Using Alchian Allen Theorem to Explore Seafood Trade Connectivity in Indonesia

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The study empirically explored the Alchian-Allen proposition by applying it to Indonesia's interregional seafood trade network. Seafood distribution center connectivity was analyzed by combining degree, betweenness, and accessibility indices with the Alchian-Allen theorem. Data were obtained from the Quarantine authority of the Indonesian Ministry of Marine Affairs and Fisheries. Our results showed that Surabaya, Jakarta, and Makassar are highest connectivity nodes in the seafood distribution network, as well as the market centers of seafood trade based on high reachability index values. This result supports the assumption of the Alchian-Allen theorem, stating that more high-quality seafood products are marketed outside their area of origin than on the local market.

KEY WORDS

~ Alchian-Allen theorem
~ Connectivity
~ Network analysis

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1. INTRODUCTION

The questions posed in this paper are: Why are the best coffee and tea consumed more overseas? Why are European and American luxury cars found in Indonesia? Why do commodity-producing regions often not enjoy their best products? Why is our country flooded with imported food products? Why are imported apples from Washington more prevalent in supermarkets than local apples? Why is it that if the prices of goods go up, we tend to buy more, and when prices go up again, we buy even more? In addition, numerous other questions demonstrate the "zero homogeneity" property of costs and revenues.

Neoclassical theory assumes that the Marshall demand curve is not homogeneous with respect to price and income. This means that it is the relative price, not the nominal price, that matters to consumers. This argument is related to the third law of demand from the Alchian-Allen Proposition (AAP). According to Borcherding et al. (1978), the Alchian-Allen Proposition states that when additional costs are charged on high-value and low-value goods, the demand for high-value goods increases because their relative prices are lower than the prices of low-value goods. This theory was first proposed in 1964 and has become an economic phenomenon. For example, a country being flooded by imported goods is not just an export-import activity. It indicates the existence of an Alchian-Allen proposition, where charging the same fee on exported high-quality and low-quality goods results in increased demand for high-quality goods when their relative prices decrease.

Similarly, the case of regional leakage is not merely a phenomenon that involves the flow of goods and services from the periphery to the centre or from rural to urban areas, but a consequence of the application of the AAP theorem. In Indonesia, regional leakage results from the evolving inequality between the island of Java and the regions outside Java, western and eastern Indonesia (Yusuf et al., 2014). Some of the causes of the development gap are the unbalanced maritime transport system between the islands, especially in the eastern part of Indonesia (Zaman et al., 2015) and the inefficiency of the inter-port shipping network (Fahmiasari & Parikesit, 2017). Uneven development results in trade imbalances as the flow of goods and services is concentrated in higher demand areas. Regions with high consumption levels require high-quality products. As a result, the relative consumption of high-quality goods in the target market area increases with lower comparable prices (Bertonaui et al., 1993).

On the other hand, good quality goods are more expensive in commodity-producing areas. As a result, good quality goods are sold and get exported more often, making it complicated to bring them to their area of origin (Umbeck et al., 1980). Transportation costs force exportation companies to export high-value goods and keep low-value goods for domestic consumption (Hummels, 2004).

In this study, a transportation network analysis was developed to identify seafood trade distribution centers. Transportation network analysis results are expected to support the assumptions of the traditional Alchian Allen hypothesis, that good quality goods are more likely to be transported and sold abroad than on the local market. The structure of the paper is as follows: Part 2 explains interregional trade connectivity and the Alchian-Allen theorem. The following section discusses the data and methodology, and section four gives results and discussion. Conclusions and theoretical implications are presented at the end of the paper.

2. LITERATURE REVIEW

2.1. Interregional trade connectivity

The word region refers to a series of places with specific characteristics within the same region. It is also a group of areas that include parts of geographical regions combined into basic spatial units. The term region may also imply that areas belonging to the same region are similar in one way or another (Behrens, 2007). Losch (1938) said that region is a system of different areas where a number of commodities are produced and traded outside a system. Ullman (1956) divided the characteristics of functional relationships between regions into three categories, including complementarity, intervening opportunities, and transferability between regions.

