Impact of ICT on Export Indonesia's Specialization Products: Gravity Model Approach

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ABSTRACT

This study aims to investigate the impact of Information and Communication Technology (ICT) on the export growth of Indonesia's leading specialized products. A sample of this study was selected by identifying every commodity that holds more than a 25% share in the international market. The five specialized products also represent Indonesia's leading sectors, which include the manufacturing industry (palm oil, HS Code: 151190, and coconut oil, HS Code: 151319), agricultural products (rubber, HS Code: 400122), and natural resources (coal, HS Code: 270119, and tin, HS Code: 800110). The analytical model was tested on Indonesia's leading products in 15 importing countries during the 2010-2020 period and estimated using PPML and GMM as a robustness test. The ICT variable was proxied by bandwidth capacity, which represents the quality of internet access, both in Indonesia as an exporting country and in importing countries for Indonesia's leading products. The results of the analysis indicate that the quality of internet access has a positive impact on export growth. Additionally, other control variables, such as GDP, population, RTA, language, and importers from Asia, also have a positive impact on the export growth of Indonesia's leading commodities. It can be concluded that Indonesia's export pattern remains concentrated in Asia's partner countries, driven by economies of scale and hindered by geographical distance. This study suggests that the development of ICT is typically a long-term process, so it takes some time to experience the significant impact of ICT, especially on exports.

INTRODUCTION

One of the efforts a country can undertake to remain competitive in the international market is to innovate. Innovation in the production process can be divided into two, namely input innovation and output innovation. (Moshiri, 2016). Innovations can be realized in several ways, one of which is by mastering and adopting a technology, such as *Information Communication Technology* (ICT). ICT via the Internet is the face of globalization and serves as the primary facilitator in increasing integration between countries across various agendas, especially in trade. The Internet can contribute to improving the quality of communication, as it plays a vital role in different business processes. The adoption of ICT technology can strengthen integration between countries and create network effects among them (Chang & Chen Wang, 2008). ICT encompasses the concepts of the Internet of Things (IoT) and Internet of Services (IoS), which have a significant impact on business processes. In general, ICT can contribute to several aspects,

such as increased production efficiency (Steyaert & Gould, 2009), more effective communication (Jaruwachirathanakul & Fink, 2005), and more optimal workforce management (Acemoglu, 2007). Adopting ICT enables a country to become more competitive due to its significant impact on various aspects of business.

The network effect is a concept that explains the value of benefits produced by a good or service, where the value of these benefits increases with the quantity and intensity of use of the good or service. (Shapiro, 1986). This concept is often used to explain the magnitude of the benefits of the internet itself, which is strongly influenced by the intensity and quantity of internet use. The primary objective of this study is to investigate the benefits of ICT on export performance through the internet. The contribution made by ICT to the business sector will have an impact on increasing a country's export performance. Several studies have empirically proven that ICT can contribute to improving export performance in various countries, particularly in Asia. (Minges, 2005), Europe (Priede & Pereira, 2013), and even Africa (Lefophane & Kalaba, 2021). However, some empirical findings suggest ICT has a limited effect on export performance, especially in developing countries. (Sinha et al., 2020).

ICT statistics in Indonesia, represented by the percentage of internet users, also show an increase, with up to 54% of Indonesia's population now being internet users. From a quality perspective, internet access in Indonesia remains relatively low. Until now, Indonesia's bandwidth capacity has only reached 119.998 Mbit/s (see Figure 1). This bandwidth value is relatively low, considering the large number of internet users in Indonesia, which is approximately 54% or equivalent to 147.42 million users. The quality of this aspect of Indonesia's bandwidth is also relatively low compared to other countries, among which the number of internet users is lower than in Indonesia (see Figure 2). Based on this phenomenon, this study aims to investigate whether the Internet, from a quality perspective, plays a role in the Indonesian export process. If it is empirically proven to play a role, then developing Indonesia's telecommunications infrastructure is a crucial agenda for enhancing Indonesia's presence in the international market.

