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Assessing the Effect of Internet Indicators on Agri-Food Export Competitiveness

Arif Imam Suroso [1,*], Idqan Fahmi [1], Hansen Tandra [2] and Adi Haryono [1]

[1] School of Business, IPB University, Bogor 16151, Indonesia; ifahmi@apps.ipb.ac.id (I.F.); adiharyono@hotmail.com (A.H.)
[2] Resource and Environmental Economics, Faculty of Economic and Management, IPB University, Bogor 16680, Indonesia; hansen75tandra@apps.ipb.ac.id
* Correspondence: arifimamsuroso@apps.ipb.ac.id

Abstract: The agricultural sector contributes to the national economy by engaging in export activities within the global market. Conversely, the rapid development of the Internet has greatly impacted output production and has introduced heightened competitiveness among various countries. This study aims to examine the impact of Internet-related indicators on the competitive standing of agri-food industries on a global scope. These indicators are represented by user engagement, infrastructure availability, and security. The panel regression analysis focused on 126 countries from 2010 to 2020. The findings reveal that Internet infrastructure and security positively affect the competitiveness of agri-food exports. However, the indicator related to Internet users exhibits a negative impact. There is a change in competitiveness structure from enhancing the Internet indicator to 50%. After simulation, we found that 80 countries have a positive value of RSCA. It is lower than the actual value of RSCA in 89 countries. This study concluded that developing countries still have better opportunities to increase their agri-food export competitiveness than developed countries.

Keywords: agri-food; business analytics; export competitiveness; international trade; Internet

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1. Introduction

Agriculture is one of the main sectors accelerating economic growth (Awokuse and Xie 2015; Odetola and Etumnu 2013). This sector also drives regional economic growth after years of declining shares in a country's gross domestic product (Khan et al. 2020). On the other hand, the agriculture sector strongly links with the rest of the economy due to suppliers for downstream industries (Raza et al. 2012). The competition for agricultural trade globally is fierce, as seen from the market structure. Based on (FAO 2023), no country with an export share in the global world reached above 10%. The United States of America (USA), Netherlands, Brazil, Germany, and France are the top five countries with the highest export share of agriculture globally, respectively. Agriculture has already integrated with technology as an implication of digital transformation. Mentsiev et al. (2020) revealed that there are six substantial transformations in the agriculture industry, namely, (1) the integration of the Internet of Things (IoT) into the fields, (2) the integration of IoT with farm equipment, (3) drones for crop monitoring, (4) the use of robotics in farming, (5) RFID tracking in farming, and (6) the use of ML and big data in farming. Currently, supply and demand can be facilitated by the enterprise system through a simultaneous system (Rachmaniah et al. 2022). This technology can produce higher yields until 60% of output is produced by 2030. Furthermore, the development of software defect prediction also involves reducing the cost of the software testing process, which can be applied in an agriculture system (Bahaweres et al. 2020). A similar topic was explained by Balamurugan et al. (2016), in which agriculture technology has already improved the IoT for food and farming technology, as shown by many studies on the application of IoT in agriculture. Suroso et al. (2022) found that improving Internet indicators can accelerate

agricultural performance through Internet users (%), fixed broadband subscriptions, and secure Internet servers. Thus, the Internet has become an important item in bridging agriculture development and technology usage. It also supports export specialization with an improvement in productivity compared with other competitors, implicating export success in the global market (Nazarczuk et al. 2018).

Internet indicators show drastic growth in user participation when data between 2010 and 2020 are compared. According to the World Development Indicator (WDI 2023), there were 29% of users of the Internet, and this grew to 60% in the world context. The growth of Internet users also implicates the high development of Internet infrastructure, which found a statistical increase that was in line with the increase in Internet users. Therefore, the nexus between internet and competitiveness must be explored to find the change in competitiveness in the agri-food global market. Technological developments can be an opportunity or a threat to participants who use them. The Internet's growth can lead to competition between countries in less competitive industrial structures (Wang and Zhang 2015). Additionally, the impact of the Internet can reduce market competition (Domenech et al. 2016). This means that the impact could lead to a decline in the competitiveness of countries for global trade. Meanwhile, the Internet is positive and significant to international trade, increasing from 0.2% to 0.4% (Lin 2015). The Internet could be used as a marketing tool to develop the agricultural industry (Heang and Khan 2015). The growth of trade also leads to an enhancement in trade competitiveness. We found that the Internet more positively contributes to national and sectoral economies in developing countries (Bahrini and Qaffas 2019; Suroso et al. 2022). The different impacts between developed and developing countries became the question for this study. On the other hand, the nexus between the Internet and competitiveness for trade between countries, especially in agriculture, is still questioned. The involvement of digital technology based on the Internet could be used as one of the tools for increasing competitiveness in the agri-food sector (Kosior 2018). However, studies about the growth of the Internet are still rare, though essential for policymakers to determine a policy for generating competitiveness in the agriculture trade. Based on the problem mentioned in our statement, this study aims to assess the effect of the Internet on agri-food export competitiveness. Specifically, this research is divided into three main objectives, namely:

(1) Analyze the impact of Internet indicators on the competitiveness of agri-food exports in the global market, including users, infrastructure, and security aspects.
(2) Conduct a simulation related to the influence of the Internet on the competitiveness of agri-food exports.
(3) Compare the results before and after the simulation of the competitiveness of agri-food exports by continent and income categories, investigating the new structure of agri-food export competitiveness after an enhancement in Internet indicators.