The complementarity process is a relationship between two regions that results from mutual complementarity, where one region meets the demand of the other. The intervening opportunity mechanism is the interaction between two regions based on one region having more profitable offers than other regions. The process of portability is a connection between two regions based on shared infrastructure. Rondinelli (1985) stated that the function of interregional links can be categorized according to seven criteria related to spatial development: physical, economic, population movement, technology, social interaction, service, political and administrative interaction. This concept describes the economic relationship inherent to the pattern of commodity flows in consumption and production activities. Similarly, population movement is from the place of origin to growth centers. The provision of all services needed by the population, such as energy, education, healthcare, and transportation is critical.

In maritime trade, Stopford (2009) identified at least four factors that illustrate the different characteristics of maritime trade networks within a region. First is the balance of export and import levels. In this case, exports and imports are the primary cause of trade between resource-poor regions and resource-rich areas. Second is the level of welfare or the size of the region's economy, i.e. GDP. Areas with higher GDP have high need for material resources and manufactured goods, transported mainly by sea. In addition, regions with extensive local natural resources sometimes still need imports for further development and possess strong import and export capabilities. The third is the physical size of the land area and the quantity of local resources, such as energy sources, minerals, agricultural produce, forests, industry, and other natural resource potentials. Fourth, population is a factor that results in the formation of trade inter-countries or interregions connected through the sea freight service. More densely populated regions certainly expect more sea transportation to meet local needs and export their products to other regions.

Income per capita, population, geographical distance, and culture influence international trade flows. Márquez-Ramos et al., (2011) proved that income per capita, population, "sharing a language," being an island, and geographical distance determine the relationship between maritime trade and freight rates. In multilateral maritime trade, improved hinterland connectivity and short-sea shipping are a solution for regional trade integration between the periphery and the central region (Mohamed-Chérif & Ducruet, 2016). Maritime trade connectivity increased the cost efficiency of maritime transportation, removing the barrier to international trade flows (Calatayud et al., 2017; Tovar & Wall, 2022). Kazutaka (2015) revealed that the high maritime transportation costs hinder the supply of high-quality goods from producing areas far removed from their market centers. Therefore, the relationship between distance and product quality implies that the demand for high-quality goods will increase as an effect of the Alchian-Allen theorem (Lugovskyy & Skiba, 2015).

2.2. Alchian-Allen Theorem

According to the Alchian-Allen's proposition if a unit cost, i.e. transportation costs (fixed cost or unit fee), is charged on two similar commodities of different quality, one high and the other low, the relative price of the higher quality commodity decreases, boosting the consumption of the higher quality commodity. Mathematically, the Alchian-Allen proposition is as follows.

$$\frac{\partial\left(\frac{X1}{X2}\right)}{dt} > 0 \quad (1)$$

The formula means that if unit fees (t) increase, the consumption of higher quality commodity (X1) will increase relatively more than the consumption of the low-quality commodity (X2). In other words, if fixed costs are added to both types of goods, consumers will choose the higher quality goods more frequently than the lower quality goods because the relative price of the higher quality commodity is lower.

$$\frac{\partial\left(\frac{X1}{X2}\right)}{\partial t} > 0 \;=\; \left(\frac{1}{X2^2}\right)\left(X2\left(\frac{dX1}{dP1}+\frac{dX1}{dP2}\right)-X1\left(\frac{dX2}{dP1}+\frac{dX2}{dP2}\right)\right) \quad (2)$$

Substitution compensated elasticity $\in_{ij} = = \frac{Pj}{Xi} * \frac{dXi}{dPj}$:

$$\frac{\partial\left(\frac{X1}{X2}\right)}{\partial t} = \left(\frac{X1}{X2}\right)\left(\frac{\epsilon 11}{P1}+\frac{\epsilon 12}{P2}-\frac{\epsilon 21}{P1}-\frac{\epsilon 22}{P2}\right)$$

$$\frac{\epsilon 11}{P1}+\frac{\epsilon 12}{P2}-\frac{\epsilon 21}{P1}-\frac{\epsilon 22}{P2} > 0$$

Therefore:

$$\frac{\partial\left(\frac{X1}{X2}\right)}{\partial t} = \epsilon 12 - \epsilon 22\left(\frac{1}{P2}-\frac{1}{P1}\right) > 0, \text{ in which } P_1 > P_2 > 0 \quad (3)$$

Borcherding et al. (1978) studied the Alchian Allen proposition by introducing the idea of cost per item, such as transportation cost or tax per unit. Alchian Allen's theorem does not take into account whether the goods are delivered to consumers or consumers come to the location of the products. The Alchian Allen proposition reflects the mathematical demand. It proves comparative statics that explain the demand curve with a constant utility rate or equal income of buyers in different regions, and higher and lower quality products.