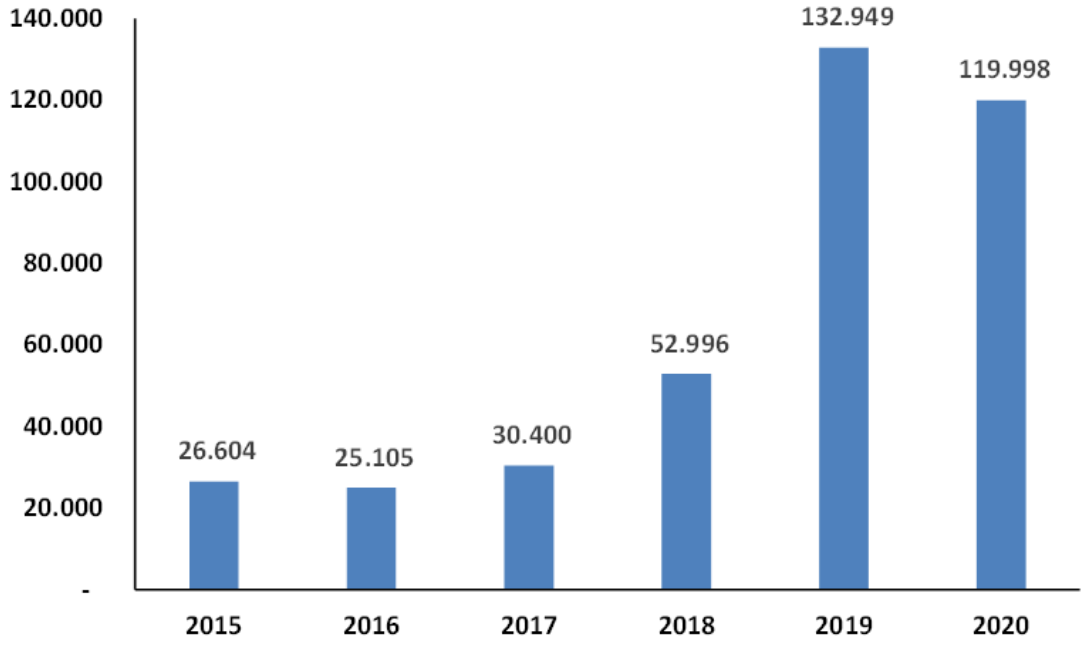

Figure 1. Indonesia Bandwidth Capacity Growth 2015 - 2020 (Mbit/s)

Source: International Telecommunication Union, 2021

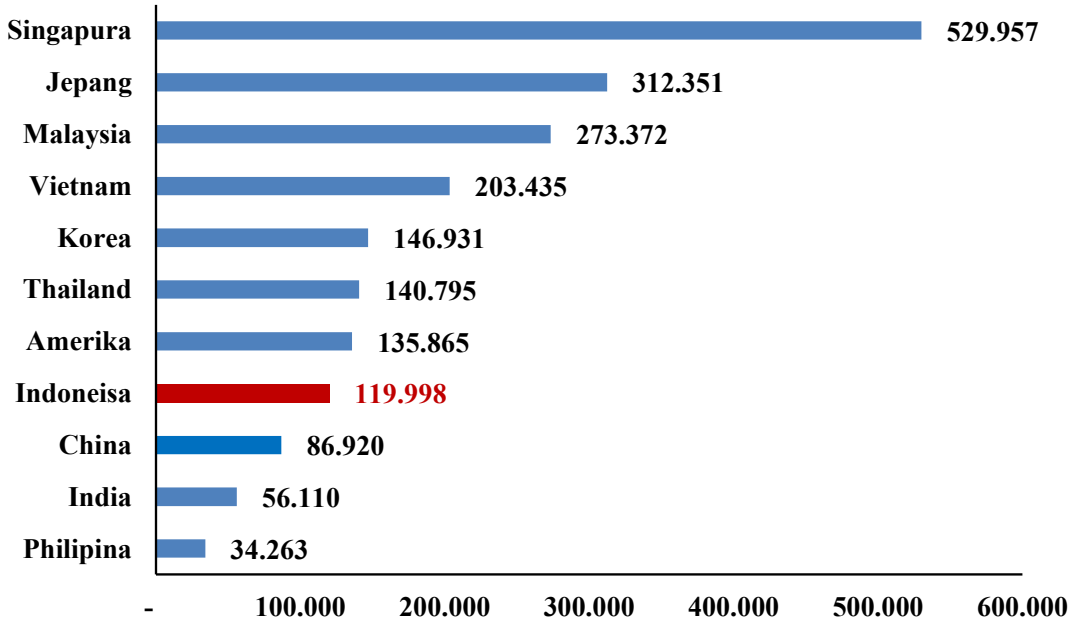

Figure 2. Indonesia Bandwidth Capacity Rank Compared with Main Trading Partner 2020

