Finland)	0.000137	0.000172	0.000168	0.000164	0.000159
D(France)	0.000155	0.000177	0.000170	0.000165	0.000168
D(Germany)	0.000393	0.000401	0.000391	0.000413	0.000402
D(Greece)	0.000610	0.000665	0.000661	0.000690	0.000686
D(Hungary)	0.001539	0.001557	0.001762	0.001778	0.002092
D(Ireland)	0.000204	0.000248	0.000245	0.000242	0.000259
D(Italy)	0.000945	0.001038	0.001061	0.001057	0.001051
D(Latvia)	7.72×10^{-5}	7.96×10^{-5}	9.34×10^{-5}	8.79×10^{-5}	8.28×10^{-5}
D(Lithuania)	0.000162	0.000161	0.000173	0.000193	0.000189
D(Luxembourg)	0.000187	0.000175	0.000166	0.000158	0.000152
D(Malta)	0.000942	0.000946	0.000949	0.000955	0.000986
D(Netherlands)	0.000185	0.000175	0.000224	0.000244	0.000240
D(Poland)	0.000256	0.000247	0.000284	0.000275	0.000266
D(Portugal)	3.47×10^{-5}	3.47×10^{-5}	3.08×10^{-5}	2.73×10^{-5}	2.27×10^{-5}
D(Romania)	0.000223	0.000210	0.000200	0.000222	0.000281
D(Slovakia)	0.001056	0.001080	0.001215	0.001280	0.001396
D(Slovenia)	0.011080	0.011066	0.011742	0.011799	0.011785
D(Spain)	0.000119	0.000113	0.000109	0.000122	0.000148
D(Sweden)	0.000191	0.000184	0.000179	0.000188	0.000182
Pseudo R-squared	0.205871	0.210892	0.215829	0.220629	0.225338
Adjusted R-squared	0.200077	0.205135	0.210109	0.214943	0.219687
Prob(Quasi-LR stat)	0.000000	0.000000	0.000000	0.000000	0.000000

Sample (adjusted): 2001–2019. Included observations: 3591 after adjustments. Huber sandwich standard errors and covariance. Sparsity method: Kernel (Epanechnikov) using residuals. The results not significant at $p < 0.05$ level are greyed out.

Table 6 analyses Croatia's trade linkages with VA at higher quantiles ($\tau = 0.55$ to $\tau = 0.75$), which captures periods of increased economic activity. The largely significant coefficients highlight the importance of Croatian trade relations with EU member states in prosperous times. Slovenia remains the most influential partner with consistently high coefficients, peaking at 0.013086 at $\tau = 0.65$, underlining its crucial role in the integration of the Croatian value chain. Austria, Hungary, and Italy also show strong and stable contributions, reflecting their significant role in regional trade. In contrast, Latvia, Lithuania, and Portugal have lower and less consistent coefficients, indicating potential areas for strengthening trade relations. The pseudo R-squared values, which increase from 0.229858 at $\tau = 0.55$ to 0.247213 at $\tau = 0.75$, show that the explanatory power of the model increases with increasing economic activity, while the consistently significant quasi-likelihood ratio statistics confirm its robustness. Fluctuations in significance at higher quantiles may reflect non-linearities or different economic effects between partners. These results underscore the value of strategic partnerships with key trading nations during economic growth, alongside efforts to deepen relationships with less integrated partners.

Table 6. Quantile regression of Croatia's VA as a dependent variable from Tau = 0.55 to Tau = 0.75.