Umbeck (1980) argued that individuals who buy apples want higher quality apple juice because the higher the apple content, the better the juice ("quality attribute"). When transportation costs are added to apple cartons, consumers buy high-quality apple juice, and the demand for that quality attribute shifts consumer demand to apples. According to Umbeck, if the charge exceeds consumer surplus, the buyer will still buy more apple juice (higher quality apples). However, if the cost exceeds consumer surplus, the consumers will stop buying apples.

3. DATA AND METHODOLOGY

3.1. Data

The study used interregional seafood traffic data in December 2021, collected from the Seafood Quarantine and Quality Control Agency (BKIPM) of the Indonesian Ministry of Marine Affairs and Seafood. Domestic transaction shipments in as many as 132 seafood distribution nodes in Indonesia, including KIPM offices, KIPM stations, and seafood ports, have been examined. The distribution centres were selected based on the availability of data on the frequency of traffic between nodes, as some distribution centres do not have a record of shipping transaction frequency. Based on origin-destination shipment traffic data, the lowest seafood product quantity transported was approx. 10 tons.

3.2. Methodology

Analyzing transport networks and developing connectivity measuring indicators using the graph theory approach is an old issue. However, the studies of connectivity between seafood distribution centers and seafood ports are still relatively new in Indonesia's network analysis relying on marine transportation modes. Several analytical techniques have been applied to identify port interconnections, establish network structure and describe objectives relying on the number of nodes, edges, average path length, and network density (Tovar et al, 2015). In addition, the average clustering coefficient (ACC) was also used to identify areas with high edge levels and distinguish them from other sites within a cluster (Watts & Strogatz, 1998).

The study identifies seafood distribution centers using a set of modes formulated by Opsahl et al. (2010) and adopted by Freeman (1978), namely, the degree and betweenness centrality index, while the accessibility index was calculated using the technique employed by Cullinane & Wang (2009). The degree is the level of network connectivity of a seafood port. It has become the standard approach to measuring the potential connections of each node in the network with strong connections to a port (Tovar et al., 2015). The degree index formula is as follows:

$$Deg(i) = \sum_j \frac{Aij+Aji}{2} \quad (4)$$

A_{ij} is the adjacency matrix, where A_{ij} = 1 if port *i* is connected to port *j*, if the ports are not connected, A_{ij} = 0.

Betweenness centrality is used to identify the center with the highest influence on connectivity in a network by calculating how often a node is on the shortest path among two others (Caraka et al., 2023). Betweenness centrality index can be described as (Freeman, 1978):

$$Cb(v) = \sum_{S \neq v \neq V} \frac{\sigma st(v)}{\sigma st} \quad (5)$$

where σst is the number of shortest distances between nodes s ∈ V and t ∈ V, and $\sigma st(v)$ is the number of such distances consisting of $v \neq$ V. Seafood ports with high betweenness levels are strategically placed close to the main lines of maritime transport. Therefore they are in a privileged, central position compared to other ports (Tovar et al., 2015).

Connectivity and accessibility are the key elements in the transport network since they are often used to measure the ability to reach nodes. Cullinane & Wang (2009) established economic accessibility based on the maximum transportation capacity (TEUs/day) of ports to assess the accessibility of each transport element within the shipping network. In this case, the maximum transport capacity between a pair of fishing ports using the weight of the graph is to assess the graph relationship matrix (L) using the following formula:

$$L = V_{ij} = \sum_k T_{ckij} \frac{F_k}{365} \quad (6)$$

T_{ckij} is the cargo capacity of the vessel in tons and F_k is the frequency of traffic between seafood ports *i* and *k*.

The study does not provide data on product quality and sea transportation costs. The assumption, strengthening the relationship between the betweenness index and connectivity using the Alchian-Allen preposition, is that all seafood commodities shipped by distributors or local entrepreneurs from the area of origin are good-quality. As Kazutaka, (2015) and Lugovskyy & Skiba, (2015) mentioned, the market center that far away from much demand for high-quality products.