The expected result of this study is the impact of the Internet on the competitiveness of agri-food exporters. A simulation was also carried out to investigate the change in the global market for agri-food, implying that the role of the Internet can be considered an essential factor for trade competitiveness. The novelty of this research lies in its pioneering exploration of the influence of Internet indicators on the competitiveness of agri-food exports. Previous scholarly investigations have predominantly focused on economic-, organization-, and commodity-related factors (Tandra et al. 2022; Török et al. 2020; Torok and Jambor 2016), as well as climate change factors (Abbas 2022; Nugroho et al. 2023). The agenda of this study is to investigate whether there has been a significant change from involvement in the development of Internet technology in the structure of the competitiveness of world agricultural food exports, supported by higher utilization levels in the future.

2. Literature Review

The meaning of competitiveness varies depending on the context in which it is observed. Competitiveness is commonly defined as productivity, which in turn is a function

of factors related to the cost of products, as well as those related to non-price factors (Verma 2002). In a national context, competitiveness is the ability of an economy to provide its residents with a rising standard of living and high employment on a sustainable basis (Porter 1990). From a firm context, competitiveness can refer to its economic strength against rivals in the global marketplace where products, services, people, and innovations move freely despite geographical boundaries (Wang and Hsu 2010). Additionally, this concept refers to the growth and strengthening of the position of a particular enterprise (Jansik et al. 2014). In a trade context, competitiveness can be defined as the ability of a region to export more in value-added terms than it imports by including terms of trade, which reflect all government discounts and import barriers (Atkinson 2013). (Berger 2008) explained the source of competitiveness by distinguishing two basic concepts: the market-based view—which depends on product-related cost or differentiation advantages—and the resource-based view—which depends on the utilization of core competencies or ability to create future products. In this paper, we focused on export competitiveness in agriculture. The development of the literature related to export competitiveness is now growing, especially for agri-food trade. Commonly, there are three levels of analysis that can be found: the first one deals with countries, the second with regions, and the third one with firms. Furthermore, the competitive position is determined by static advantages, which identify the scale of the differences (in absolute or relative terms) in the productivity of labor and capital (Umiński and Borowicz 2021). Many scholars have already investigated its export competitiveness to the global market (Balogh and Jámbor 2017; Bojnec and Fertő 2017; Jambor et al. 2018; Mizik et al. 2020; Tandra et al. 2022).

Currently, this topic is still interesting due to the important role of a country or firm in competing with its rivals due to fierce competition in the global agri-food trade. (Jambor and Babu 2016) stated that countries with net exporters can compete in this trade; however, there is a change in trade patterns in the global market. This means that agri-food trade competition is still unpredictable. Thus, an investigation of factors increasing the export competitiveness of agri-food must be considered, especially the utilization of determinant factors. There are several previous studies that have analyzed the competitiveness of agri-food trade and its determinants. According to (Mizik 2021), the revealed comparative advantage (RCA), or simply Balassa, index is regularly used by researchers all over the world, which was developed by (Balassa 1965). (Torok and Jambor 2016) found that the ham trade competitiveness in Europe is determined by several factors, such as the quality of production, EU accession, and foreign direct investment (FDI). (Balogh and Jámbor 2017) investigated the determinant of competitiveness in the cheese trade in the European Union, showing that GDP/capita, geographical indication, FDI, and EU membership are influential factors. Additionally, the exchange rate and international palm oil processing are essential determinants of the export competitiveness of palm oil for 26 countries' observations (Lugo Arias et al. 2020). A previous study by (Török et al. 2020) found that the determinant factors of the beer trade are total beer production, per capita consumption, barley production, the level of foreign direct investments, population, GDP/capita, the high-quality level of the beer export EU membership, and the number of beers with geographical indications. (Tandra et al. 2022) determined that the determinant factors of the global palm oil trade are the size of the population, import of animal or vegetable fats and oils, GDP per capita, and RSPO certification.

Recently, the Internet has become an important way to lead competitiveness. According to (Lollar et al. 2010), the operational efficacy and efficiency of businesses, as well as the competitive climate, have altered substantially as a result of the integration of information and communications technology (ICT), namely, Internet and web-based technologies. The development of information technology can be applied to developing a competitive advantage with several activities, such as differentiation, innovation, channel domination, cost reductions, and efficiency improvements (Bilgihan and Wang 2016). From a micro perspective, there is a positive contribution from the role of information technology toward the competitiveness of micro, small, and medium enterprises (MSMEs) in Cimahi District, Jawa

Barat Province, Indonesia (Setiawan et al. 2015). Adopting technology from developing the platform and web capabilities is positively significant toward export marketing capabilities and performance, which are implicated in the internationalization of small and medium enterprises (SMEs). However, the study of macro perspectives by connecting country competitiveness is still rare. Otherwise, plenty of studies about technology and competitiveness at the micro-scope exist. Therefore, this study fills this gap by investigating the role of Internet indicators toward export competitiveness in agri-food. This study's importance is in exploring the Internet's impact and its simulation in the global world for agri-food trade competition. One direction for policymakers is to consider the role of the Internet in competitiveness. We select the agri-food commodity due to its essential contribution to the national economy through trade, especially for developing countries (Sanjuán-López and Dawson 2010). In this study, we also classified into two groups: (1) continents and (2) income categories to explore the specific effect of the Internet on competitiveness.