Country	Coef. Tau = 0.55	Coef. Tau = 0.6	Coef. Tau = 0.65	Coef. Tau = 0.7	Coef. Tau = 0.75
D(Austria)	0.001770	0.002026	0.002015	0.002105	0.002152
D(Belgium)	0.000200	0.000234	0.000223	0.000292	0.000318
D(Bulgaria)	0.000436	0.000500	0.000492	0.000481	0.000468
D(Cyprus)	0.000383	0.000372	0.000332	0.000276	0.000320
D(Czech Republic)	0.000850	0.000827	0.000989	0.000977	0.000970
D(Denmark)	0.000280	0.000265	0.000259	0.000269	0.000259
D(Estonia)	0.000152	0.000147	0.000148	0.000148	0.000148
D(Finland)	0.000194	0.000174	0.000167	0.000162	0.000156
D(France)	0.000163	0.000148	0.000173	0.000175	0.000167
D(Germany)	0.000394	0.000496	0.000528	0.000520	0.000515
D(Greece)	0.000687	0.000678	0.000672	0.000748	0.000743
D(Hungary)	0.002112	0.002079	0.002071	0.002059	0.002049
D(Ireland)	0.000255	0.000243	0.000239	0.000250	0.000420
D(Italy)	0.001096	0.001073	0.001065	0.001153	0.001262
D(Latvia)	7.52×10^{-5}	7.40×10^{-5}	5.57×10^{-5}	6.21×10^{-5}	2.44×10^{-5}
D(Lithuania)	0.000186	0.000176	0.000256	0.000259	0.000311
D(Luxembourg)	0.000145	0.000123	0.000135	0.000111	8.06×10^{-5}
D(Malta)	0.000973	0.000984	0.001282	0.001197	0.001051
D(Netherlands)	0.000236	0.000221	0.000204	0.000196	0.000255
D(Poland)	0.000278	0.000250	0.000266	0.000409	0.000400
D(Portugal)	1.92×10^{-5}	2.52×10^{-5}	1.91×10^{-5}	1.70×10^{-5}	7.17×10^{-6}
D(Romania)	0.000297	0.000279	0.000275	0.000260	0.000243
D(Slovakia)	0.001723	0.001670	0.001637	0.001761	0.001753
D(Slovenia)	0.012971	0.012944	0.013086	0.013071	0.013055
D(Spain)	0.000167	0.000156	0.000154	0.000147	0.000145
D(Sweden)	0.000236	0.000241	0.000234	0.000229	0.000263
Pseudo R-squared	0.229858	0.234731	0.239445	0.243721	0.247213
Adjusted R-squared	0.224240	0.229149	0.233896	0.238204	0.241721
Prob(Quasi-LR stat)	0.000000	0.000000	0.000000	0.000000	0.000000

Sample (adjusted): 2001–2019. Included observations: 3591 after adjustments. Huber sandwich standard errors and covariance. Sparsity method: Kernel (Epanechnikov) using residuals. The results not significant at $p < 0.05$ level is greyed out.

Table 7 focuses on the upper quantiles ($\tau = 0.8$ to $\tau = 0.99$), where the statistical significance of the coefficients for some variables decreases further and some even lose significance altogether. This decline may indicate that Croatia's trade relations are becoming more selective and concentrated on peaks and highly dependent on a smaller group of trading partners. This variability underlines the importance of diversifying Croatia's trade network and strengthening its resilience to possible overdependence on selected economies. Overall, Croatia's trade integration strengthens at higher economic quantiles ($\tau = 0.8$ – 0.99), reinforcing the hypothesis that regional integration enhances resilience during economic expansions.

The significant trade elasticity at $\tau = 0.85$ suggests that Croatia scales exports effectively during periods of economic growth, benefiting from high-value trade sectors. However, weaker or insignificant coefficients at $\tau = 0.05$ – 0.25 indicate that in economic downturns, trade volumes remain relatively fixed, underscoring the need for policy interventions to enhance flexibility in low-demand conditions.

Figure 4 visualizes Croatia's trade integration with key EU partners across different economic conditions using quantile regression and data from the UNCTAD–Eora MRIO database. For reasons of space, only the upper half of the countries is represented.

Table 7. Quantile regression of Croatia's VA as a dependent variable from Tau = 0.8 to Tau = 0.99.