4. RESULT AND DISCUSSION

The research used directed strategy and weight in tons on the edge to establish the relationship between different points in the distribution channel. The network had n = 132 nodes and m = 501 edges, i.e. network density = 0.029, and the average clustering coefficient (ACC) of 0.308, which means that the network has low cluster tendency. The maximum load was 9,523.01 tons. Table 2 gives the degree and betweenness for the 20 highest and lowest ranking seafood distribution points in the network system. Surabaya, Jakarta, and Makassar have become the most important ports in the Indonesian seafood distribution network. Other areas, such as Medan, Semarang, Merak, Batam, and Tarakan, rank among top 10 with respect to both indicators (Table 1).

Figure 1 shows the seafood trade distribution network based on two indicators, degree centrality, and betweenness centrality. The image was generated by the Gephi software and the "force-directed" algorithm which helped distribute the nodes. As Tovar et al. (2015) mentioned, force-directed algorithms generate a compact network display whereby the most relevant nodes are located in the center of the graph while the less important ones are left on the periphery. The relative position of each port with respect to degree centrality and betweenness centrality is illustrated by size and color scale hierarchy.

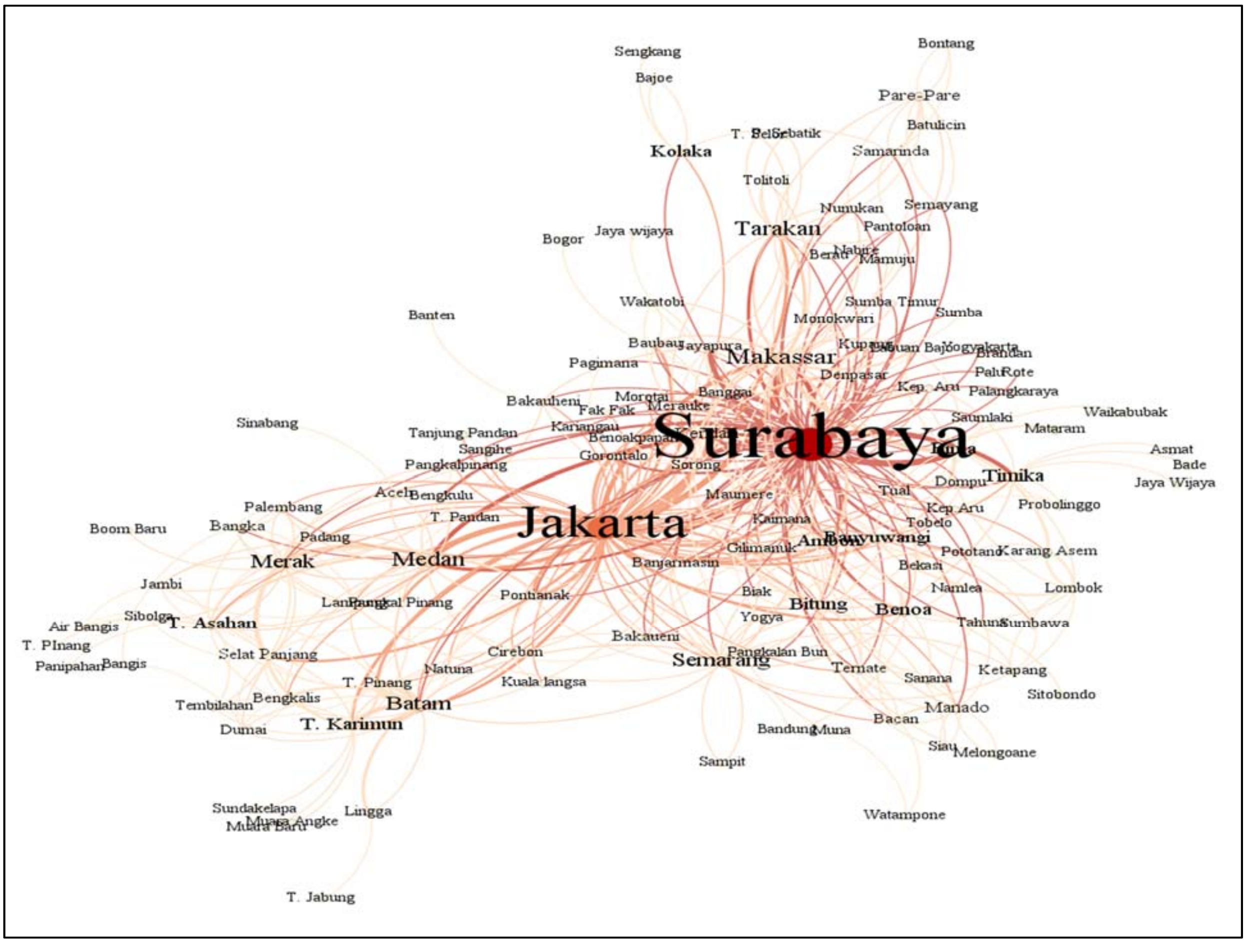

Figure 1. Graphic visualization of the main seafood shipping network, Indonesia, December 2021 (Source: data analysis using Gephi software and “force-directed” algorithm).

Table 1. Top and bottom 20 on the degree and betweenness index scale.

Top 20					Low 20				
id	City	Between-ness	City	Degree	id	City	Between-ness	City	Degree
1	Surabaya	6017.19	Surabaya	100	1	Sanana	3.64	Tahuna	4
2	Jakarta	3658.16	Jakarta	81	2	Natuna	0.5	Biak	4
3	Makassar	980.75	Makassar	39	3	Saumlaki	0	Kep.Aru	3
4	Medan	824	Semarang	29	4	Aru Islands	0	Tobelo	3
5	Tarakan	772.17	Merak	27	5	Bajoe	0	Morotai	3
6	Semarang	722.5	Medan	24	6	Rote	0	Bontang	3
7	Batam	716.4	Bitung	22	7	Tobelo	0	Saumlaki	3
8	Merak	664.36	Tarakan	21	8	T. Jabung	0	Kaimana	3
9	Bitung	510.39	Batam	19	9	Bontang	0	Dompu	3
10	T. Karimun	501.97	Benoa	18	10	Asmat	0	FakFak	3