3. Data and Methodology

To evaluate the export competitiveness of agri-food trade, we utilize the Revealed Symmetric Comparative Advantage (RSCA) for export competitiveness analysis. According to (Laursen 2015), RCA is an asymmetric measurement with a biased range of values from zero to infinity, which motivated him to propose the RSCA. On the other hand, RSCA is the symmetric form, which ranges from −1 (the lowest value of country competitiveness, proxy of zero in case of RCA) to 1: the highest value of country export competitiveness. Furthermore, Laursen (2015) also implied that RSCA provides a more accurate representation of trade specialization than other indexes, such as the Michaely index and chi-square measure, as it concentrates on a specific economic sector within a country and offers a shallower analysis of other sectors.

The equation of the RCA and RSCA can be written as follows:

$$RCA_{ab} = (X_{ab}/X_{aw})/(X_{bw}/X_w) \quad (1)$$

$$RSCA = (RCA_{ab} - 1)/(RCA_{ab} + 1) \quad (2)$$

where RCA_{ab} stands for the revealed comparative of the country a for product b. X_{ab} refers to the total exports of country a for product b. X_{aw} refers to the total export of all products (merchandise) from the country to the world w. X_{bw} refers to the overall export of product b to world w. X_w refers to the total export of all products (merchandise) in the world w.

To determine the connection between Internet indicators and agri-food export competitiveness, panel regression was applied in this study by adding this indicator and other variables. Based on several previous studies (Tandra et al. 2022; Török et al. 2020; Torok and Jambor 2016), other factors influence RSCA that are essential factors for competitiveness. We also added agricultural land as a proxy for the input factor. The conceptual model based on endowment factor theory indicated that the Internet in this study is the crucial input. Hence, the framework for the regression in this study can be expressed as follows:

$$RSCA_{it} = \alpha + \beta_1 Log(GDPC_{it}) + \beta_2 Log(AGL_{it}) + \beta 3(FDI_{it}) + \beta 4 Log(INT_{it}) + \beta 5 Log(FBS_{it}) + \beta 6 Log(SIS_{it}) + e_{it} \quad (3)$$

Hypothesis: $\beta_1 < 0$, and β_2, β_3, β_4, β_5, $\beta_6 > 0$.

Where $RSCA_{it}$ is the revealed symmetric comparative advantage in country i in year t, $GDPC_{it}$ is the gross domestic product per capita in country i in year t, AGL_{it} is the agriculture land in country i in year t, FDI is the foreign direct investment in country i in year t, INT_{it} is the percentage of individuals using the Internet in country i in year t, FBS_{it} is the fixed broadband subscriptions in country i in year t, SIS_{it} is the secure Internet server in country i in year t, and e_{it} is the residual term.

Similar to the measurement of potential export by several scholars (Abbas and Waheed 2015; Irshad et al. 2018; Tandra and Suroso 2023), we utilize the prediction value from the

regression to estimate the potential RSCA. Furthermore, a comparison between actual and predicted values was implemented to determine if the country has already reached the potential RSCA or otherwise. There are three models in our panel regression, namely, the common effect model (CEM), fixed effect model (FEM), and random effect model (REM). Before we ran our model, a correlation matrix was performed to check multicollinearity, where a value must be below 0.8 or 0.9 for regression (Franke 2010; Senaviratna and Cooray 2019). The determination of the best model by comparing these three models utilizes the Chow and Hausman tests. A significant value of the Chow test at 1%, 5%, or 10% level means that the FEM is utilized more than the CEM, while a significant value of the Hausman test at the same level implies that the FEM is better than the REM, based on the study by Bansal et al. (2018). After model selection, we use the estimate of regression to produce the predicted value of RSCA. This model is also used to simulate the enhancement in the three Internet indicators based on the rapid growth in this technology, nearly 50% by 2045, by increasing the actual value of Internet indicators to 50% to obtain simulation values and maintain the value of other variables. The actual and simulation values are compared by investigating the values before and after simulation. The study data were compiled from several sources in 126 countries from 2010 to 2020. We selected this number of countries based on data availability from dependent and independent variables between this analysis period. This study was conducted from March to August 2023. Table 1 summarizes all our variables, describing the notations, definitions, units, and sources. The classification of the developed and developing countries are shown in Appendix A through continent and income categories. These classifications could provide specific results about the impact of Internet indicators on agri-food export competitiveness.

Table 1. Notation, definition, unit, and source.

Notation	Definition	Unit	Source
$RSCA_{it}$	Export competitiveness, by utilizing RSCA in country i in year t	Index	Author's calculation
$GDPC_{it}$	GDP per capita in country i in year t	Current USD	WDI (2023)
AGL_{it}	Agricultural land in country i in year t	Sq. Km	WDI (2023)
FDI_{it}	Foreign direct investment, net inflows in country i in year t	% of GDP	WDI (2023)
INT_{it}	Individuals using the Internet	% of population	WDI (2023)
FBS_{it}	Fixed broadband subscription in country i in year t	Fixed subscriptions to high-speed access to the public Internet at downstream speeds equal to, or greater than, 256 kbit/s	WDI (2023)
SIS_{it}	Secure Internet servers in country i in year t	The number of distinct, publicly trusted TLS/SSL certificates found in the Netcraft Secure Server Survey	WDI (2023)