Country	Coef. Tau = 0.8	Coef. Tau = 0.85	Coef. Tau = 0.9	Coef. Tau = 0.95	Coef. Tau = 0.99
D(Austria)	0.002089	0.002062	0.002054	0.002146	0.002636
D(Belgium)	0.000292	0.000290	0.000290	0.000332	0.000513
D(Bulgaria)	0.000428	0.000599	0.000762	0.001216	−0.002773
D(Cyprus)	0.000109	0.001016	0.002018	0.006960	−0.024002
D(Czech Republic)	0.000932	0.000858	0.000646	0.000705	0.001378
D(Denmark)	0.000235	0.000239	0.000259	0.000312	0.000707
D(Estonia)	7.79×10^{-5}	0.000146	0.000349	0.001032	0.005707
D(Finland)	0.000132	0.000124	0.000143	0.000203	0.000503
D(France)	0.000138	0.000130	0.000126	0.000142	0.000197
D(Germany)	0.000610	0.000593	0.000582	0.000592	0.000395
D(Greece)	0.000726	0.000732	0.000783	0.001053	0.002905
D(Hungary)	0.002038	0.002015	0.002039	0.002324	0.002827
D(Ireland)	0.000375	0.000333	0.000218	0.000198	−0.000658
D(Italy)	0.001380	0.001365	0.001353	0.001317	0.001170
D(Latvia)	−0.000165	−0.000185	−0.000276	0.001102	−0.006205
D(Lithuania)	0.005827	0.004153	0.000749	0.002414	0.004107
D(Luxembourg)	2.84×10^{-5}	$−2.02 \times 10^{-5}$	0.000357	−0.000463	0.002673
D(Malta)	0.001408	0.001304	0.001934	0.005026	−0.025321
D(Netherlands)	0.000212	0.000216	0.000230	0.000238	0.000315
D(Poland)	0.000322	0.000299	0.000308	0.000392	6.08×10^{-5}
D(Portugal)	2.31×10^{-6}	$−2.81 \times 10^{-5}$	$−8.52 \times 10^{-5}$	0.000729	−0.001174
D(Romania)	0.000210	0.000208	0.000232	0.000392	−0.001334
D(Slovakia)	0.002642	0.006093	0.008709	0.004902	0.003961
D(Slovenia)	0.014314	0.014315	0.014386	0.014833	0.017532
D(Spain)	0.000123	0.000210	0.000237	0.000289	0.000839
D(Sweden)	0.000225	0.000213	0.000196	0.002146	0.000479
Pseudo R-squared	0.249299	0.248090	0.239587	0.208549	0.101474
Adjusted R-squared	0.243822	0.242604	0.234040	0.202775	0.094919
Prob(Quasi-LR stat)	0.000000	0.000000	0.000000	0.000000	0.000000

Sample (adjusted): 2001–2019. Included observations: 3591 after adjustments. Huber sandwich standard errors and covariance. Sparsity method: Kernel (Epanechnikov) using residuals. Bandwidth method: Hall-Sheather. The results not significant at $p < 0.05$ level are greyed out.

It shows that during lower economic activity ($\tau = 0.05$ – 0.25), Croatia maintains stable but less dynamic trade relationships, indicating resilience. In contrast, at higher quantiles ($\tau = 0.75$ – 0.85), trade integration strengthens significantly, demonstrating Croatia's ability to scale exports during economic growth.

The strongest trade linkages are observed with Slovenia, Austria, Hungary, Italy, and Germany, confirming Croatia's deep participation in EU regional supply chains, while weaker ties with Portugal, Lithuania, and Sweden suggest regional concentration rather than broad diversification. The analysis underscores that Croatia is statistically integrated into EU value-added trade networks, with economic resilience but room for policy-driven diversification. By relying on a value-added trade analysis rather than gross trade figures, the Eora data highlight Croatia's supply chain dependencies and the need for strategic interventions to enhance competitiveness and trade stability. Notably, Slovenia exhibits the strongest and most consistent trade integration with Croatia across all quantiles, being Croatia's key regional trade partner. Our study also shows that Croatian trade dynamics remain robust during the economic boom, but are more vulnerable during the downturn, especially at the lower quantiles. This points to the need for strategic measures to cushion external shocks and stabilize trade flows. In addition, the strong performance in the higher quantiles underlines Croatia's potential to deepen regional integration and develop high-value sectors.

