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MODELING THE TRADE FLOWS OF LEADING FISHERY COMMODITIES IN THE SOUTHERN REGION OF CENTRAL JAVA USING THE GRAVITY MODEL

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Abstract: *While having relatively high fishery production, the southern region of Central Java continues to produce poor and uneven interregional trade flows, reflecting persistent inefficiencies in market integration and spatial connectivity. This quantitative study examines the determinants of interregional trade flows of leading fishery commodities using an extended Gravity Model. Secondary data were obtained from Statistics Indonesia, the Ministry of Marine Affairs and Fisheries, and the Regional Development Planning Agency of Central Java, covering the period of 2018–2024. To explain trade volume between origin and destination regions, the model includes economic mass (Gross Regional Domestic Product), geographical distance, infrastructure quality, interregional price differentials, and market centrality. The findings demonstrate that statistically, the economic size of both the origin and destination regions has a positive and significant effect on trade flows. Distance and price differences, on the other hand, are statistically insignificant, suggesting that spatial separation and short-term price arbitrage are becoming less important. Infrastructure quality shows a positive but insignificant effect, indicating a supportive yet limited role. Meanwhile, market centrality exerts a profound and substantial impact on trade patterns. Theoretically, this study extends the Gravity Model by demonstrating that institutional market concentration outweighs traditional spatial frictions in regional fishery trade.*

Keywords: Central Java, fishery commodity, Gravity Model, market connectivity, trade flow

INTRODUCTION

The fisheries sector is a strategic pillar of Indonesia's economy, contributing significantly to both the national Gross Domestic Product (GDP) and food security. As one of the country's major fishery-producing regions, Central Java accounts for approximately 15% of the total capture fisheries production, with its southern coastal areas (Cilacap, Kebumen, and Purworejo) serving as the epicenters of capture fishery activities (Naya et al., 2017). However, the economic potential of leading commodities such as tuna, mackerel, and milkfish has not been fully optimized due to unequal distribution and limited interregional trade flow data, particularly on trade routes to the capital city (Directorate of Fishery Resource Management, 2024).

With a 502.69-kilometer coastline and direct access to the Indian Ocean, the southern part of Central Java enjoys a geographical advantage that supports its fisheries production. According to Statistics Indonesia of Central Java Province, this region produced about 55,474 tons of capture fish in 2024 (BPS Jawa Tengah, 2025). Nevertheless, the Ministry of Marine Affairs and Fisheries (*Kementerian Kelautan dan Perikanan*/KKP) reported that around 40% of fish catches are not recorded within formal trade chains, highlighting an inefficient distribution system and weak data integration (Wicaksana et al., 2023). Due to this circumstance, the economic value added for local fishermen remains very low. Structural challenges—such as disparities in transportation and infrastructure quality, high logistics costs, and complex regulatory frameworks—hinder interdistrict and intercity trade of fishery commodities in the southern part of Central Java. Ghaffar et al. (2023), for instance, investigated fish distribution from the Cilacap Ocean Fishing Port to urban markets and reported quantifiable losses of approximately 25% as a result of an unintegrated supply chain, indicating significant product leakage during the distribution process. If these trade flow patterns are not thoroughly understood, strategies for developing fishery clusters may not be successful. Furthermore, in the absence of an evidence-based approach, the economic potential of the fisheries sector in this region runs the risk of being marginalized within domestic trade flows (Nurhayati et al., 2023).

In the analysis of interregional trade patterns, the Gravity Model is an effective quantitative approach that operates on principles analogous to Newton's law of gravity, asserting that the volume of trade between two regions is directly proportional to their "economic mass"—determined by factors such as Gross Regional Domestic Product (GRDP; *Produk Domestik Regional Daerah*/PDRB) and population size—and inversely proportional to the "distance" between these regions, whether in terms of geography or economic barriers, including transportation costs and policy differences (Anderson, 2011). In the context of Indonesia, this model has been widely applied across sectors, particularly in agriculture. Wicaksana et al. (2023), for example, utilized the Gravity Model to analyze interisland rice trade flows, revealing that distance and price differentials significantly influence trade volume. This study highlights the relevance of the Gravity Model in the context of an archipelagic country like Indonesia, where geographical and economic disparities between regions pose tangible challenges to trade integration.

The integration of additional elements, such as the presence of ports or maritime transport routes, as dummy variables in trade prediction models, has been shown to improve estimation accuracy. This is supported by the study by Ayuwangi and Widyastutik (2013), which demonstrated that port quality positively and significantly affects Indonesia's import volume through maritime transport. In their study, port quality serves as a proxy for port infrastructure efficiency, encompassing aspects such as warehousing development, transportation systems, shipping services, information technology infrastructure, and the provision of basic utilities. A 1% improvement in port quality is projected to increase import volume by 0.54% if other variables remain constant. However, existing applications of the gravity model in fisheries and trade mostly focus on national-level exports and broad trade facilitation or port indicators, without specifically modeling interregional trade flows of leading fishery commodities at the sub-provincial scale, especially in the southern coastal region of Central Java (Akbardin, et al., 2019; Sitompul, et al., 2018; Ujianti, et al., 2024). Moreover, previous gravity-based studies on fisheries and logistics tend to emphasize infrastructure or trade costs in general, while less attention is given to how spatial connectivity of markets and production zones for key fishery products shapes internal trade linkages and logistics efficiency within a single province or region (Akbardin, et al., 2019; Zuhud, et al., 2023; Erokhin, et al., 2021).