4. Results

Table 2 provides descriptive statistics, including mean, median, maximum, minimum, and standard deviation (Std. Dev). Mean and Std. Dev are presented for determining the range and coverage of the data. $RSCA_{it}$, $GDPC_{it}$, AGL_{it}, FDI_{it}, and FBS_{it} have a higher value of Std. Dev than mean, which implies that data for these variables are variance. Furthermore, Table 3 reveals a correlation matrix with all variable values below 0.8% or 0.9%, excluding the correlation between Log(FBSit) and Log(SISit) values (Franke 2010; Senaviratna and Cooray 2019). We still maintain this variable because the value is below 0.9%, which means that there is no multicollinearity issue in our model. Table 4 lists the estimated result of the panel regression by utilizing three models, which include the common effect model (CEM), fixed effect model (FEM), and random effect model (REM). In the CEM, we found that the issue of heteroskedasticity and autocorrelation with significance

at the 1% level. Hence, based on model selection (Chow and Hausman tests), we found that the FEM is the best model to estimate the nexus between Internet indicators and agri-food export competitiveness due to significance at the 10% level. This model can be used to deal with endogeneity, where individual characteristics from a firm or country can be correlated with the independent variables (Wintoki et al. 2012). The estimation reveals that there is a negative and significant influence of GDP per capita on RSCA. For GDP per capita, this result is similar to a previous study by (Tandra et al. 2022; Török et al. 2020). A decline in GDP per capita can lead to an enhancement in RSCA through excessive consumption. High consumption also implicates the output for export decrease due to the fulfillment of domestic needs. Furthermore, there is a negative impact and significance at 1% from agricultural land toward RSCA. It is due to other inputs having more contribution to enhancing competitiveness, particularly the technology aspect as one of the main inputs to increasing competitive advantage (Bilgihan and Wang 2016). Surprisingly, we found various findings in Internet indicators proxied by users, infrastructure, and security. The percentage of Internet users has a negative and significant effect on RSCA, which means that the high number of Internet users implicate a decline in competitiveness. We found that the Internet infrastructure and security still positively influence export competitiveness. The utilization of the Internet can lead to more fierce competition in the agriculture market, especially in market structure and profitability, based on a previous study by (Wang and Zhang 2015).

Table 2. Descriptive statistics.

Variable	Mean	Median	Maximum	Minimum	Std. Dev.
RSCA	0.128	0.226	0.862	−1.000	0.471
$GDPC_{it}$	17,488.71	7720.61	123,678.7	430.99	21,641.66
AGL_{it}	299,329.2	38,200	5,289,168	6.60	760,908.7
FDI_{it}	5.697	2.882	279.361	−104.060	16.615
INT_{it}	54.876	57.895	100	1	27.634
FBS_{it}	6,535,714	600,411	4.84 × 108	350	29,734,129
SIS_{it}	189,181.8	1386.50	46,678,110	1	1,826,564

Table 3. Correlation matrix.

	$Log(GDPC_{it})$	$Log(AGL_{it})$	FDI_{it}	$Log(INT_{it})$	$Log(FBS_{it})$	$Log(SIS_{it})$
$Log(GDPC_{it})$	1.000					
$Log(AGL_{it})$	−0.222	1.000				
FDI_{it}	0.099	−0.227	1.000			
$Log(INT_{it})$	0.798	−0.201	0.041	1.000		
$Log(FBS_{it})$	0.552	0.420	−0.065	0.583	1.000	
$Log(SIS_{it})$	0.641	0.261	−0.030	0.673	0.832	1.000

The high amount of Internet users makes the agricultural industry switch to other industries along with the rapid development of technology. The manufacturing industry is one of the industries that contributes highly to the economy through exports (Asbiantari et al. 2016; Kalaitzi and Cleeve 2018). Therefore, technological improvements will make a country switch to this industry and export manufactured products, including processed agricultural products with high-added value. The support of infrastructure and security must be considered to maintain the value of RSCA in agri-food export positively by producing the agriculture output stably (Oyelami et al. 2022; Suroso et al. 2022).

Table 4. Estimation of panel regression.

Variable	CEM	FEM	REM
Constant	1.465 ***	2.668 ***	1.320 ***
	(0.130)	(0.805)	(0.238)
$Log(GDPC_{it})$	−0.208 ***	−0.132 ***	−0.145 ***
	(0.015)	(0.024)	(0.019)
$Log(AGL_{it})$	0.002	−0.146 **	−0.006
	(0.006)	(0.073)	(0.014)
FDI_{it}	0.001 *	3.52×10^{-5}	4.10×10^{-6}
	(0.001)	(0.000)	(0.000)
$Log(INT_{it})$	0.056 **	−0.051 ***	−0.050 ***
	(0.027)	(0.014)	(0.013)
$Log(FBS_{it})$	0.017 *	0.024 **	0.024 ***
	(0.009)	(0.010)	(0.009)
$Log(SIS_{it})$	0.009	0.006 **	0.007 **
	(0.007)	(0.003)	(0.003)
R-Squared	0.201	0.944	0.055
Adjusted-R Squared	0.198	0.938	0.051
F-Statistics	57.886 ***	160.139 ***	13.484 ***
Chow Test		3673.695 ***	
Hausman Test			10.999 *
Heteroskedasticity LR Test (Cross-section)	1614.81 ***		
Heteroskedasticity LR Test (Period)	1.911 ***		
Breusch–Godfrey Serial Correlation LM Test	1071.85 ***		

Notes: *, **, and *** = significant at 10%, 5,% and 1%.

Table 5 reveals the value of RSCA between actual and simulation values (increase of 50% value of three Internet indicators). In terms of average value from 2010 to 2020, there are 89 countries have a positive value of actual RSCA. Meanwhile, 37 countries have a negative RSCA. The country with the highest actual value of RSCA is Malawi (0.828) followed by Uruguay (0.791), Paraguay (0.790), Saint Vincent and the Grenadines (0.766), New Zealand (0.762), Argentina (0.753), Kenya (0.734), Nicaragua (0.728), Grenada (0.710), and the Republic of Moldova (0.706). According to the simulation value, this result shows that there are 80 countries that still have a positive value of RSCA, while 46 countries have a negative value. The countries with the highest value of simulation are Singapore (1.116), Seychelles (1.055), the Maldives (0.925), Saint Vincent and the Grenadines (0.912), Grenada (0.896), China, Hong Kong SAR (0.877), Saint Lucia (0.834), Bahrain (0.781), Malta (0.755), and Tonga (0.721). When compared between actual and simulation, there is a decline in country numbers from 89 countries (actual) to 80 countries (simulation). This means that an increase in Internet indicators changes the structure of export competitiveness in the global world.