Source: *International Telecommunication Union, 2021*

Furthermore, the trend of Indonesian exports, in general, has also increased, with primary sector exports accounting for the majority. The information in Table 1 shows that Indonesia has superior commodities, which control more than 25% of the world market. The commodities listed in Table 1 are Indonesia's leading commodities, which are the study samples in this research. This selection was based on two main reasons: firstly, this commodity has strong competitiveness, a large proportion of Indonesian exports, and a position as a market leader in the international market. The following reason is that these five commodities each represent a primary industry, such as the processing industry (Palm oil and coconut oil), agricultural (rubber), and natural resources (coal and tin). The use of this level of analysis at the commodity data level is expected to enable a more specific explanation of the Internet's role in exports and formulate more targeted strategies.

Table 1. Indonesia Specialization Products Share Market

HS Code	Commodity	Exports (Tons)	% Share International Market
270119	Coal	272.177.234	81,81%
151190	Palm oil	23.033.912	65,72%
400122	Rubber	2.277.117	34,34%
151319	Coconut Oil	332.649	31,11%
800110	Tin	74.877	28,70%

Source: *International Trade Centre, 2021*

Furthermore, to address the objectives of this study, a research model was developed based on the gravity model. (Ozcan, 2017). The gravity model is an ideal framework for identifying international trade patterns and testing the contribution of each factor that is thought to influence exports (Asgari, 2011). Furthermore, this study aims to explore the determinants of Indonesian exports in greater depth by incorporating additional variables, including free trade agreements, language similarities, and market segmentation in Asian partner countries. The identification of the internet's impact through the

development of a gravity model and the analysis of exports at the commodity level is the main contribution of this study.

Information and Communication Technology (ICT) has a significant impact on business culture worldwide. Through the concept of digitization, the presence of ICT can contribute to increasing the effectiveness of several important aspects of business, such as communication. (Demirkan et al., 2009) management control partners, workforce, and distribution (Jaruwachirathanakul & Fink, 2005). Improving the quality of this communication aspect has a good impact on the improvement of aggregate economic sector activities. (Acemoglu, 2007; Brynjolfsson & Hitt, 1998). The improvisation that occurs due to the presence of ICT in the business sector will stimulate the emergence of innovations, making businesspeople more competitive in the international market. (Priede & Pereira, 2013). Several empirical studies have proven that the presence of ICT can have a positive impact on a country's export performance. (Freund & Weinhold, 2002), And the higher the intensity of ICT development investments made by a country, the greater the impact on the country's export performance (Mattes, 2002).

In many studies examining the contribution of ICT to exports, variations exist in the use of indicators to describe a country's ICT development condition. The indicators that researchers often use are the percentage of cellular phone users and the percentage of internet users in a country's population. (Ahmad et al., 2011; Clarke & Wallsten, 2006) In another, more comprehensive model, researchers use indicators of broadband and the availability of ICT infrastructure as variables. ICT in models (Demirkan et al., 2009). Abeliansky (2017) Uses *bandwidth data* as a proxy for internet quality and estimates this proxy for export performance to 122 countries from 1995 to 2008. The estimation results show that internet quality/internet speed has a positive and significant coefficient on the export performance of developing and developed countries. Martínez-Zarzoso (2019) Examines the impact of internet penetration on commodity exports, which are diversified based on the intensity of technology used to produce these commodities. The method of calculating the intensity of technology use refers to the PCI (*Product Complexity Index*) index number. The estimation results indicate that internet use is more sensitive in influencing the export volume of commodities that require high levels of technology. Export volumes for complex commodities are also influenced by the level of ICT adaptation of the exporting and importing countries.