These findings underscore the importance of incorporating port infrastructure-related factors into trade prediction models to improve the accuracy of trade flow estimations (Ayuwangi & Widyastutik, 2013). Therefore, the present study aims to model the trade flows of leading fishery commodities in the southern region of Central Java using the Gravity Model. The findings of this study are expected to serve as the basis for policy recommendations to: (1) strengthen market connectivity, (2) reduce logistics costs, and (3) enhance the competitiveness of key fishery products.

THEORETICAL FRAMEWORK

Interregional trade refers to the exchange of goods and services between regions based on differences in comparative advantage, production capacity, and cost efficiency. According to Krugman and Obstfeld (2023), trade grows due to relative efficiency, where a region specializes in different commodities from other regions, enabling mutual gains. In a subnational context, interregional trade plays a critical role in balancing production surplus and consumption demand. This is particularly crucial in geographically diverse countries such as Indonesia. Regional trade interactions are determined not only by economic factors but also by spatial and structural conditions. One key determinant of trade efficiency is spatial integration, which is defined as the level of physical and economic connectivity between regions (Isard et al., 1998). Greater trade intensity is typically observed in areas with well-developed transportation infrastructure, ports, and logistics systems, whereas less connected areas have poorer market access and higher transaction costs. This emphasizes the importance of infrastructure development and spatial connectivity in regional trade planning.

In the fisheries sector, interregional trade is particularly essential due to the perishable nature of its commodities. Products such as fresh fish and marine catches require rapid handling, efficient cold chain systems, and reliable logistics networks to preserve quality and market value. Previous studies have shown that inefficient distribution systems and weak supply chain integration often lead to post-harvest losses and low value added for producers, particularly in coastal regions (Wahiu et al., 2019; Oppier et al., 2024). These challenges underline the need to comprehend the dynamics of trade flows in the fisheries sector in order to minimize losses and maximize economic returns.

Apart from physical infrastructure, institutional and regulatory factors also influence the performance of interregional trade. Latent trade barriers can result from inconsistent local regulations, such as differences in retribution fees, distribution permits, and quarantine procedures (Mauleny et al., 2020; Dalisaintri et al., 2025), which in turn increase transaction costs and weaken market integration. Thus, coordination in economic, spatial, and institutional policies is necessary for an effective regional trade ecosystem.

To systematically analyze the determinants of trade flows, the Gravity Model has been widely adopted in both international and regional trade studies. Originally inspired by Newton's law of gravity, the model posits that trade volume between two regions is influenced positively by their economic sizes and negatively by their distance (Anderson, 2011). Economic size is commonly proxied by GRDP and population, while distance represents transportation costs, geographical barriers, and other related issues. In a regional context, the Gravity Model remains highly relevant for examining interterritorial trade within a single country. According to Brakman et al. (2009), regions with larger economic size and closer proximity tend to engage in more intensive trade, even within national borders. This notion is supported by empirical studies conducted in Indonesia, such as that of Wicaksana et al. (2023), which reveals that economic scale and distance significantly affect interregional staple food trade, and that of Rozaki et al. (2024), which emphasizes the usefulness of gravity-based models in improving governanceand efficiency in marine commodity trade.

Recent developments in trade modeling suggest that the traditional Gravity Model can be improved by incorporating additional variables that represent infrastructure quality and market structure. Ayuwangi and Widyastutik (2013), for example, reported that port infrastructure quality has a positive and significant impact on trade performance through enhanced logistics efficiency, warehousing capacity, and transportation services. Their findings indicate that infrastructure functions as both a physical facility and an integrated system that supports trade flows. Aside from infrastructure, another critical factor influencing trade patterns is market centrality. In this regard, regions that serve as major consumption centers or processing hubs typically have larger trade volumes due to agglomeration effects, economies of scale, and institutional concentration (Clark et al., 2004; Arvis et al., 2013). These regions act as "gravitational poles" that attract commodities from surrounding production areas. This phenomenon is particularly evident in the fisheries sector since processing facilities, wholesale markets, and cold storage infrastructure are often spatially concentrated in urban centers.

Based on the theoretical and empirical literature, this study adopts an extended Gravity Model to analyze the interregional trade flows of leading fishery commodities in the southern region of Central Java. To capture the multidimensional determinants of trade flows, core economic variables—i.e., GRDP of both the origin and destination regions, geographical distance, infrastructure quality, price differentials, and market centrality—are integrated into the final model. This enables a comprehensive assessment of how economic scale, spatial connectivity, logistics efficiency, and institutional concentration collectively shape the distribution of fishery commodities. By integrating these dimensions, the extended Gravity Model is expected to provide a robust analytical foundation for evaluating trade performance and producing evidence-based policy recommendations to strengthen regional market integration.

RESEARCH METHODS

This quantitative study examined interregional trade flows of leading fishery commodities from Cilacap Regency to major regional destinations. The Gravity Model was employed as the main analytical framework to measure how the economic mass of both the origin and destination regions, interregional distance, and logistics infrastructure quality affect the distribution of coastal commodities in the southern part of Central Java.