Table 5. The actual and simulation of RSCA, average value from 2010 to 2020.

Country	Actual	Simulation	Country	Actual	Simulation	Country	Actual	Simulation
Albania	−0.251	0.306	Greece	0.418	−0.062	Norway	−0.808	0.002
Angola	−0.967	−0.169	Grenada	0.710	0.896	Oman	−0.459	0.069
Argentina	0.753	−0.394	Guinea	−0.161	0.117	Pakistan	0.418	0.118
Armenia	0.506	0.284	Honduras	0.566	0.270	Panama	0.112	0.109
Australia	0.307	−0.764	Hungary	0.039	0.009	Paraguay	0.790	−0.098
Austria	0.004	−0.060	Iceland	−0.570	−0.117	Peru	0.237	−0.106
Bahrain	−0.480	0.781	India	0.148	−0.096	Poland	0.221	−0.099
Belarus	0.290	0.039	Indonesia	0.467	−0.090	Portugal	0.159	0.013
Belgium	0.121	0.063	Iran (Islamic Republic of)	−0.175	−0.142	Qatar	−0.984	0.333
Belize	0.696	0.520	Ireland	0.111	−0.181	Republic of Korea	−0.762	0.124
Benin	0.533	0.346	Israel	−0.372	0.198	Republic of Moldova	0.706	0.288
Bolivia (Plurinational State of)	0.356	−0.114	Italy	0.065	−0.179	Romania	0.129	−0.061
Bosnia and Herzegovina	0.047	0.228	Jamaica	0.476	0.438	Russian Federation	−0.362	−0.442
Botswana	−0.534	−0.210	Japan	−0.864	−0.033	Rwanda	0.637	0.478
Brazil	0.647	−0.427	Jordan	0.366	0.358	Saint Lucia	0.478	0.834
Bulgaria	0.351	0.088	Kazakhstan	−0.279	−0.506	Saint Vincent and the Grenadines	0.766	0.912
Burkina Faso	0.520	0.237	Kenya	0.734	0.054	Senegal	0.450	0.197
Canada	0.146	−0.454	Kuwait	−0.859	0.294	Serbia	0.459	0.154
Chile	0.338	−0.151	Kyrgyzstan	0.252	0.176	Seychelles	−0.654	1.055
China, Hong Kong SAR	−0.632	0.877	Lao People's Democratic Republic	0.250	0.307	Singapore	−0.497	1.116
China, mainland	−0.553	−0.445	Latvia	0.396	0.099	Slovakia	−0.288	0.101
Colombia	0.345	−0.184	Lesotho	−0.452	0.317	Slovenia	−0.157	0.212
Costa Rica	0.677	0.165	Lithuania	0.363	0.046	South Africa	0.108	−0.313
Croatia	0.239	0.175	Luxembourg	0.042	0.188	Spain	0.328	−0.274
Cyprus	0.272	0.404	Madagascar	0.551	0.144	Suriname	−0.203	0.598
Czechia	−0.248	0.026	Malawi	0.828	0.366	Sweden	−0.364	−0.087
Denmark	0.358	−0.083	Malaysia	0.190	−0.009	Switzerland	−0.387	−0.036
Djibouti	0.358	0.320	Maldives	−0.994	0.925	Thailand	0.300	−0.042
Dominican Republic	0.444	0.181	Malta	−0.338	0.755	Timor-Leste	0.576	0.574
Ecuador	0.542	0.092	Mauritania	−0.718	−0.109	Togo	0.508	0.398
Egypt	0.376	0.291	Mauritius	0.294	0.592	Tonga	0.667	0.721
El Salvador	0.424	0.372	Mexico	−0.058	−0.312	Tunisia	0.108	0.054
Estonia	0.012	0.157	Mongolia	−0.212	−0.297	Türkiye	0.164	−0.186
Eswatini	0.486	0.265	Montenegro	0.337	0.413	Ukraine	0.602	−0.056
Fiji	0.571	0.427	Morocco	0.226	−0.083	United Arab Emirates	−0.531	0.216
Finland	−0.444	−0.043	Mozambique	0.354	0.129	United Kingdom of Great Britain and Northern Ireland	−0.119	−0.246

Table 5. *Cont.*

Country	Actual	Simulation	Country	Actual	Simulation	Country	Actual	Simulation
France	0.236	−0.310	Namibia	0.062	−0.223	United States of America	0.099	−0.689
Gabon	−0.857	0.078	Nepal	0.582	0.407	Uruguay	0.791	−0.199
Gambia	0.279	0.583	Netherlands (Kingdom of the)	0.285	0.024	Uzbekistan	0.193	0.019
Georgia	0.530	0.248	New Zealand	0.762	−0.254	Viet Nam	0.123	0.162
Germany	−0.160	−0.236	Nicaragua	0.728	0.246	Zambia	0.085	0.065
Ghana	0.497	0.099	North Macedonia	0.214	0.282	Zimbabwe	0.586	0.125