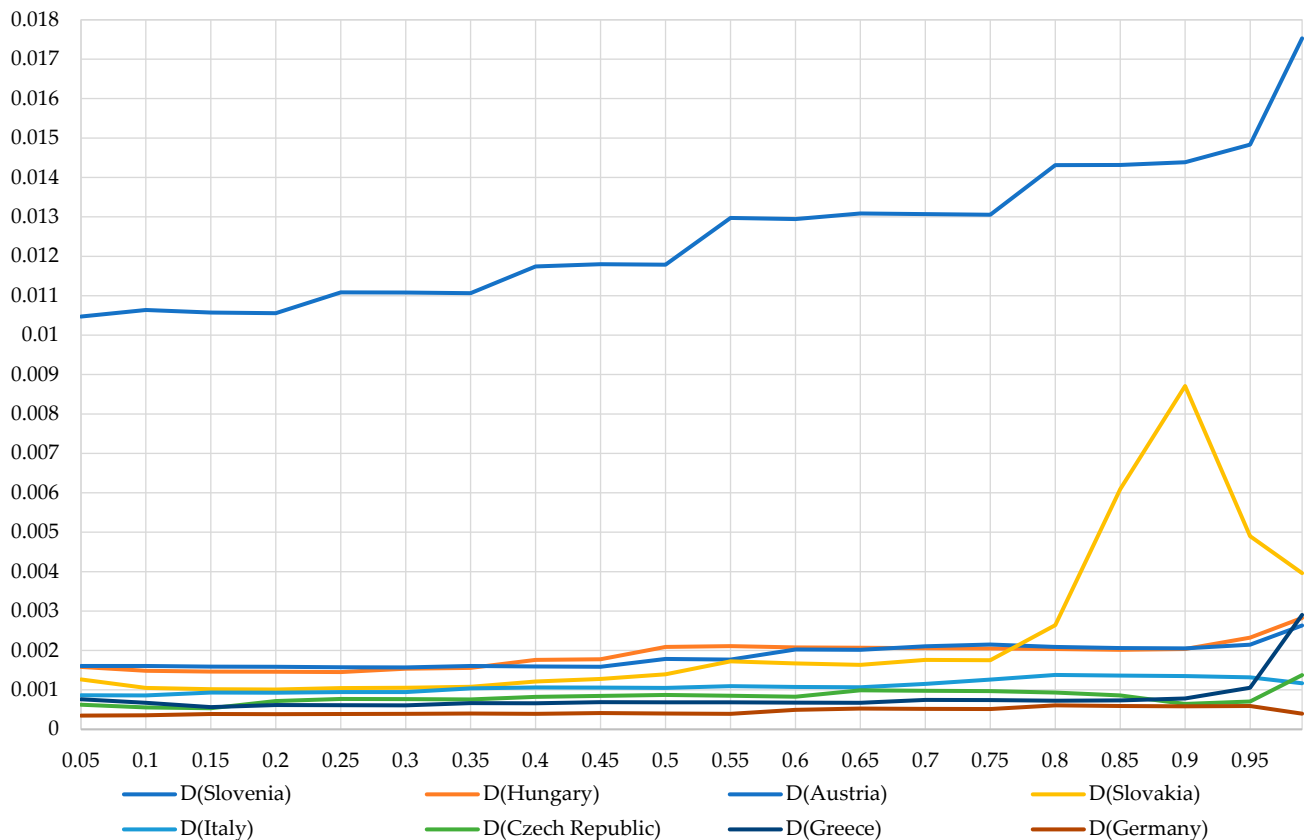


Figure 4. Croatia's trade integration across economic quantiles: a quantile regression analysis. Source: Author's calculations based on UNCTAD-Eora MRIO database (2000–2019).