11	Timika	435.21	T. Asahan	17	11	Muna	0	Namlea	2
12	Benoa	432.09	T. Karimun	17	12	Mamuju	0	Bajoe	2
13	Bima	352.94	Sorong	15	13	Sampit	0	P. Sebatik	2
14	Ambon	352.55	Banyuwangi	14	14	Jaya Wijaya	0	Sinabang	1
15	T. Asahan	331.13	Manado	14	15	Bangis	0	T. PInang	1

16	Banyuwangi	330.58	Ambon	14	16	Morotai	0	Nabire	1
17	Kolaka	320	SelatPanjang	14	17	Bade	0	T. Pandan	1
18	Kendari	289.67	Bima	13	18	Sinabang	0	Sangihe	1
19	Manado	287.71	Ternate	13	19	T. Pinang	0	Rote	1
20	Pare-Pare	244.49	Kendari	12	20	Nabire	0	Sitobondo	1

Source: data analysis, 2022

Table 2. Top 40 accessibility index for domestic seafood trade, December 2021.

Source	**Target**	**Ton**	**Frequency**	**Accessibility index**	**Rank**
Aru Islands	Surabaya	6,425.75	265	4,665.27	1
Bitung	Jakarta	5,931.79	276	4,485.41	2
Gilimanuk	Banyuwangi	2,177.03	735	4,383.88	3
Banyuwangi	Surabaya	5,216.45	306	4,373.24	4
Banyuwangi	Gilimanuk	1,383.05	1020	3,864.96	5
Merak	Jakarta	3,956.42	268	2,904.99	6
Makassar	Jakarta	2,891.09	242	1,916.83	7
Banjarmasin	Surabaya	1,109.92	618	1,879.26	8
Surabaya	Banjarmasin	1153.5	509	1,608.58	9
Timika	Surabaya	9,523.01	58	1,513.25	10
Palembang	Bangka	1,586.41	318	1,382.13	11
Surabaya	Jakarta	5,305.36	95	1,380.85	12
Denpasar	Surabaya	2,642.09	161	1,165.42	13
Bakauheni	Jakarta	1,368.62	302	1,132.39	14
Cirebon	Jakarta	2,078.43	140	797.21	15
Semarang	Surabaya	2,347.52	122	784.65	16
Tarakan	Surabaya	2,475.65	110	746.09	17
Merak	T. Asahan	2,102.85	122	702.87	18
Pangkal Pinang	Lampung	891.45	286	698.51	19
Tarakan	Pare-Pare	922.41	251	634.31	20
T. Pandan	Jakarta	570.87	311	486.41	21
Bangka	Palembang	676.34	242	448.42	22
Merak	Palembang	514.49	317	446.83	23
Makassar	Surabaya	1,364.31	110	411.16	24
Medan	Jakarta	846.17	163	377.88	25
Surabaya	Makassar	1,714.23	79	371.03	26
Pontianak	Jakarta	849.26	153	355.99	27
Nunukan	Makassar	796.92	138	301.30	28
Surabaya	Timika	3,531.48	31	299.93	29
Jakarta	Surabaya	8259.8	13	294.18	30
Bitung	Surabaya	1,393.38	76	290.13	31
Aru Islands	Jakarta	1,299.95	80	284.92	32
Lampung	Jakarta	666.66	115	210.04	33
Benoa	Jakarta	982.15	67	180.29	34
Jakarta	Makassar	935.32	70	179.38	35
Sumbawa	Ketapang	837	69	158.23	36
Surabaya	Ambon	744.16	70	142.72	37
Merak	Jambi	791.3	65	140.92	38
Ambon	Surabaya	1,045.9	47	134.68	39
Merak	Medan	834.05	58	132.53	40