Particularly, Figures 1 and 2 show the change in RSCA before and after simulation between continent and income, respectively. In Figure 1, we found that there are changes in the proportion of both positive and negative RSCA in all continents. Oceania is the continent with the highest positive change in RSCA (100%) before simulation, while Asia is the continent with the highest negative change in RSCA (48%). After simulating three Internet indicators, there are drastic changes in the proportion between continents. In the case of after simulation, Africa and North America are the continents with the highest positive change in RSCA (79%). Otherwise, South America is the continent with the highest negative change in RSCA (80%). Figure 2 also revealed the change in the proportion of RSCA between three income categories: high, middle, and low. We found that there is a change in only one category: the middle category. For the high- or low-income categories, we found that there is no change from before to after simulation in RSCA. Conversely, the middle category has a change in the enhancement of a negative value of RSCA from 21% to 34%. Only the low category is still stable at a proportion of 100% positive RSCA in these two cases. Thus, the impact of internet development is significant for African countries dominantly categorized as low- and middle-income countries. This is supported by previous results by (Chavula 2014; Oyelami et al. 2022), which show that the impact of the Internet is relatively found in developing economies with a structural change in the agri-food market.

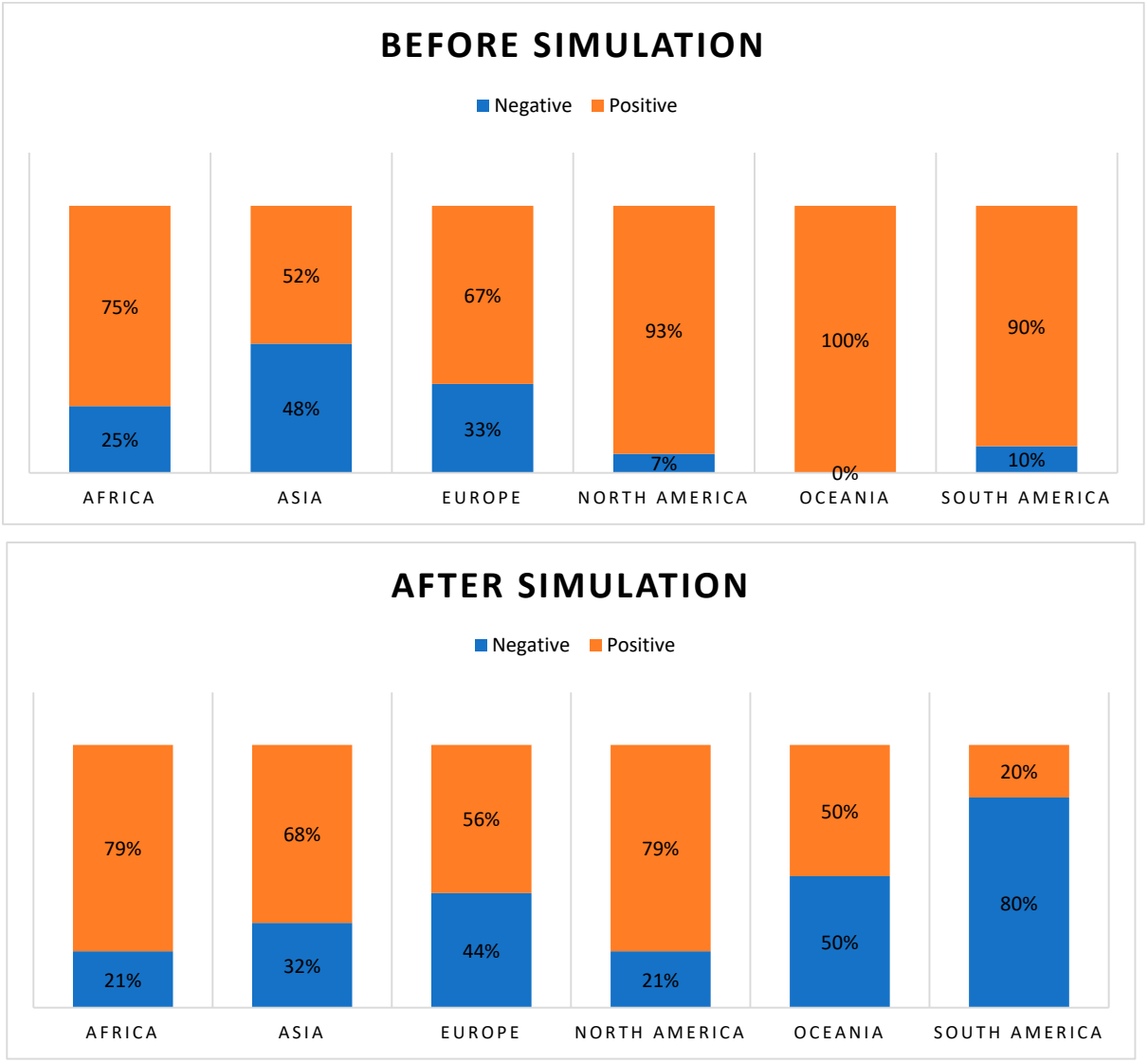

Figure 1. The change in RSCA before and after simulation by continent.