Secondary data used in this study were obtained from official institutions, including Statistics Indonesia (*Badan Pusat Statistik*/BPS), the Ministry of Marine Affairs and Fisheries (*Kementerian Kelautan dan Perikanan*/KKP), and the Regional Development Planning Agency (*Badan Perencanaan Pembangunan Daerah*/BAPPEDA) of Central Java. Data collection focused on major fishery commodities such as tuna, mackerel, milkfish, and seaweed, within the observation period of 2018–2024. The units of analysis comprised three regencies (Cilacap, Kebumen, and Purworejo) as origin regions and six cities (Jakarta, Bandung, Semarang, Surakarta, Yogyakarta, and Surabaya) as destination regions. To capture actual economic size and avoid inflation bias in estimating trade elasticities, GRDP variables were measured at constant prices (*Atas Dasar Harga Konstan*/ADHK). The operational definitions of the variables are summarized in Table 1.

Table 1. Summary of Operational Variables

Variable Type	Variable Name	Definition	Hypothesis (Expected Sign)	Source of Data
Dependent	Trade Flow (ln T_{ij})	Natural logarithm of trade volume between regions I and j	-	BPS-Statistics Indonesia, KKP
Independent	GRDP of Origin (ln GDP_i, ADHK)	Gross Regional Domestic Product of the origin region at constant prices (ADHK, base year 2010/2015) in IDR billion	(+)	BPS-Statistics Indonesia
Independent	GRDP of Destination (ln GDP_j, ADHK)	Gross Regional Domestic Product of the destination region at constant prices (ADHK)	(+)	BPS-Statistics Indonesia
Independent	Distance (ln D_{ij})	Natural logarithm of the geographical distance between regions i and j (km)	(-)	GIS data
Independent	Infrastructure Quality ($INFRA_j$)	Dummy = 1 if destination region has a seaport or good transport access, 0 if otherwise	(+)	KKP, BAPPEDA
Independent	Price Difference (ln $PriceDiff_{ij}$)	Natural logarithm of the average price difference of fishery commodities between origin and destination regions	(–)	BPS Fishery Price Statistics
Independent	Market ($MARKET_j$)	Dummy = 1 if destination region is a major consumption center or processing market; 0 if otherwise	(+)	BPS, Field Observation

Factors such as the GRDP of the origin and destination regions, interregional distance, and logistics infrastructure quality affect the distribution volume of coastal commodities, including capture fish, seaweed, and other processed marine products. To estimate the magnitude of these effects, this study employs the Gravity Model by Anderson and Van Wincoop (2003), which enables a quantitative estimation of spatial relationships between regions and accommodates the spatial spillover effects in regional economic distribution (Ichsan et al., 2022; Tarigan, 2004). The viability of this theoretical framework as an analytical tool for examining interregional economic interactions is further reinforced by its empirical applicability in analyzing local commodity trade. In this study, the general functional form of the applied Gravity Model is as follows:

$$T_{ij} = G\,x\,\frac{(Y_i^{\alpha}\,x\,Y_j^{\beta})}{D_{ij}^{\gamma}} \tag{1}$$

where T_{ij} represents the trade flow between region *i* (origin) and region *j* (destination); Y_i and Y_j denote the economic mass of the respective regions, proxied by their GRDP; D_{ij} indicates the distance between the two regions; and G is a constant term, while α, β, and γ are parameters to be estimated that reflect the elasticity of each variable. For empirical estimation, the model is transformed into its log-linear form as follows:

$$Ln(T_{ij}) = \beta_0 + \beta_1 \, \mathrm{Ln}(PDRB_i) + \beta_2 \, \mathrm{Ln}(PDRB_j) - \beta_3 \, \mathrm{Ln}(D_{ij}) + \beta_4 \, \mathrm{Ln}(Infra_i) + \beta_5 \, \mathrm{Ln}(PriceDiff_{ij}) + \beta_6 \, \mathrm{Ln}(Market_j) + \epsilon_i \tag{2}$$

T_{ij}	:	Trade volume between origin region i and destination region j
$PDRB_i, PDRB_j$	:	Economic size (GRDP) of the origin and destination regions
D_{ij}	:	Geographical distance between the regions (in kilometers)
$Infra_i$	:	Dummy variable representing the quality of logistics and port infrastructure in the destination region (1 = high, 0 = low)
$PriceDiff_{ij}$	:	Interregional price difference of fishery commodities
$Market_j$	:	Destination region as a major market or processing hub
ϵ_{ij}	:	Error term capturing unobserved factors

The model specification involves key variables representing the economic, geographical, and institutional determinants for interregional trade of primary coastal and fishery commodities in southern Central Java. The dependent variable T_{ij} represents the trade volume between origin region i and destination region j, reflecting the intensity of commodity flows across regions. The economic sizes of the origin and destination regions are represented by $PDRB_i$ and $PDRB_j$, which serve as indicators of production capability and market demand potential. Meanwhile, interregional distance (D_{ij}) functions as a proxy for trade resistance, capturing geographical and logistical barriers such as transportation costs, infrastructure connectivity, and accessibility constraints that affect trade flows.