Several empirical studies have proven that ICT has a different impact in each country. The difference is based on the intensity of ICT use. Many studies focus more on the impact of the intensity of ICT use on the quantity of users. Thus, to fill the research gap, the primary objective of this study is to investigate the impact of ICT access quality on exports, particularly in Indonesia. The process of identifying the impact of ICT on exports is carried out by adopting the gravity model, one of the most effective analytical models for explaining the determinants and patterns of international trade. (Malau et al., 2022; Prasetyo et al., 2017; Soori & Tashkini, 2012)

RESEARCH METHOD

The type of data used in this study is panel data, which includes data from Indonesia and its importing countries, as well as trading partners of Indonesia's five leading commodities, from 2010 to 2020. There are independent variables that are thought to be the determinants of the dependent variable, namely export volume. The export volume of Indonesia's leading commodities is obtained from the International Trade Center (ITC) in tons, specifically the 8-digit HS Code. All data for the ICT variable are obtained from the International Telecommunication Union (ITU), where the data used in the ICT Indicator Database (ITU, 2020) are on the maximum bandwidth capacity in Mbit/s units. Another control variable in the model is a variable adapted from the development of the gravity model. Gross domestic product (GDP) and population variables were obtained from the World Bank. Data for dummy control variables, such as distance, RTA, and language, were obtained from the CEPII GeoDist Dataset.

This study employs several empirical models to examine the impact of ICT penetration on the export performance of key commodities in Indonesia. This study comprises five models, each representing a distinct commodity (the baseline model). The preparation of this analytical model is expected to provide a more detailed analysis of the impact of ICT penetration on commodity exports in Indonesia. The model specification in this research is presented in Equation 1.

$$lnExport_{ijt} = \beta_0 + \beta_1 ln(ICT_{it} * ICT_{jt}) + \beta_2 ln(GDP_{it} * GDP_{jt}) + \beta_3 ln(POP_{it} * POP_{jt}) + \beta_3 lnDIST_{ijt} + \beta_6 RTA_{ijt} + \beta_7 Langeuage_{ijt} + \beta_8 ASIA_{ijt} + \mu_{ijt} \quad (1)$$

The dependent variable in this study is the volume of exports for commodity (i) to country (j) as an importer in year (t). The independent variable in this research model is the ICT variable, represented by the interaction construct of Indonesian ICT and the ICT of the importing country. $ICT_{it} * ICT_{jt}$ and also adopted from the components in the gravity model, such as the interaction of Indonesia's gross domestic product (GDP) and the importing country $GDP_{it} * GDP_{jt}$ The interaction of the Indonesian population and the importing country $POP_{it} * POP_{jt}$ And the geographical distance between Indonesia and the importing country, *DIST*. This model also contains several *dummy* variables, namely *RTA*, *LANGUAGE*, and *ASIA*. The interaction of some of these variables is used to minimize estimation errors, resulting from the repetitive arrangement of data. Previous research suggests that the analysis of bilateral relations between one exporting country and several importing countries tends to have repetitive data structures for exporting countries, so interacting several variables in the model is one of the solutions carried out by previous researchers to minimize bias in estimation results due to data repetition (Ozcan, 2017).

The model in this study was estimated to use *pseudo-poisson maximum likelihood* (PPML). PPML was developed by Silva and Tenreyro (2006) as a statistical method considered superior to the OLS method in estimating gravity models. PPML is a new estimator that combines the Poisson estimator and Pseudo Maximum Likelihood (PPML) with the aim of better handling the problem of heteroscedasticity. This is because PPML is more sensitive to data with a value of 0, which is a characteristic of trading data. Data with a value of 0 will be automatically excluded from the OLS regression; however, PPML captures more observations with a value of 0 than OLS. Additionally, the bias generated by the estimator is consistently slight compared to other estimators.