6. Discussion

The results of this study provide important insights into Croatia's integration into the EU's regional value chains (RVCs). They show the variability of trade relations depending on economic conditions and the central role of key partners such as Slovenia, Hungary, Austria, Slovakia, Italy, and Germany. The results support the working hypothesis that Croatia is significantly integrated into the EU's regional value chains, especially with its geographically and economically close partners. This is in line with previous studies, such as Baldwin and Lopez-Gonzalez [34], and De Backer and Miroudot [25], which emphasize the regional concentration of trade in Europe. Croatia's trade patterns reflect broader regionalization trends driven by economic and geopolitical factors, while highlighting the importance of value-added contributions for assessing economic impacts within supply chains, as highlighted by Dedrick et al. [44]. By focusing on value-added trade rather than gross trade flows, the study provides a more accurate picture of Croatia's role in the EU supply chain and shows how its integration promotes knowledge transfer, technological development, and specialization in competitive sectors.

A quantile regression analysis revealed that Croatia's integration benefits greatly from participating in high-value segments of EU supply chains, which supports economic resilience and growth. Conversely, weaker integration at lower quantiles indicates weaknesses that need to be addressed. These weaknesses could be due to the limited diversification of trade relations and insufficient links with underrepresented EU member states, especially during the economic downturn. To close these gaps, targeted policy measures are needed to strengthen trade relations and improve Croatia's role within the EU RVCs, especially in high-value sectors. Policy measures that focus on reducing trade

barriers and promoting sectoral specialization would further strengthen Croatia's trade performance and its integration into the RVCs.

Although this study contributes to the literature on regional trade dynamics, it is not without limitations. The reliance on the UNCTAD–Eora database, while robust, potentially ignores informal trade flows and certain sectoral nuances, which could limit the scope of the analysis. Future studies could address these limitations by including additional data sources and examining Croatia's integration into specific value chains, such as those of renewable energy or digital industries.

The way in which global value chains (GVCs) are governed plays a crucial role in shaping trade relations, business development, and economic growth. Gereffi et al. [45] developed an influential framework that classifies GVC governance into five types: market, modular, relational, captive, and hierarchical. These categories are shaped by factors such as the complexity of transactions, the extent to which information can be codified, and the capabilities of suppliers. Their study highlights the role of governance structures in enabling firms from developing and emerging economies, including those in Croatia's regional supply chains, to strengthen their position within value chains. The study also emphasizes that regional supply networks often operate under relational and modular governance, allowing businesses to integrate more smoothly into the European trading system. This framework is particularly relevant for assessing Croatia's regional economic integration, as it provides insights into trade resilience, opportunities for upgrading, and interdependencies within the EU's supply chains. Comparative studies with other EU Member States could also provide a broader perspective on the dynamics of regional integration and Croatia's relative performance.

Given the lower responsiveness at lower quantiles, policies should focus on diversifying trade partnerships and enhancing supply chain resilience in weaker economic conditions. Meanwhile, the strong trade elasticity at higher quantiles suggests that Croatia could further leverage economic booms by increasing its export capacity in high-growth industries.

To improve the resilience of Croatian trade, policymakers could try to strengthen regional partnerships with key neighbors such as Slovenia, Austria, and Hungary and prioritize investments in infrastructure that enable smoother trade flows. Expanding participation in regional trade agreements and promoting sectoral specialization in high-value industries will further integrate Croatia into the EU supply chains. Given the observed asymmetric trade responses, targeted financial support for exporters during downturns and incentives to diversify the supply chain can mitigate economic shocks. In addition, investment in logistical efficiency will improve competitiveness and reduce transaction costs to ensure sustainable, long-term integration.

7. Conclusions

While this study provides valuable insights into Croatia's integration into the EU's regional value chains, there are still some areas for further research. One important starting point is to extend the model to other small EU economies to investigate whether similar trade patterns and dynamics of resilience exist. A comparison of the Croatian trade structure with countries of a similar size and economic development, such as Slovenia or Bulgaria, could provide a more comprehensive understanding of regional integration strategies.

Another possible extension is the inclusion of firm-level data to improve the granularity of the analysis. This would allow researchers to examine how firms of different sizes and sectors contribute to Croatian value-added trade and whether certain industries benefit disproportionately from regional integration. In addition, further research could

investigate the role of new technologies, such as digitalization and artificial intelligence, in optimizing the resilience and efficiency of supply chains.