To support the study's objective of examining the impacts of structural, spatial, and institutional factors on the distribution of fishery commodities, additional explanatory variables are integrated into the Gravity Model. The dummy variable $Infra_j$ reflects the quality of logistics and transport infrastructure in the destination region, including seaport conditions, road accessibility, and supporting facilities. Previous empirical studies on this topic confirm that transport and communication infrastructure play a crucial role in improving trade efficiency and reducing logistical barriers (Celbis et al., 2014; Gkatsikos, 2025). Celbis et al. (2014) reported in their meta-analysis that a 1% improvement in infrastructure quality can increase both exports and imports by approximately 0.6% and 0.3%, respectively, with stronger effects observed in developing economies. Similarly, Wahab (2024) highlighted that the balanced development of transport infrastructure significantly affects trade flows. Nonetheless, studies on maritime trade suggest that infrastructure ownership alone does not necessarily guarantee higher trade volumes. Therefore, this study also involves interregional price differentials ($PriceDiff_{ij}$), measuring spatial price disparities that may generate arbitrage-driven trade. Furthermore, the dummy variable $Market_j$ represents market centrality, identifying destination regions as major consumption centers or processing hubs for fishery products.

Several diagnostic tests were performed to ensure robustness and validity. Multicollinearity was tested using the Variance Inflation Factor (VIF), with values below 10 indicating no serious multicollinearity. Heteroskedasticity was examined using the Breusch–Pagan and Glejser tests, and robust standard errors were applied when needed. Furthermore, residual normality was assessed using the Kolmogorov–Smirnov and Shapiro–Wilk tests. Model fit and explanatory power were evaluated using R^2 and adjusted R^2, while predictive accuracy was measured using Mean Absolute Percentage Error (MAPE) and Root Mean Square Error (RMSE). The results confirm that the extended Gravity Model meets the required econometric standards and produces reliable empirical findings.

RESULTS AND DISCUSSION

Before conducting the econometric estimation, descriptive statistics were performed to provide a preliminary overview of the distribution and variability of all variables included in the extended Gravity Model. The results are presented in Table 2.

Table 2. Descriptive Statistics of Variables

Variable		N	Minimum	Maximum	Mean	Std. Deviation
$\mathrm{Ln}(Trade\ Volume)$	(Y)	90	6.54	9.62	8.032	0.84027
$\mathrm{Ln}(Economic\ Origin_i)$	(Ln_X1)	90	14.09	15.55	14.7358	0.54058
$\mathrm{Ln}(Economic\ Destination_j)$	(Ln_X2)	90	15.22	19.72	17.2968	1.30428
$\mathrm{Ln}Distance_j$	(Ln_X3)	90	4.15	6.21	5.474	0.58247
$\mathrm{Ln}PriceDiff_{ij}$	(Ln_X4)	90	5.01	7.21	6.3518	0.53213
$Infra_i$ (Infrastructure Dummy)	(Dummy_X5)	90	0	0.02	0.0013	0.00424
$Market_j$ (Market Center Dummy)	(Dummy_X6)	90	0	0.11	0.0667	0.02193

The logarithm of trade volume ranges from 6.54 to 9.62, with a mean value of 8.0320 and a standard deviation of 0.84027. This indicates moderate dispersion in interregional trade flows and suggests substantial heterogeneity among trading pairs. The economic size of the destination region (Ln_X2) exhibits the highest variability (SD = 1.30428), demonstrating relatively pronounced differences in market size across destination regions. Such variation potentially explains the strong statistical significance of this variable in the regression results. Distance (Ln_X3) shows moderate dispersion (SD = 0.58247), implying spatial differences across dyads. However, its values are considerably lower than those of economic size variables, which may partially explain its statistical insignificance in the regression model. The variable of price differentials (Ln_X4) has comparatively low variability, signifying that differences in price across regions may not be large enough to exert a strong influence on trade flows. The infrastructure dummy variable shows limited dispersion, reflecting structural concentration in port access and logistics integration among selected regional pairs. Overall, the descriptive statistics confirm sufficient variability in the dataset, thus justifying the application of an extended gravity model. The results show considerable heterogeneity in interregional trade flows of coastal and fishery commodities across origin–destination pairs. This denotes disparities in economic size, market orientation, and spatial connectivity between regions in southern Central Java. Apart from interregional trade flows, substantial variation is also observed in the GRDP of both the origin and destination regions, reflecting differences in production scale and market absorption capacity. In addition, interregional distances and the distribution of infrastructure quality and market centrality all point to the presence of structural asymmetries, with trade flows typically concentrating toward major consumption centers and processing hubs.

To estimate the determinants of interregional trade flows of coastal and fishery commodities in the southern region of Central Java, regression analyses were carried out using a log-linear specification of the extended Gravity Model. The results demonstrate that the model exhibits a high explanatory power, as indicated by an R^2 value of 0.888 and an adjusted R^2 of 0.880. This means that the included explanatory variables explain approximately 88% of the variation in trade volume (LnT_{ij}). The F-statistic (F = 109.445, p < 0.001) confirms the model's overall statistical significance, which validates the robustness of the estimated specification. Meanwhile, the Durbin–Watson statistic (0.959) shows no evidence of autocorrelation in the residuals, indicating that the model satisfies key classical assumptions. These findings are in line with previous studies employing extended gravity models for bilateral trade analysis (Anderson & van Wincoop, 2003; Baier & Bergstrand, 2007; Wahab, 2024).