Source: data analysis, 2022.

As previously noted, the cities of Surabaya, Jakarta and Makassar are the best hubs with the most vital connectivity in Indonesia's seafood distribution network. On the lower level, Medan, Tarakan, Merak, Semarang and Bitung are gateways for shipping raw materials to main market areas. The regions with a low degree and betweenness index value are peripheral regions with small-town status, classified as raw seafood material supply regions. According to Table 1, 20 lowest ranking regions are the peripheral areas in the national distribution network. They are neither strategically located nor close to main sea transport routes. Table 2 shows the results for the top 40 most accessible ports, with Aru Islands – Surabaya having the highest index. These results suggest that cargo capacity and frequency of shipping are critical factors in determining strong connections between ports.

Another factor strongly influencing interregional shipping activity is location. For example, Gilimanuk-Banyuwangi has a high market share, is close to raw material sources, and has a high accessibility index. Stopford (2009) stated that differences in the level of GDP cause differences in the market share. High GDP regions need more high-quality resources and manufactured goods transported by sea, as illustrated by accessibility indices showing that regions with higher GDP, such as Jakarta, Surabaya, and Makassar, are the main centers of domestic seafood trade.

The high demand for seafood consumption in high GDP regions increases the sale of high-quality seafood in the producing areas. Another factor is the location of the producing region, as maritime transportation costs are largely dependent on distance (Clark et al., 2004). The greater the distance between a seafood supply area and its market center, the more expensive the transportation, which is in line with the Alchian Allen theorem hypothesis stipulating that high sea transportation costs force exporters to sell more high-quality seafood commodities outside their local markets (Hummels, 2004).

4.1. Alchian Allen proposition

The degree, betweenness, and connectivity index results indicate that the interregional seafood trade flow pattern should be considered empirical evidence and prove the consequences of applying the Alchian-Allen proposition. All higher-quality seafood commodities flow to the center of growth through the ports of Tanjung Priok in Jakarta, Tanjung Perak in Surabaya, and Makassar. Bertonaui et al., (1993) suggested that the demand for higher-quality goods heavily depends on society's income level. Communities with a significant income will tend to consume higher quality goods even at a higher price. In this case, the demand for high-quality seafood commodities will increase after transportation costs are charged because their relative price is lower than the price of low-quality seafood. Besides, higher quality seafood will be more easily accessible to city dwellers than rural communities where it is harvested. In other words, high-quality seafood is less available in rural areas (Borcherding et al, 1978). The degree and betweenness index results indicate that regions such as Surabaya and Jakarta have the highest index. These cities are not seafood producers, while seafood-producing regions such as Aru Islands, Sanana, Saumlaki, and Natuna have a low degree and betweenness index and are categorized as peripheral areas (Figure 1). Exporters in remote areas distant from the primary market have additional incentives to increase specialization in their export products with higher quality, given high transportation costs (Lugovskyy & Skiba, 2015). According to the Alchian-Allen theorem, the relative prices of high-quality products are lower in distant export markets (Liu, 2011; Minagawa & Upmann, 2013).