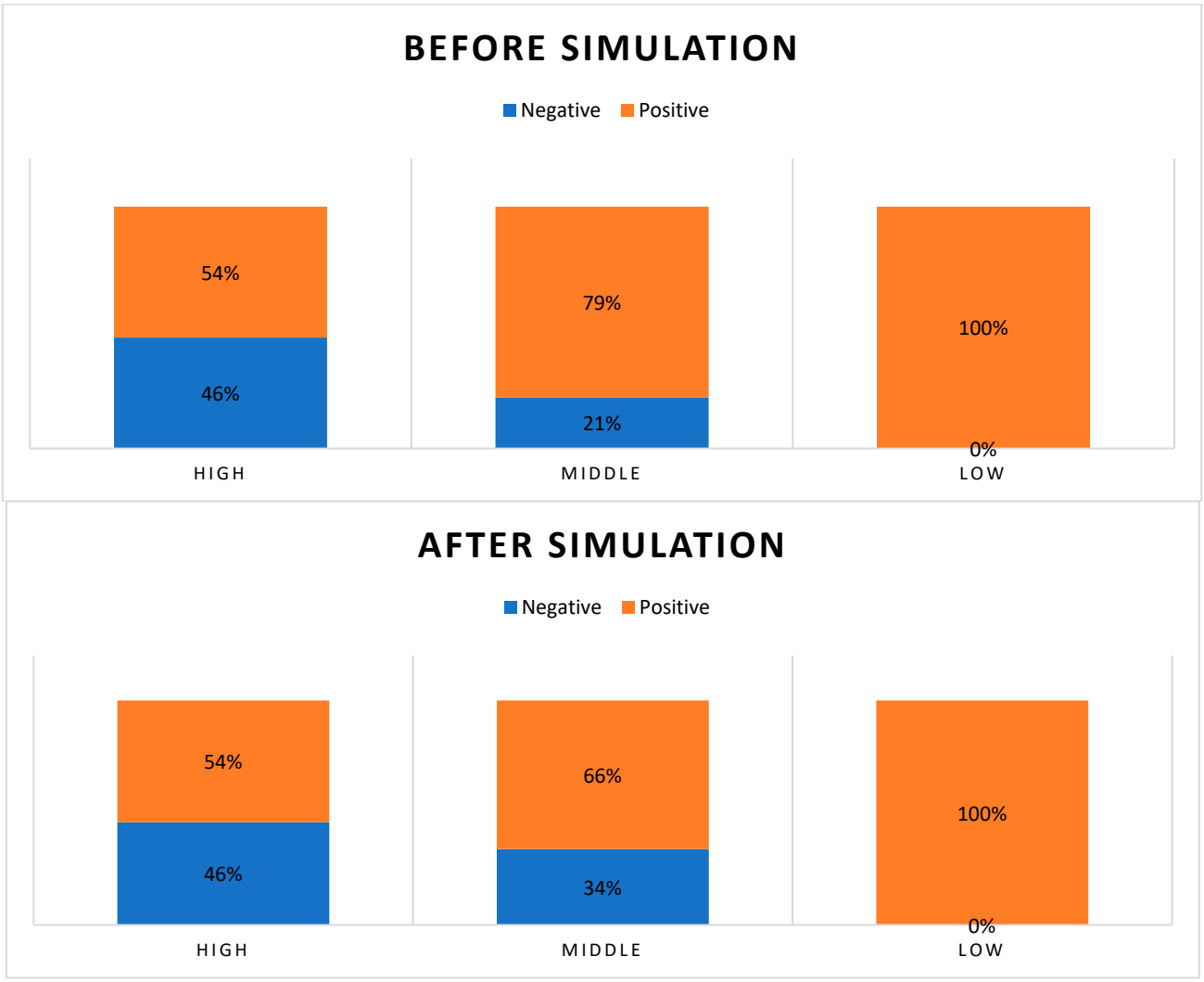

Figure 2. The change in RSCA before and after simulation by income.

5. Discussion

There is an impact from three Internet indicators in determining the competitiveness of agri-food exports, including positive and negative effects. In this result, we found that the amount of Internet users in percentage (%) has a negative effect. Internet usage is also essential in agri-food marketing, especially the marketing function (Fernández-Uclés et al. 2020). This function can decrease competitiveness through high Internet use, increasing the domestic consumption of agri-food. This is implicated in the better accessibility and purchasing of agri-food by using the Internet to maintain the agri-food value chain, especially during the coronavirus disease 2019 (COVID-19) pandemic (Das and Roy 2022). Furthermore, high consumption implicates a decline in agri-food exports to the global market. Meanwhile, the infrastructure and security of the Internet can increase agri-food competitiveness. The Internet application, by providing various forms of infrastructure, significantly enhances agricultural activity's competitive advantage (Hristoski et al. 2017). Additionally, the Internet facilitates further technology to support traceability in the case of hydroponic vegetables (Suroso et al. 2021). The term "FoodTech" has already developed as an essential implication of the Internet on agri-food chains to maintain sustainable food security in the global world (Renda 2019). Therefore, the key to increasing agri-food competitiveness through the Internet depends on infrastructure and security.

The simulation results showed that there is a significant change in agri-food competitiveness using both the continent and income categories. This proves that the Internet has

already become the driving force of change by creating new chances for innovation and supporting the processes (Apăvăloaie 2014). However, the results of the simulation also revealed that the Internet can be a technology for an industrial transition from agriculture to industry. Additionally, the results also revealed that the adoption of the Internet is critical for developing countries due to its positive impact on the competitiveness of agri-food export, as supported by previous research by (Oyelami et al. 2022; Suroso et al. 2022) in the case of agriculture sector performance. It also suggests that ICT can support competitiveness in agriculture, similar to previous findings by (Ollo-López and Aramendía-Muneta 2012). The development of the Internet in agri-food export competitiveness can be applied by considering these activities: monitoring, automation, and decision support (Trivelli et al. 2019). The emergence of Industry 4.0 or integrated digital technology based on the Internet can make the producer compete by increasing the creation of innovation processes and output (Oltra-Mestre et al. 2021). This study enables the application of the Internet to lead the structural competition of agri-food export in the global market, changing the exporter position from before to after simulations. Policymakers can utilize the decision support system for investment or appraisal to increase agriculture productivity (Suroso and Ramadhan 2014; Suroso and Ramadhan 2012).