Finally, future studies could examine longer-term structural shifts in EU trade policy, particularly in the context of geopolitical developments, sustainability goals, and post-pandemic economic recovery. Examining the evolution of Croatian trade networks under these conditions could provide deeper insights into the adaptability and future trajectory of regional value chains.

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References

1. Briguglio, L.; Cordina, G.; Farrugia, N.; Vella, S. Economic Vulnerability and Resilience: Concepts and Measurements. *Oxf. Dev. Stud.* **2009**, *37*, 229–247. [CrossRef]
2. UNCTAD (United Nations Conference on Trade and Development). *Trade and Development Report 2021: From Recovery to Resilience—The Development Dimension*; United Nations: Geneva, Switzerland, 2021; Available online: https://unctad.org/system/files/official-document/tdr2021_en.pdf (accessed on 18 February 2025).
3. Martin, R.; Sunley, P. On the Notion of Regional Economic Resilience: Conceptualization and Explanation. *J. Econ. Geogr.* **2015**, *15*, 1–42. [CrossRef]
4. Gereffi, G.; Fernandez-Stark, K. *Global Value Chain Analysis: A Primer*, 2nd ed.; Duke CGGC, Duke University: Durham, NC, USA, 2016; pp. 1–34. Available online: <https://scholars.duke.edu/display/pub1138337> (accessed on 20 February 2025).
5. Koopman, R.; Powers, W.; Wang, Z.; Wei, S.-J. *Give Credit Where Credit Is Due: Tracing Value Added in Global Production Chains*; National Bureau of Economic Research Working Paper 16426; National Bureau of Economic Research: Cambridge, MA, USA, 2010. [CrossRef]
6. OECD. *31st OECD/UNCTAD Report on G20 Trade and Investment Measures*; OECD Publishing: Paris, France, 2023; Available online: https://www.oecd.org/en/publications/31st-oecd-unctad-report-on-g20-trade-and-investment-measures_ea409cda-en.html (accessed on 20 February 2025).
7. United Nations Conference on Trade and Development (UNCTAD). General Profile: Croatia. UNCTADstat. Available online: <https://unctadstat.unctad.org/CountryProfile/GeneralProfile/en-GB/191/index.html> (accessed on 18 January 2025).
8. UNCTAD. *Eora Global Multi-Region Input-Output Database (Eora MRIO), 2000–2019*; United Nations Conference on Trade and Development: Geneva, Switzerland, 2020; Available online: <https://worldmrio.com/unctadgvc/> (accessed on 18 January 2025).
9. Miao, X.; Wang, S.; Han, J.; Ren, Z.; Ma, T.; Xie, H. The Regional Heterogeneity of the Impact of Agricultural Market Integration on Regional Economic Development: An Analysis of Pre-COVID-19 Data in China. *Sustainability* **2024**, *16*, 1734. [CrossRef]
10. Duan, D.; Zhang, Y.; Chen, Y.; Du, D. Regional Integration in the Inter-City Technology Transfer System of the Yangtze River Delta, China. *Sustainability* **2019**, *11*, 2941. [CrossRef]
11. Pehlken, A.; Wulf, K.; Grecksch, K.; Klenke, T.; Tsydenova, N. More Sustainable Bioenergy by Making Use of Regional Alternative Biomass? *Sustainability* **2020**, *12*, 7849. [CrossRef]