For instance, good quality tuna (X1) costs \$2.85/kg, and low-quality tuna (X2) \$1.42/kg. The ratio of high to low-quality tuna is 2, i.e. one kg of high-quality tuna costs the same as two kilograms of low-quality tuna. If the same cost is charged for the transportation of high and low-quality tuna from Aru Islands to Surabaya, \$0.71/kg, ratio of high to low-quality tuna is (\$2.85 + \$0.71 / \$1.42 + \$0.71) =1.67. The added cost of transportation causes the high to low-quality tuna ratio to drop from 2 to 1.67. Due to the reduction of the relative price of high-quality tuna compared to lousy tuna, the relative consumption of high-quality tuna (X_1) is higher in Surabaya than in Aru Islands. This makes traders in the Aru Islands ask for more high-quality tuna to be marketed in Surabaya. Mathematically, the above example can be represented as follows:

X_1 = high-quality tuna, price in P_1 = \$2.85/kg

X_2 = low-quality tuna, price in P_2 = \$1.42/kg

Where $P_1 > P_2$ the relative price of X_1 is lower than X_2 or $1/P_1 < 1/P_2$.

The basic Alchian-Allen theorem: $\frac{\partial\left(\frac{X_1}{X_2}\right)}{dt} > 0$

$$= \frac{\left[\frac{\partial X1}{\partial t} \cdot X2\right] - \left[\frac{\partial X2}{\partial t} \cdot X1\right]}{X2^2} \quad \text{where the chain role is } \frac{\partial x1}{\partial t} = \frac{\partial x1}{\partial P1} + \frac{\partial x2}{\partial P2}$$

$$= \frac{X2\left[\frac{\partial X1}{\partial P1} + \frac{\partial X1}{\partial P2}\right] - X1\left[\frac{\partial X2}{\partial P1} + \frac{\partial X2}{\partial P2}\right]}{X_2{}^2}$$

$$= \frac{1}{X2}\left[\frac{\partial X1}{\partial P1} + \frac{\partial X1}{\partial P2}\right] - \frac{X1}{X2^2}\left[\frac{\partial X2}{\partial P1} + \frac{\partial X2}{\partial P2}\right]$$

Substituting compensated elasticity:

$$\epsilon_{11} = \frac{\partial X1}{\partial P1} \cdot \frac{P1}{X1} \quad \text{thus} \quad \frac{\partial X1}{\partial P1} = \epsilon_{11} \cdot \frac{X1}{P1}$$

$$\epsilon_{12} = \frac{\partial X1}{\partial P2} \cdot \frac{P2}{X1} \quad \text{thus} \quad \frac{\partial X1}{\partial P2} = \epsilon_{12} \cdot \frac{X1}{P2}$$

$$\epsilon_{21} = \frac{\partial X2}{\partial P1} \cdot \frac{P1}{X2} \quad \text{thus} \frac{\partial X2}{\partial P1} = \epsilon_{21} \cdot \frac{X2}{P1}$$

$$\epsilon_{22} = \frac{\partial X2}{\partial P2} \cdot \frac{P2}{X2} \quad \text{thus} \frac{\partial X2}{\partial P2} = \epsilon_{22} \cdot \frac{X2}{P2}$$

So $\frac{1}{X2}\left[\left(\epsilon 11 . \frac{X1}{P1}\right) + \left(\epsilon 12 . \frac{X1}{P2}\right)\right] - \frac{X1}{X2^2}\left[\left(\epsilon 21 . \frac{X2}{P1} + \epsilon 22 . \frac{X2}{P2}\right)\right]$

$$= \frac{1}{X2}\left[X1\left(\frac{\epsilon 11}{P1} + \frac{\epsilon 12}{P2}\right)\right] - \frac{X1}{X2^2}\left[X2\left(\frac{\epsilon 21}{P1} + \frac{\epsilon 22}{P2}\right)\right]$$

$$= \frac{X1}{X2}\left[\frac{\epsilon 11}{P1} + \frac{\epsilon 12}{P2}\right] - \frac{X1}{X2}\left[\frac{\epsilon 21}{P1} + \frac{\epsilon 22}{P2}\right]$$

$$= \frac{X1}{X2}\left[\frac{\epsilon 11}{P1} + \frac{\epsilon 12}{P2} - \frac{\epsilon 21}{P1} - \frac{\epsilon 22}{P2}\right] > 0$$

Given that there are only two commodities, the final result is $\epsilon_{12} - \epsilon_{22}\left(\frac{1}{P2} - \frac{1}{P1}\right) > 0$, where $P_1 > P_2$, giving the relative price of $\frac{1}{P1} < \frac{1}{P2}$ or in other words, high-quality tuna $\left(\frac{1}{P1}\right)$ is less expensive than low-quality tuna $\left(\frac{1}{P2}\right)$.