Table 2. Variable Definition and Source

Variable	Definition	Source
Export	Export Volume (tons)	*International Trade Center* (ITC)
ICT	Bandwidth Capacity (Mbit/s).	*International Telecommunication Union* (ITU)
GDP	GDP current (US$)	*World Bank*
Population	Total Population	*World Bank*
Distance	Geographical distance (Km)	*CEPII GeoDist*
RTA	Dummy for a regional trade agreement between Indonesia and its trading partner	*CEPII GeoDist*
Language	Dummy for the same language between Indonesia and its trading partner	*CEPII GeoDist*
ASIA	Dummy for importers of Indonesia's specialized products located in Asia.	*CEPII GeoDist*

As an effort to test the consistency of estimation results, this research tries to elaborate the baseline model in Equation 1 into a dynamic model. One of the advantages of using a dynamic model is that it overcomes various problems such as endogeneity, simultaneity, and autocorrelation, which often cause the

estimation results in the baseline model to be biased. The process of preparing a dynamic model involves adding several variables as predictors; some of these variables include the dependent lag variable and the bandwidth lag variable, as referenced in research conducted by Ozcan (2018). The following is a dynamic model developed from the baseline model in this research.

$$lnExport_{ijt} = \beta_0 + \beta_1 lnExport_{t-1} + \beta_2 ln(ICT_{it-1} * ICT_{jt-1}) + \beta_3 ln(GDP_{it} * GDP_{jt}) + \beta_4 ln(POP_{it} * POP_{jt}) + \beta_5 lnEcoDIST_{ijt} + \beta_6 RTA_{ijt} + \mu_{ijt} \quad (2)$$

Based on the previous explanation, two lag variables were added, namely Exports and ICT. Furthermore, several explanatory variables in the baseline model are excluded from this dynamic model because they do not exhibit time variance; these variables include *LANGUAGE* and *ASIA*. There is a special treatment in modifying the *DIST* variable so that it can still be involved as a predictor in the dynamic model. The *DIST* variable, as a data construct, does not exhibit time variance; therefore, a recalculation process was carried out by adding economic scale weighting and transforming this variable into an economic distance variable, *EcoDist*.

This Economic Distance terminology is quite commonly used as an indicator to explain geographic distance in estimating gravity models. (Banik & Roy, 2021). Economic distance is also considered a better representation of the cost of trade between the two countries because it not only considers distance but also takes into account the economic scale, which plays a role in determining the quantity of trade volume. The following is the calculation of Economic Distance.

$$EcoDIST_{ijt} = \frac{DIST_{ij}}{GDP_{jt} \Big/ \Sigma GDP_{jt}} \quad (3)$$

The estimation technique used in this research to estimate the dynamic model, which serves as a robustness test, is the Generalized Method of Moments (GMM). Medote GMM has suitable and ideal properties for estimating dynamic models. Furthermore, the prerequisites in this GMM estimation technique also enable the testing of the instrument's validity, which is carried out using the Hausman test technique, and the detection of autocorrelation, which is tested using the Arellano-Bond Test. It is hoped that these several estimation stages will produce more accurate estimation results and be free from problems that cause bias in the estimation process.

RESULTS AND DISCUSSION

In general, the average observation in each model is 150, and the number of exports for Indonesia's leading commodities is 14.459. The control variables GDP and POP have an average value of 55.716 and 34.566, respectively. On average, importing countries for Indonesia's leading products are located on the Asian continent, but tend not to have regional trade agreements with Indonesia. Furthermore, the descriptive statistics results are presented in Table 3.

The estimation results of the model in this study are presented in 5 columns, where each column represents the estimation results for each of Indonesia's leading commodities (see Table 4). The analytical technique used to estimate the model uses the *pseudo-Poisson maximum likelihood* (PPML) method. The reason for using the PPML estimator is that the dependent variable contains a zero value, and PPML is the estimator that best aligns with the model's structure.

Table 3. Descriptive Statistics

Variable	Obs.	Mean	St. Dev.	Min	Max
lnExport	150	14.459	14.670	8.542	16.162
Bandwidth	150	31.183	32.389	22.996	34.432
GDP	150	55.716	56.420	39.909	58.035
POP	150	34.566	35.930	21.084	37.544
Distance	150	8.991	8.320	7.477	9.651
RTA	150	0,440	0,486	0,000	1,000
Language	150	0,092	0,255	0,000	0,800
ASIA	150	0,522	0,485	0,000	1,000