12. Ascencio, L.M.; González-Ramírez, R.G.; Bearzotti, L.A.; Smith, N.R.; Camacho-Vallejo, J.F. A Collaborative Supply Chain Management System for a Maritime Port Logistics Chain. *J. Appl. Res. Technol.* **2014**, *12*, 444–458. [\[CrossRef\]](#)
13. Tovar, B.; Hernández, R.; Rodríguez-Déniz, H. Container Port Competitiveness and Connectivity: The Canary Islands Main Ports Case. *Transp. Policy* **2015**, *38*, 40–51. [\[CrossRef\]](#)
14. Yeo, G.-T.; Ng, A.K.Y.; Lee, P.T.-W.; Yang, Z. Modelling Port Choice in an Uncertain Environment. *Marit. Policy Manag.* **2013**, *41*, 251–267. [\[CrossRef\]](#)
15. Mensah, P.; Merkuriev, Y. Developing a Resilient Supply Chain. *Procedia Soc. Behav. Sci.* **2014**, *110*, 309–319. [\[CrossRef\]](#)
16. Ponomarov, S.Y.; Holcomb, M.C. Understanding the Concept of Supply Chain Resilience. *Int. J. Logist. Manag.* **2009**, *20*, 124–143. [\[CrossRef\]](#)
17. Negri, M.; Cagno, E.; Colicchia, C.; Sarkis, J. Integrating Sustainability and Resilience in the Supply Chain: A Systematic Literature Review and a Research Agenda. *Bus. Strategy Environ.* **2021**, *30*, 7. [\[CrossRef\]](#)
18. Frankowska, M.; Cheba, K. The Relational Embeddedness as the Differentiator of the Cluster Supply Chain Collaboration—A Multidimensional Comparative Analysis. *Compet. Rev. Int. Bus. J.* **2021**, *32*, 59–84. [\[CrossRef\]](#)
19. Jaehne, D.M.; Li, M.; Riedel, R.; Mueller, E. Configuring and Operating Global Production Networks. *Int. J. Prod. Res.* **2009**, *47*, 2013–2030. [\[CrossRef\]](#)
20. Gao, Y.; Zong, Y. Benefit-Sharing Mechanism in Cross-Regional Agricultural Product Supply Chain: A Grounded Theory Approach. *Sustainability* **2024**, *16*, 10842. [\[CrossRef\]](#)
21. Ferreira, F.C.M.; Biazzin, C.; Hong, P.C. Transition Paths of Brazil from an Agricultural Economy to a Regional Powerhouse: A Global Supply Chain Perspective. *Sustainability* **2024**, *16*, 2872. [\[CrossRef\]](#)
22. Gruchmann, T.; Melkonyan, A.; Krumme, K. Logistics Business Transformation for Sustainability: Assessing the Role of the Lead Sustainability Service Provider (6PL). *Logistics* **2018**, *2*, 25. [\[CrossRef\]](#)
23. Kritchanai, D.; Senarak, D.; Supeekit, T.; Chanpuypetch, W. Evaluating Supply Chain Network Models for Third Party Logistics Operated Supply-Processing-Distribution in Thai Hospitals: An AHP-Fuzzy TOPSIS Approach. *Logistics* **2024**, *8*, 116. [\[CrossRef\]](#)
24. Lu, H.; Li, L.; Zhao, X.; Cook, D. A Model of Integrated Regional Logistics Hub in Supply Chain. *Enterp. Inf. Syst.* **2018**, *12*, 1308–1335. [\[CrossRef\]](#)
25. De Backer, K.; Miroudot, S. *Mapping Global Value Chains*; OECD Trade Policy Papers, No. 159; OECD Publishing: Paris, France, 2013. [\[CrossRef\]](#)
26. Mance, D.; Debelić, B.; Vilke, S. Croatian Regional Export Value-Added Chains. *Economies* **2023**, *11*, 202. [\[CrossRef\]](#)
27. Mance, D.; Vilke, S.; Debelić, B. Impact of ICT on Regional Supply Chains in CEECs. *Ekon. Vjesn.* **2023**, *36*, 373–384. [\[CrossRef\]](#)
28. Gereffi, G.; Fernandez-Stark, K. *Global Value Chain Analysis: A Primer*; Center on Globalization, Governance & Competitiveness, Duke University: Durham, NC, USA, 2011; Available online: <https://gvcc.duke.edu/cggc-briefing-papers> (accessed on 20 February 2025).
29. Bair, J. Global Capitalism and Commodity Chains: Looking Back, Going Forward. *Compet. Change* **2005**, *9*, 153–180. [\[CrossRef\]](#)
30. Gereffi, G. Global Production Systems and Third World Development. In *Global Change, Regional Response: The New International Context of Development*; Stallings, B., Ed.; Cambridge University Press: Cambridge, UK, 1995; pp. 100–142.
31. Gereffi, G. The Organization of Buyer-Driven Global Commodity Chains: How U.S. Retailers Shape Overseas Production Networks. In *Commodity Chains and Global Capitalism*; Gereffi, G., Korzeniewicz, M., Eds.; Praeger: Westport, CT, USA, 1994; pp. 95–122.
32. Cumbers, A.; Nativel, C.; Routledge, P. Labour Agency and Union Positionalities in Global Production Networks. *J. Econ. Geogr.* **2008**, *8*, 369–387. [\[CrossRef\]](#)
33. United Nations Conference on Trade and Development (UNCTAD). *World Investment Report 2013: Global Value Chains: Investment and Trade for Development*; United Nations: Geneva, Switzerland, 2013; Available online: https://unctad.org/system/files/official-document/wir2013_en.pdf (accessed on 18 January 2025).
34. Baldwin, R.; Lopez-Gonzalez, J. Supply-Chain Trade: A Portrait of Global Patterns and Several Testable Hypotheses. *World Econ.* **2013**, *36*, 1417–1459. [\[CrossRef\]](#)
35. McKinsey Global Institute (MGI). *Globalization in Transition: The Future of Trade and Value Chains*; McKinsey & Company: Chicago, IL, USA, 2019; Available online: <https://www.mckinsey.com> (accessed on 20 February 2025).
36. Friesenbichler, K.; Glocker, C.; Hölzl, W.; Kaniovski, S.; Kügler, A.; Reinstaller, A.; Streicher, G.; Siedschlag, I.; Di Ubaldo, M.; Studnicka, Z.; et al. Drivers and Obstacles to Competitiveness in the EU: The Role of Value Chains and the Single Market. WIFO Studies, No. 60837. 2017. Available online: <https://ideas.repec.org/b/wfo/wstudy/60837.html> (accessed on 20 February 2025).
37. OECD. *Towards Balanced Regional Development in Croatia*; OECD Publishing: Paris, France, 2024; Available online: <https://www.oecd.org> (accessed on 18 February 2025).
38. World Bank. *Croatia Country Economic Memorandum: Laying the Foundations—Boosting Productivity to Ensure Future Prosperity*; World Bank: Washington, DC, USA, 2023; Available online: <https://www.worldbank.org> (accessed on 18 February 2025).