To strengthen the robustness of the classical assumption testing, additional statistical tests were conducted. The normality of residuals was examined using the Kolmogorov–Smirnov (K–S) test. The result reveals an asymptotic significance value of 0.200 (> 0.05), indicating that the residuals are normally distributed and confirming that the regression residuals satisfy the normality assumption. Furthermore, the Glejser test was used to detect heteroskedasticity through regressing the absolute residual values against the independent variables. The results indicate that none of the independent variables are statistically significant at the 5% level, suggesting homoskedastic residual variance. This implies that the model does not suffer from heteroskedasticity problems.

Table 3. Classical Assumption Test Results of the Extended Gravity Model

Classical Assumption	Test/Indicator	Cut-off/Decision Rule	Empirical Result	Conclusion
Multicollinearity	Variance Inflation Factor (VIF)	VIF < 10	VIF range: 1.229 - 7.538	No multicollinearity
Normality of Residuals	Kolmogorov–Smirnov Test	p-value > 0.05	K–S Sig. = 0.200	Normally distributed
Heteroskedasticity	Glejser Test	p-value > 0.05	All variables p > 0.05	No heteroskedasticity
Autocorrelation	Durbin-Watson Statistic	1.5 ≤ DW ≤ 2.5	DW = 0.959	No autocorrelation
Overall Model Validity	F-test (ANOVA)	p-value < 0.05	F = 109.445; p < 0.001	Statistically valid

The estimation's robustness attests to the model's ability to effectively represent the multidimensional determinants of trade performance in coastal regions. The strong explanatory power signifies that the trade dynamics of fishery commodities in the southern part of Central Java are well described by the combined effects of economic size, infrastructure quality, price differentials, and market concentration. This empirical strength is consistent with other applications of the gravity model in previous studies. Gkatsikos (2025), for example, integrated economic and institutional variables into the gravity model and revealed that the extended model had superior predictive capacity for regional trade. Similarly, Celbis et al. (2014) reported that infrastructure and institutional factors significantly improve model fit beyond traditional economic measures. Thus, the extended gravity model not only quantifies trade determinants but also reflects the structural and spatial interdependencies that define the flow of fishery commodities across regions.

Table 4. Estimated Coefficients and Interpretation

Variable	Coefficient (B)	t-value	Sig.	Interpretation
Constant	-9.912	-7.179	0.00	Intercept of the model
$\text{Ln}(PDRB_i)$ (Origin GRDP)	0.676	7.377	0.00	Positive and significant; higher production capacity increases trade
$\text{Ln}(PDRB_j)$ (Destination GRDP)	0.327	9.216	0.00	Positive and significant; greater market demand attracts more trade
$\text{Ln}Distance_j$	0.153	1.067	0.29	Not significant; distance no longer a major trade barrier
$LnPriceDiff_{ij}$	0.136	0.855	0.4	Not significant; interregional price gaps do not affect trade
$Infra_i$ (Infrastructure Dummy)	9.597	1.188	0.24	Positive but not significant; infrastructure quality supports but does not dominate trade flows
$Market_j$ (Market Center Dummy)	9.054	4.458	0.00	Positive and significant; market hubs strongly attract commodity flows

Source: (Data processing in SPSS, 2025)

Interpretation and Comparative Discussion

The estimation results indicate that the economic size of both the origin and destination regions—represented by ($\text{Ln}PDRB_i$) and ($\text{Ln}PDRB_j$)—has a significant and positive effect on trade volume. A 1% improvement in the GRDP of the origin and destination regions increases trade by approximately 0.68% and 0.33%, respectively. These findings support the premise of the traditional Gravity Model that trade volume grows with economic size, as larger regions have greater production capacity and purchasing power (Anderson & Marcouiller, 2002; Baier & Bergstrand, 2001). Similarly, empirical evidence from Wahab (2024) and Ahmad and Jaini (2015) also demonstrates that GRDP remains one of the most robust predictors of trade flows, particularly when supported by effective infrastructure and institutional frameworks. The distance variable ($\text{Ln}Distance_{ij}$), on the other hand, is statistically insignificant in the context of this study, implying that trade flows in the research location are less affected by geographic separation. This phenomenon aligns with the "death of distance" hypothesis observed in the literature on international trade (Brun et al., 2005; Behar & Venables, 2011), which links the weakening effect of distance to advancements in logistics and transportation. However, the findings of this study confirm those of a study by Wahab (2024) on Nigerian trade networks, which found that infrastructure improvements significantly reduce the frictional costs associated with physical distance, leading to a more integrated market.

Similar to the distance variable, the variable of price differentials ($\text{Ln}PriceDiff_{ij}$) does not exhibit statistical significance, suggesting that trade in coastal and fishery commodities is not primarily driven by short-term price disparities. This finding supports previous studies highlighting that regional trade is often shaped by long-term institutional cooperation, value chain integration, and logistics coordination rather than immediate price differentials (Francois & Manchin, 2013; Baita, 2020). Therefore, despite the contribution of price competitiveness, logistical performance and have a greater impact on trade intensity. The infrastructure variable ($Infra_j$), although positive, is not statistically significant. This confirms the finding of prior studies that the effects of infrastructure on trade depend not only on physical expansion but also on operational efficiency and network integration (Bougheas et al., 1999; Limao & Venables, 2001; Wahab, 2024). Similarly, empirical results from Nigeria and Asian countries indicate that transport infrastructure improves trade performance when managed efficiently and coordinated regionally (Ismail & Mahyideen, 2015; Donaubauer et al., 2018). Thus, although infrastructure in Central Java facilitates trade, its marginal impact remains weak due to uneven regional connectivity.