Table 4. PPML Results

Variable	Palm oil		Coconut Oil		Rubber		Tin		Coal	
	1		2		3		4		5	
Bandwidth	0,214	***	0,286	***	0,178	**	0,207	**	0,055	**
GDP	0,029	**	0,362	***	0,191	***	0,348	**	0,472	*
POP	0,350	***	0,106	**	0,065	***	0,483	**	0,061	**
DIST	-0,086	***	-0,981	***	-0,091	*	-0,199	**	-0,026	***
RTA	0,036	*	0,826	**	0,940	**	0,223	**	0,608	**
Language	2,446	***	0,313	***	-		0,204	**	0,194	
ASIA	0,440	**	0,830	***	0,118	***	0,802	*	0,786	**
R-squared	0,8089		0,6408		0,8572		0,8227		0,7022	
obs	185		121		118		90		145	

Note: *sig 10%, **sig 5%, and ***sig 1%.

The model's average performance yields satisfactory results, with an average of 0.7949. This indicates that all independent variables in the model collectively explain 79.49% of the variation in the dependent variable, while variables outside the model explain 20.50%. The estimation results show that the interaction of ICT, GDP, and Population variables has a positive coefficient. This means that the quality of internet access and the economies of scale of the two countries, both Indonesia and the importing country of Indonesia's leading products, have a positive impact on the export of Indonesia's leading commodities. Dummy variables, such as RTA, language, and location of importing countries in the Asian continent, also yield results consistent with the hypothesis, indicating a positive effect on Indonesia's leading commodity exports. The distance variable, however, yields interesting results, with the model estimation indicating a positive coefficient.

The estimation results in the model show that the interaction of Indonesia's *bandwidth capacity* as an exporter country and other countries as importers of Indonesia's leading products shows positive and significant results for Indonesia's leading commodity exports. This result is in line with research conducted by Abeliansky (2017) which States that the quality of ICT technology (*bandwidth*) provides a greater impact than the quantity of ICT technology users (*subscriptions*) on bilateral trade relations between countries.

Economies of scale in this study are represented by GDP and population, both of which have positive and significant coefficients throughout the estimation model. This means that the interaction between Indonesia's GDP and its population, as an exporting country, and other countries as importers, has a positive impact on the export of Indonesia's leading commodities. The estimation results align with previous theoretical studies and research, which indicate that the larger the economic scale of the exporting and importing countries, the greater the volume of trade transactions between them (Bergstrand, 1985; Edquist & Henrekson, 2017; Timmis, 2012).

The next property in the gravity model is geographic distance, which is directly represented in the baseline model of this research by the distance between the capital cities of Indonesia and its trading partner countries for each of the leading commodities. The estimation results show that, in general, the

impact of geographic distance is determined by the assumptions in the gravity model. The results of testing the baseline model using the PPML method show that geographic distance has a coefficient ranging from -0.061 to 0.483.

The three *dummy* control variables in this research model were adapted from the augmented gravity model. These three factors are thought to influence the volume of trade transactions between countries. The three dummy variables hypothesize that they have a positive impact on the volume of trade between countries. (Ozcan, 2017).

The estimation results in this study confirm the findings predicted by the previous hypothesis. The RTA variable indicates whether there is a trade agreement between Indonesia and the importing country. The estimation results show that all the leading commodity models in this study indicate that the RTA has a positive and significant coefficient on the export volume of Indonesia's leading commodities. The language variable explains whether Indonesia and the importing country have similarities in the mastery of the language, the estimation results show that the majority of the leading commodity models in this study indicate that the language shows a positive and significant coefficient on the export volume of Indonesia's leading commodities, except for the model for rubber commodities, because all importing countries None of the Indonesian rubber masters mastered Indonesian, so that in this model the language variable could not be estimated. The ASIA variable indicates whether there are importing countries for Indonesian products in the Asian continent. The estimation results show that in all models of the leading commodities in this study, ASIA exhibits a positive and significant coefficient on the export volume of Indonesia's leading commodities.

To ensure the consistency of estimation results, this research elaborates on the baseline model by constructing a dynamic model. The preparation of this dynamic model is not limited only to testing the consistency of coefficients but also to overcoming several problems of simultaneity, endogeneity, and time invariance. The treatment involves modifying the baseline model into a dynamic model by adding a lag-dependent variable and an independent variable that is thought to have an endogeneity relationship, namely the bandwidth variable, which serves as an ICT indicator (Ozcan). Next, the treatment involves transforming the distance data by adding a weighting value based on the economic scale of each partner. This is done so that the distance variable, which is a property of the gravity model, can still be involved in the robustness test process, considering that the distance data construct only has a cross-sectional variant.