39. Li, C.; He, Q.; Ji, H.; Yu, S.; Wang, J. Re-examining the Impact of Global Value Chain Participation on Regional Economic Growth: New Evidence Based on a Nonlinear Model and Spatial Spillover Effects with Panel Data from Chinese Cities. *Sustainability* **2023**, *15*, 13835. [CrossRef]
40. Taguchi, H.; Lar, N. Servicification in Global Value Chains in Emerging and Developing Asian Economies. *Economies* **2024**, *12*, 125. [CrossRef]
41. Sada, S.; Ikeda, Y. Regional Economic Integration via Detection of Circular Flow in International Value-Added Network. *arXiv* **2021**, arXiv:2103.08179. Available online: <https://arxiv.org/abs/2103.08179> (accessed on 20 February 2025).
42. UNCTAD. *World Investment Report 2023: Investment and Value Chains in a Post-Pandemic World*; United Nations: Geneva, Switzerland, 2023; Available online: https://unctad.org/system/files/official-document/wir2023_en.pdf (accessed on 18 February 2025).
43. Wooldridge, J.M. *Introductory Econometrics: A Modern Approach*, 5th ed.; South-Western Cengage Learning: Boston, MA, USA, 2010; ISBN 9781111531041.
44. Dedrick, J.; Kraemer, K.L.; Linden, G. Who Profits from Innovation in Global Value Chains? A Study of the iPod and Notebook PCs. *Ind. Corp. Chang.* **2010**, *19*, 81–116. [CrossRef]
45. Gereffi, G.; Humphrey, J.; Sturgeon, T. The Governance of Global Value Chains. *Rev. Int. Polit. Econ.* **2005**, *12*, 78–104. [CrossRef]

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