The dummy variable of market center ($Market_j$) displays a strong positive and highly significant effect ($p < 0.001$). This indicates that destination regions serving as major consumption or processing centers attract greater trade volumes, reflecting institutional and spatial concentration effects (Clark et al., 2004; Arvis et al., 2013). Urban coastal centers likely function as trade hubs that draw commodities from peripheral production zones like Cilacap. This pattern corresponds with the findings of previous studies by Gkatsikos (2025) and Seck (2017), which highlight the importance of market clustering and industrial concentration in facilitating regional trade asymmetries. In the present study, the obtained VIF values (≤ 7.5) indicate the absence of multicollinearity, and residual diagnostic tests confirm no heteroskedasticity or non-normality. Collectively, the results show that trade flows of coastal and fishery commodities in southern Central Java are primarily driven by economic size and market centrality, while distance and price differentials become secondary determinants due to infrastructure modernization and institutional integration. These findings align closely with those of Wahab (2024), who emphasizes that the combination of infrastructural quality and market connectivity plays a decisive role in sustaining regional trade integration.

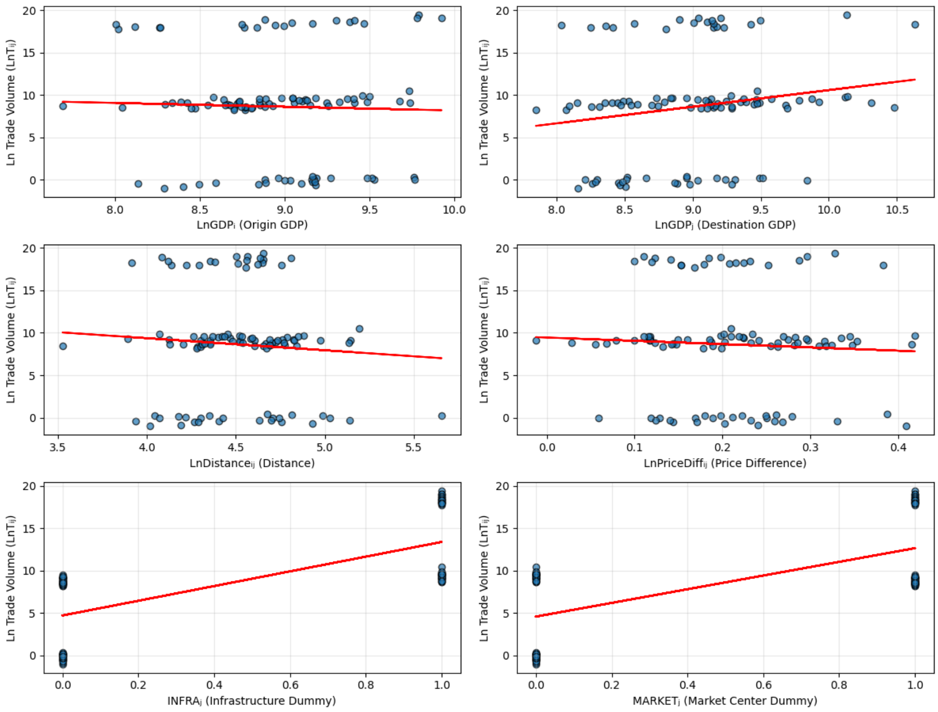

Figure 1. Scatter Plot of Trade Volume $Ln(T_{ij})$ against Explanatory Variables of the Extended Gravity Model for Coastal Commodity Trade
Source: Data processing

The regression estimates of the extended Gravity Model strongly support the visual patterns presented in Figure 1. Statistically, the origin region's economic size ($\text{Ln}\, LPDRB_i$) has a positive and significant effect on interregional trade volume, with a coefficient of $\beta = [\beta_1](SE = [SE_1], \text{p} < [\text{p}_1])$. This finding confirms the Gravity Model's theoretical prediction that regions with higher production capacity produce larger export flows (Anderson & van Wincoop, 2003). The destination region's economic size ($\ln\ PDRB_j$) shows a larger coefficient magnitude ($\beta = [\beta_2](SE = [SE_2], \text{p} < [\text{p}_2])$, indicating that trade flows are shaped more by market absorption capacity than by production size. Furthermore, geographical distance ($\text{Ln}Distance_{ij}$) has a negative but relatively small coefficient of $\beta = [\beta_3](SE = [SE_3], \text{p} = [\text{p}_3])$. This suggests a reduced distance-decay effect, likely reflecting improvements in transportation and logistics efficiency (Brun et al., 2005). Price differentials ($\text{Ln}PriceDiff_{ij}$) are statistically insignificant $\beta = [\beta_4](SE = [SE_4], p > 0.10)$, indicating that trade flows are not driven by short-term arbitrage mechanisms but by stable supply chain structures (Francois & Manchin, 2013; Felbermayr & Gröschl, 2024). Meanwhile, infrastructure quality ($Infra_i$) and market centrality ($Market_j$) both have positive and significant coefficients of $\beta = [\beta_5](\text{p} < [\text{p}_5])$ and $\beta = [\beta_6](\text{p} < [\text{p}_6])$ highlighting their critical roles in facilitating interregional trade through improved logistics performance and spatial concentration of demand (Limao & Venables, 2001; Clark et al., 2004; Arvis et al., 2013; Donaubauer et al., 2018).