6. Conclusions

This study provides knowledge about the nexus of Internet indicators (users, infrastructure, and security) toward export competitiveness in the case of agri-food using 126 countries from 2010 to 2020. According to our empirical results, we found that all the Internet indicators have a significant effect on agri-food export competitiveness. However, there are various findings in these Internet indicators: Internet users have a negative and significant effect, while infrastructure and security positively influence agri-food export competitiveness. There are changes in competitiveness structure by enhancing the Internet indicator to 50%. After simulation, we found that 80 countries have a positive value of RSCA. However, the values are still lower than the actual value of RSCA in 89 countries. On the other hand, a developing country has a better opportunity to increase the agri-food export competitiveness than a developed country by comparing the competitiveness condition before and after the simulation.

The simulation results indicated that enhancing three Internet indicators could lead to new competitors for the agri-food global market, which means that Internet development can be a threat to countries with high actual competitiveness value. There are several implications from this study, namely, (1) an improvement in the Internet must be considered by policymakers in developing countries to expand agri-food exports to the global market, and the consideration of quality and quantity is important to maintain export competitiveness; (2) the Internet infrastructure and security must be considered due to the positive impact on agri-food export competitiveness; and (3) policymakers from developed countries can maintain agri-food export competitiveness by diversifying the country destination or product to increase the share in the global market. Last but not least, this study concluded that the impact of Internet development on competitiveness is different based on geographical conditions (continent) and income. Therefore, policymakers must adapt based on their position in the global market. However, this study only investigates the agriculture sector due to the limitation of data. It implies that future studies can explore the Internet indicators on service or manufacturing export competitiveness in the global world. Additionally, the other indicators of the Internet can be explored to re-estimate this impact on competitiveness. There are limitations of this study, such as the involvement of country amount and period due to data availability. Moreover, a consideration of factors outside the model must be applied to investigate other determinants of agri-food export competitiveness.

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Data Availability Statement: Not applicable.

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

Appendix A. The List of Countries (Two Categories)

Table A1. Continent.

Continent	Country
Africa	Angola, Benin, Botswana, Burkina Faso, Djibouti, Egypt, Eswatini, Gabon, Gambia, Ghana, Guinea, Kenya, Lesotho, Madagascar, Malawi, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Rwanda, Senegal, Seychelles, South Africa, Togo, Tunisia, Zambia, and Zimbabwe
Asia	Armenia, Bahrain, China, Hong Kong SAR, China, mainland, Cyprus, Georgia, India, Indonesia, Iran (Islamic Republic of), Israel, Japan, Jordan, Kazakhstan, Kuwait, Kyrgyzstan, Lao People's Democratic Republic, Malaysia, Maldives, Mongolia, Nepal, Oman, Pakistan, Republic of Korea, Republic of Moldova, Singapore, Thailand, Timor-Leste, Türkiye, United Arab Emirates, Uzbekistan, and Viet Nam
Europe	Albania, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Montenegro, Netherlands (Kingdom of the), North Macedonia, Norway, Poland, Portugal, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, and United Kingdom of Great Britain and Northern Ireland
North America	Belize, Canada, Costa Rica, Dominican Republic, El Salvador, Grenada, Honduras, Jamaica, Mexico, Nicaragua, Panama, Qatar, Saint Lucia, Saint Vincent and the Grenadines, and United States of America
Oceania	Australia, Fiji, New Zealand, and Tonga
South America	Argentina, Bolivia (Plurinational State of), Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Suriname, and Uruguay

Source: (Statistic Times 2019).

Table A2. Income.

Income	Country
High	Australia, Austria, Bahrain, Belgium, Canada, Chile, China, Hong Kong SAR, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Kuwait, Latvia, Lithuania, Luxembourg, Malta, Netherlands (Kingdom of the), New Zealand, Norway, Oman, Panama, Poland, Portugal, Qatar, Republic of Korea, Romania, Seychelles, Singapore, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Arab Emirates, United Kingdom of Great Britain and Northern Ireland, United States of America, and Uruguay
Middle	Albania, Angola, Argentina, Armenia, Belarus, Belize, Benin, Bolivia (Plurinational State of), Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, China, mainland, Colombia, Costa Rica, Djibouti, Dominican Republic, Ecuador, Egypt, El Salvador, Eswatini, Fiji, Gabon, Georgia, Ghana, Grenada, Guinea, Honduras, India, Indonesia, Iran (Islamic Republic of), Jamaica, Jordan, Kazakhstan, Kenya, Kyrgyzstan, Lao People's Democratic Republic, Lesotho, Malaysia, Maldives, Mauritania, Mauritius, Mexico, Mongolia, Montenegro, Morocco, Namibia, Nepal, Nicaragua, North Macedonia, Pakistan, Paraguay, Peru, Republic of Moldova, Russian Federation, Saint Lucia, Saint Vincent and the Grenadines, Senegal, Serbia, South Africa, Suriname, Thailand, Timor-Leste, Tonga, Tunisia, Türkiye, Ukraine, Uzbekistan, Viet Nam, Zambia, and Zimbabwe
Low	Burkina Faso, Gambia, Madagascar, Malawi, Mozambique, Rwanda, and Togo

Source: (WDI 2023).

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