Table 5. GMM Estimation Result

Variable	Palm Oil	Coconut Oil	Rubber	Tin	Coal
lnEXPORT (t-1)	0,598 ***	0,115 **	0,441 **	0,394 **	0,044 **
lnBandwidth (t-1)	0,067 **	0,471 **	0,064 *	0,161 *	0,057 *
lnBandwidth	0,026 **	0,051	0,018	0,051 **	0,012
lnGDP	1,001 *	0,512 **	0,112 **	0,524 ***	0,311 **
lnPOP	4,471 **	0,365 **	0,544 **	0,219	0,326 *
lnECODIST	-0,938	-0,291 *	-0,307 ***	-0,195 **	-0,195 **
rta	0,026 **	0,134	0,552 ***	0,465	0,925 ***
AR(1)	0,0193	0,431	0,009	0,146	0,067
AR(2)	0,2816	-	0,364	-	-
Sargan (1)	0,0266	0,0001	0,0407	0,0533	0,0566
Sargan (2)	0,9999	0,7862	1	-	-

Note: *sig 10%, **sig 5%, and ***sig 1%.

This dynamic model is estimated using the GMM method, a commonly employed estimation technique for dynamic models. The results of the dynamic model estimation, used as a robustness test, are presented in Table 5. The results of the GMM estimation are presented in five columns, where each column represents a superior Indonesian commodity sampled in this research. All test results for each commodity utilize valid instruments and are free from autocorrelation, at least in the second order. Based

on the results of this validity test, it can be concluded that the GMM estimation results can serve as a reference for comparison, allowing for the assessment of the consistency of the observed variable coefficients.

The GMM estimation results indicate that the coefficients in the baseline model are relatively consistent. Generally, ICT, as represented by internet quality and bandwidth capacity indicators, is found to have a positive and significant impact on the exports of Indonesia's leading commodities. What needs to be noted is that, in general, it can be concluded that the trading pattern of Indonesia's leading commodities follows a pattern that is consistent with the assumptions of the gravity model. The value of past exports also plays a significant role in current exports. Some interesting findings in the dynamic model estimation results in Table 2 are that the impact of ICT tends to exhibit inertia, where the optimal impact of improving the quality of internet aspects will have a significant effect on exports in future periods.

As previously explained, the selection of commodity samples is based on two fundamental assumptions: the term "superior" refers to Indonesian commodities that have a market share greater than 25% in the international market. This large number of shares shows the superiority and high level of competitiveness of this Indonesian product. The following reason is that the five sample commodities chosen represent the three main sectors of Indonesia: the processing industry (Palm oil and coconut oil), agriculture (rubber), and Natural resources (tin and coal). Based on this selection assumption, it is hoped that the estimation results from these five commodity samples can serve as a reference to represent the trade patterns of Indonesia's three main sectors and inform the preparation of export development strategies for these sectors.

The impact of the internet, especially on the quantity aspect, has been empirically proven to have a positive influence on exports of Indonesia's leading commodities. These results have been consistently demonstrated through various tests and are free from the fundamental problems that can cause biased coefficient results. The results of this estimation provide an academic contribution to policy advice on the urgency of developing telecommunications infrastructure. The quality aspect (bandwidth capacity) has a strong complementary relationship with the quantity aspect (number of internet users). Based on the explanation of this relationship, internet quality plays a crucial role in enhancing the value of internet benefits for users, which in turn increases the overall value of the internet and strengthens the networking effect between Indonesia and its trading partner countries.

ICT coefficient results tend to have large values for commodities representing the processing industry (palm oil and coconut oil), in contrast to agricultural commodities (rubber) and natural resources (tin and coal), which tend to have smaller coefficient values. Based on these results, it can be concluded that the endowment factor aspect, contained in Indonesia's agricultural and natural resources, plays a more dominant role in determining Indonesia's dominance in the international market. Processing industries, which tend not to have endowment aspects as strong as agricultural and natural resources, require other aspects to increase their competitiveness in international markets. One important aspect of increasing competitiveness is optimizing internet access. Good internet quality will have a significant impact, especially on aspects of communication and information seeking, which will help expand market reach and search for more efficient production inputs.