CONCLUSION

This study applies an extended Gravity Model in a log-linear specification to examine the determinants of interregional trade flows of coastal and fishery commodities in southern Central Java. The empirical results indicate that statistically, the economic size of both origin and destination regions—proxied by $\text{Ln}PDRB_i$ and $\text{Ln}PDRB_j$—exerts a strong, positive, and significant effect on trade volume, thus confirming the core prediction of the Gravity Model that larger economies engage in greater trade due to higher production capacity and market demand. Meanwhile, geographical distance ($\text{Ln}Distance_{ij}$) and interregional price differentials ($\text{Ln}PriceDiff_{ij}$) are statistically insignificant, suggesting that spatial proximity and short-term price disparities are no longer the primary drivers of trade volume. This reflects the increasing role of logistics modernization, transportation networks, and digital integration in mitigating distance-related frictions.

The infrastructure dummy ($Infra_j$) shows a positive but insignificant effect, implying that infrastructure facilitates trade only when accompanied by operational efficiency and network integration. Conversely, the market center dummy ($Market_j$) emerges as the most influential variable that significantly increases trade volume. This emphasizes the role of institutional and spatial concentration, where major consumption centers and processing hubs function as trade attractors for peripheral production areas such as Cilacap. The findings of this study suggest that strengthening market linkages, enhancing hub functionality, and facilitating better institutional coordination are more critical than physical proximity in promoting sustainable regional trade integration. Therefore, policy-making efforts should prioritize port efficiency, interregional logistics integration, and digital trade management. Furthermore, to improve the generalizability of the research findings, future studies are recommended to adopt panel data approaches, incorporate technological or environmental variables, and extend the analysis to other sectors.

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REFERENCES

Ahmad, N. A. B. & Jaini, A. B., 2015. The Impact of Infrastructure on Trade in Malaysia. *Journal of Entrepreneurship and Busines,* 3(2), pp. 42 - 49.

Akbardin, J., Samsudin, A. & Khoiriyah, K., 2019. *Application of gravity theory on the inter-regional zones activity build upon generating inland fisheries product result in Central Java.* s.l., Journal of Physics: Conference Series.

Anderson , J. E. & Marcouiller, D., 2002. Insecurity and the Pattern of Trade: An Empirical Investigation. *The Review of Economics and Statistics,* 84(2), pp. 342-352 .

Anderson, J. E., 2011. The Gravity Model. *Annual Review Economic,* Volume 3, pp. 133-160.

Anderson, J. E. & Wincoop, E. v., 2003. Gravity with Gravitas: A Solution to the Border Puzzle. *American Economic Review,* 93(1), p. 170–192.

Arvis, J.-F., Duval, Y., Shepherd, B. & Utoktham, C., 2013. *Trade costs in the developing world: 1995–2010,* s.l.: World Bank Policy Research Working Paper 6309.

Ayuwangi, A. & Widyastutik, 2013. Pengaruh Variabel Ekonomi Dan Non Ekonomi Terhadap Impor Indonesia Dari Asean+6 Melalui Moda Transportasi Laut. *Buletin Ilmiah Litbang Perdagangan,* 7(2), pp. 231-247.

Baier, S. L. & Bergstrand, J. H., 2007. Do Free Trade Agreements Actually Increase Members' International Trade ?. *Journal of International Economics,* Volume 17, pp. 72-95.

Baita, K., 2020. *Impact of Infrastructure on Trade: An Empirical Assessment by the Gravity Model in ECOWAS,* s.l.: SSRN.

Behar, A. & Venables, A. J., 2011. Transport Costs And International Trade. In: *In A Handbook of Transport Economics.* United Kingdom: Edward Elgar Publishing, pp. 97-115.

Bougheas, S., Demetriades, P. O. & Morgenroth, E. L., 1999. Infrastructure, Transport Costs And Trade. *Journal of International Economics,* 47(1), pp. 169-189.

BPS Jawa Tengah, 2025. *Volume Produksi dan Nilai Produksi Perikanan Tangkap Menurut Kabupaten/Kota dan Jenis di Provinsi Jawa Tengah, 2024,* Semarang: Badan Pusat Statistik Provinsi Jawa Tengah.

Brakman, S., Garretsen, H. & Marrewijk, C. v., 2009. Economic Geography within and between European Nations: The Role of Market Potential and Density across Space and Time. *Journal of Regional Science,* 49(4), pp. 777-800.

Brun, J. F., Carrère, C., Guillaumont, P. & de Melo, J., 2005. Has Distance Died? Evidence from a Panel Gravity Model. *The World Bank Economic Review,* 19(1), p. 99–120.

Celbis, M. G., Nijkamp, P. & Poot, J., 2014. Infrastructure and Trade: A Meta-Analysis*. *REGION,* 1(1), pp. 25-65.

Clark, X., Dollar, D. & Micco, A., 2004. Port Efficiency, Maritime Transport Costs, And Bilateral Trade. *Journal of Development Economics,* 72(2), pp. 417-450.

Dalisaintri, Noor, M. & Irawan, B., 2025. *Strategi Pemerintah Dalam Meningkatakan Pendapatan Asli Daerah.* Klaten: PT. Nas Media Indonesia.

Direktorat Pengelolaan Sumber Daya Ikan, 2024. *Laporan Kinerja Direktorat Pengelolaan Sumber Daya Ikan pada Triwulan II Tahun 2024,* Jakarta: Direktorat Pengelolaan Sumber Daya Ikan.