This phenomenon clearly illustrates that interregional trade activity or import-export between countries proves the Alchian-Allen theorem (Echazu, 2009). Higher quality seafood is always sold out because the demand is very high. By contrast, the low-quality seafood is nonmarketable and therefore consumed only by the local people. This has a negative impact on the areas of origin which cannot benefit from the multiplier effect. As Borcherding et al., (1978) mentioned, it makes no difference whether goods are transported to consumers or consumers come to the product's point of origin. In terms of local economy, if consumers visit to enjoy the commodity at its point of origin, local incomes will grow, spurring the development of other economic sectors.

The relationship between distance and demand for high-quality seafood can be observed using the Spearman rank correlation test (Table 3). The Spearman rank correlation test shows significant correlation between index degree, betweenness, connectivity, and the volume of seafood trade. Kazutaka, (2015) noticed a positive relationship between market space and the quality of goods.

Table 3. Spearman rank correlation coefficient.

	Seafood volume	Access-x	Betweenness	Degree
Seafood volume	1			
Access-x	0.6103	1		
	0.00			
Betweenness	0.4977	0.6402	1	
	0.0011	0.00		
Degree	0.4094	0.7212	0.8624	1
	0.0087	0.00	0.00	

The geographical factor represented by high degree, betweenness, and connectivity index indicates the connectedness of supply and demand regions. The additional transportation costs imposed on high-quality and low-quality tuna increase the demand for high-quality tuna. Lugovskyy & Skiba (2015) explained that multilateral geographic elements influence the quality of a country's exports and encourage the production of higher-quality goods. The variables of distance, quality of goods, and relative price are essential determinants of interregional export-import.

5. CONCLUSION

Interregional trade connectivity showed by degree, betweenness, and accessibility index supports the Alchian-Allen hypothesis. Geographical factors encourage seafood exporters in peripheral areas to raise the quality of their export commodities sold to the market center through increased specialization. So, higher quality seafood tends to be sold out compared to low-quality due to its relative price decrease. Surabaya, Jakarta, and Makassar are the main destination markets for seafood trade, as these cities are strategically placed and have robust connectivity in the Indonesian maritime trade network.

5.1. Policy implication

The Alchian-Allen effect implies that seafood in Indonesia must be high-quality to compete on the global market. Regions that have a low degree and betweenness indices are areas that produce and supply seafood products. Most of these areas are in the eastern part of Indonesia. Seafood from these areas needs more support to overcome the high sea transportation costs and the limited availability of energy supplies. Developing regional industrial centers with large-scale and high-quality products through integrated marine and seafood centers can shorten handling distances and cut long seafood supply chains. The development of integrated seafood centers depends on the characteristics of their seafood potential, such as tuna, tunny, and skipjack tuna in Bacan or Tual and shrimp in the Seram Islands.

Improving the seafood quality also requires profitable collaboration between business actors. Fishermen, seafood entrepreneurs, and distributors should realize the importance of maintaining seafood quality. Fishermen must immediately store their catch in a storage box filled with ice to ensure freshness. Furthermore, fishermen leave it to seafood collectors to organize seafood distribution to market destination areas. During the preparation period, seafood is kept in cold storage, which is an important facility that should be available in production areas and marketing destinations. The cold supply chain is crucial in maintaining the quality and safety of marketed seafood products, ensuring that consumers get good quality seafood. Modernization of fishing gear can be an alternative to another policy. The advances in fishing gear help protect the quality of the catch by shortening the time between capture and storage.

The weakness of the network model in this paper is its inability to identify and differentiate between high and low-quality seafood. The study is only limited to describing interregional seafood trade as an economic activity based on the alleged application of the Alchian Allen theorem. More in-depth evidence are required and further research should be based on accurate data on seafood quality and transportation costs on each route.

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