What needs to be noted is that the impact of ICT development tends to take time to take effect and has a greater impact on exports. This is supported by the dynamic model estimation results, which show that the positive ICT lag coefficient (t-1) is greater than the coefficient value of ICT in period t. Based on this, it can be concluded that the development of ICT infrastructure is a long-term development whose impact will be relatively greater in subsequent periods.

Based on this estimation result, it can be concluded that Indonesia's specialization product export performance depends on Indonesia’s and its partner’s economic scale, which is represented by GDP and Population. Indonesia’s economic scale explains production capability, and the partner’s economic scale

represents the foreign market potential. As previously mentioned, the economic scale variable is constructed from interaction data between Indonesia and its various partners. This interaction is not only for anticipating repeated data but also for capturing integration between Indonesia and its partner. Based on the estimation results, the economic scale consistently proved a positive impact on Indonesia's specialization product export performance. Overall, the economic growth of both exporters and importers plays a crucial role in enhancing the export performance of exporting countries.

Geographic distance in the gravity model plays a role as a factor inhibiting the flow of international trade. In the gravity model, geographic distance is a determinant that represents the cost of trade, which is assumed to increase with distance. Based on this assumption, it can be explained that the greater the distance between Indonesia and its partners, the greater the trade barrier that arises with the partner country. The estimation results show that geographic distance has been proven to have a significantly and consistently negative influence on the exports of Indonesia's leading commodities.

The application of this gravity model demonstrates that, in general, the trading patterns of Indonesia's leading commodities conform to the assumptions built into the gravity model. A key point to note is that superior commodities produced by processing industries tend to be more sensitive to geographic distance, which represents a significant barrier to trade. One of the primary reasons why commodities from the processing industry tend to be more sensitive is that they lack a strong endowment factor, making it possible for international buyers to seek alternatives to Indonesian processing industry products in other countries that offer cheaper options. This condition is not experienced by commodities that have strong factor endowments. Commodity samples, such as coal, tin, and rubber, are derived from Indonesia's natural resources, which are not typically owned by other countries. This condition enables Indonesia to hold a strong position as a market leader, as it lacks many competitors capable of producing products based on natural resources.

Some interesting points, as an extensive form of the process of identifying trade patterns in Indonesia's leading commodities, are the coefficients produced by three dummy variables adopted in the augmented gravity model. (Ozcan, 2017). Based on the estimation results, it can be concluded that most of Indonesia's superior commodities are still distributed among countries on the Asian continent, especially partner countries that have agreed to free trade agreements. The results of the RTA coefficient indicate that the primary objective of RTA is to establish a facility that enhances the volume of trade between countries that have agreed to the agreement. As a final addition, social relations, represented by similarities in language use, also play a crucial role in increasing the export volume of Indonesia's high-quality products.

CONCLUSION

The results of this study indicate that the ICT variable, measured by the quality of internet access (bandwidth), yields positive results throughout the estimation model. That is, the more optimal the quality of a country's internet access, the more positive it will be on the country's bilateral international trade relations. The variables in the gravity model also yield results consistent with the hypothesis, indicating that economies of scale have positive effects on the export of leading commodities. Furthermore, the distance variable in the case study yields negative results, which aligns with the assumption of the gravity model.

Based on the estimation result, it can be concluded that the export of Indonesia's specialized products is promoted by the growth of both Indonesia and its partners' GDP, as represented by economic scale, and slowed down by the geographical distance between Indonesia and its trading partners. Furthermore, Indonesia's exports remain concentrated in Asian countries, and the volume of exports has increased since Indonesia and its trading partners signed the free trade agreement.

The results of this study can serve as a reference to demonstrate that the quality of internet access has a positive impact on increasing exports, highlighting the internet's vital role in promoting Indonesia's

exports, particularly in the manufacturing industry. The development of ICT infrastructure also takes some time to have a significant impact, so policymakers need to be aware that the development of ICT infrastructure is typically a long-term process.

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