Donaubauer, J., Glas, A., Meyer , B. & Nunnenkamp , P., 2018. Disentangling The Impact Of Infrastructure On Trade Using A New Index Of Infrastructure. *Review of World Economics,* Volume 154, p. 745–784.

Erokhin, V., Tianming, G. & Ivolga, A., 2021. Cross-Country Potentials and Advantages in Trade in Fish and Seafood Products in the RCEP Member States. *Sustainability,* 13(7), p. 3668.

Francois, J. & Manchin, M., 2013. Institutions, Infrastructure, and Trade. *World Development,* Volume 46, pp. 165-175.

Ghaffar, A. M., Wanti, W. & Erna, 2023. Supply Chain Model of Fish Caught Landed at The Pelabuhan Perikanan Samudera (PPS) Cilacap, Central Java. *Indonesian Journal of Contemporary Multidisciplinary Research,* 2(3), pp. 507-514.

Gkatsikos, A., 2025. Port Power and Trade Flows: Evaluating China's Infrastructure Leverage in EU Markets Through a Gravity Model. *Economies,* 13(210), pp. 1-29.

Ichsan, A. K. N., Rahmawati, Y. & Anggraeni, F. N., 2022. Spatial Spillover Effect of East Java Economic Growth. *East Java Economic Journal,* 6(1), pp. 1-25.

Isard, W. et al., 1998. *Methods of Interregional and Regional Analysis.* Brookfield Vermont: Ashgate.

Ismail, N. W. & Mahyideen, J. M., 2015. *The Impact of Infrastructure on Trade and Economic Growth in Selected Economies in Asia,* Tokyo: ADBI Working Paper Series Paper 553.

Krugman, P. R. & Obstfeld, M., 2023. *International Economics: Theory and Policy.* 6th ed. Boston: Pearson.

Limão, N. & Venables, A., 2001. Infrastructure, Geographical Disadvantage, Transport Costs, and Trade. *The World Bank Economic Review,* 15(3), pp. 451-479.

Mauleny, A. T. et al., 2020. *Memajukan Logistik Indonesia yang Berdaya Saing.* Jakarta: Yayasan Pustaka Obor Indonesia.

Naya, D. A. B., Wijayanto, D. & Sardiyatmo, 2017. Analisis Komoditas Unggulan Perikanan Tangkap Di Provinsi Jawa Tengah. *Journal of Fisheries Resources Utilization Management and Technology,* 6(3), pp. 37-47.

Nurhayati, A., Suryana, A. A. H., Titin, H. & Yustiati, A., 2023. *The resilience of fishery production supply chain in West Java Province, Indonesia.* Honolulu, HI, IOP Publishing.

Rozaki, Z. et al., 2024. Optimizing Coastal Management: A Comprehensive Value Chain Analysis Approach for Sustainable Economic Development in Java, Indonesia. *Jurnal Ilmiah Perikanan dan Kelautan,* 16(1), pp. 165-179.

Seck, A., 2017. Trade Infrastructure, Trade Participation, and Trade Propensity of sub-Saharan African Firms. *Journal of African Development,* 19(1), pp. 1-26.

Sitompul, T. K., Sahara, S. & Anggraeni, L., 2018. The Effects of Trade Facilitation on Indonesian Fisheries Export. *Jurnal Manajemen dan Agribisnis,* 15(3), pp. 230-238.

Tarigan, R., 2004. *Ekonomi regional : teori dan aplikasi / Robinson Tarigan.* 1st ed. Jakarta: Bumi Aksara.

Ujianti, R. M. D., Burhanuddin, A. & Novita, M., 2024. Blue Economic Analysis in Coastal Areas of the IndonesianJava Sea Based on Fisheries. *Advances in Agriculture,* 2024(1), pp. 1-12.

Wahab, B. A., 2024. Trade-related infrastructure and bilateral trade flows: evidence from Nigeria and its trading partners. *Journal of Economic Structures,* 13(13), pp. 1-31.
Wahab, B. A., 2024. Trade-related infrastructure and bilateral trade flows: evidence from Nigeria and its trading partners. *Journal of Economic Structures,* 13(13), pp. 1-31.
Wahiu, R. Y., Andaki, J. A. & Wasak, M. P., 2019. Analisis Rantai Pasok Produk Perikanan Tangkap Bagan Apung. *Akulturasi,* 7(2), pp. 1299-1310.
Wicaksana, I., Wijaya, I. P. E., Suhaeni , S. & Syahputra , A., 2023. Analisis Faktor-Faktor yang Memengaruhi Ekspor Komoditas Perikanan: Pendekatan Gravity Model. *Jurnal Agrimanex Agribusiness Rural Management and Development Extension,* 3(1), pp. 1-13.
Yuniarti, D., 2007. Analisis Determinasi Perdagangan Bilateral Indonesia Pendekatan Gravity Model. *Jurnal Ekonomi Pembangunan: Kajian Ekonomi Negara Berkembang,* 12(2), pp. 99-109.
Zuhud, A. S. et al., 2023. Optimizing Coastal Management: A Comprehensive Value Chain Analysis Approach for Sustainable Economic Development in Java, Indonesia. *Jurnal Ilmiah Perikanan dan Kelautan,* 16(1), pp. 165-179.