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Competitiveness of Indonesian spices in the world market and its determining factors

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ABSTRACT

This study examined the competitiveness of Indonesian spice exports in the global market and identified the major factors influencing their trade performance. The data used was extracted from UN Comtrade, the Food and Agriculture Organization (FAO), the International Monetary Fund (IMF), the Ministry of Trade, and the Ministry of Agriculture for the period 2002–2021. Methods for analysing the data were Revealed Comparative Advantage (RCA), Export Product Dynamics (EPD), and the Gravity Model. The RCA assessed the competitiveness of spices in the global markets. The EPD captured dynamic changes in the competitiveness of Indonesian spice export, and the Gravity model determined factors that affect the world spice trade and the Indonesian spice trade in the world market. The findings show that Indonesian spice competitiveness has fluctuated and generally weakened over the past two decades. However, six spices continued to maintain relatively strong positions in several export destinations. Export performance was shaped not only by economic size and market demand but also by Covid-19-related disruption, food-related intangible cultural heritage, and destination-market requirements, particularly in the European Union market. These findings suggest that Indonesia's spice competitiveness depends on improving production capacity, product quality, compliance with standards, and export readiness. To further increase spice production capacity and maintain competitiveness in the global market, the government of Indonesia should prioritize commodity-specific good agricultural practices and good handling practices (GAPs/GHPs), export assistance for small- and medium-sized businesses, stronger farmer institutions, and alignment with downstream-oriented spice policies.

1. Introduction

Spices are an essential trade commodity but are often overlooked by policymakers. This neglect partly reflects the fact that spices are still widely cultivated for subsistence purposes and are perceived as less commercially promising than horticultural and plantation crops. Yet, spices have long been part of one of the oldest trade networks, with the potential to increase farmers' incomes, absorb labor, and encourage economic growth due to their potential health benefits (Szűcs et al., 2018; Thomas & Sanil, 2021).

These potential benefits are closely linked to the distinctive nature of the spice. First, the spice trade involves considerable geographical distance between production centers in Asia and Africa, with significant buyers in Europe and the United States, making logistics and market access important elements of competitiveness (Henson & Loader, 2001). Second, major spice producers are generally from developing or least developed countries, where economic, social, and political dynamics can increase uncertainty in global spice supply chains. Third, the frequent mixing of products from different geographical origins makes traceability, quality consistency, and origin-based differentiation increasingly important. Fourth, demand for spices is stimulated by the expansion of the food industry and culinary development, which continues to shape global trade intensity (Lu et al., 2018; Sherman & Billing, 1999).

Against this backdrop, Indonesia is recognized as one of the world's leading spice producers, alongside India, Nigeria, and China. Indonesia's spice production increased significantly from 44,000 tons in 1961–750,700 tons in 2022, representing 5.4 % of global spice

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production. Nevertheless, export performance differs across spice commodities. Nutmeg, for example, accounted for 29.2 % of global production and 26.7 % of global exports in 2022 (FAO, 2024), highlighting Indonesia's strong comparative advantage in this commodity.

Despite this substantial production capacity, Indonesia continues to face challenges in meeting growing domestic demand for spices, particularly due to the expansion of the food and beverage industry, which grew by 4.7 % in 2023 (Waluyo, 2024). This condition presents a paradox: although Indonesia is a major global spice producer and exporter, domestic supply pressures remain significant. Over the past six decades, Indonesian spice exports increased by an average of 5.9 % annually, while imports grew even faster at 6.4 % per year (FAO, 2024).

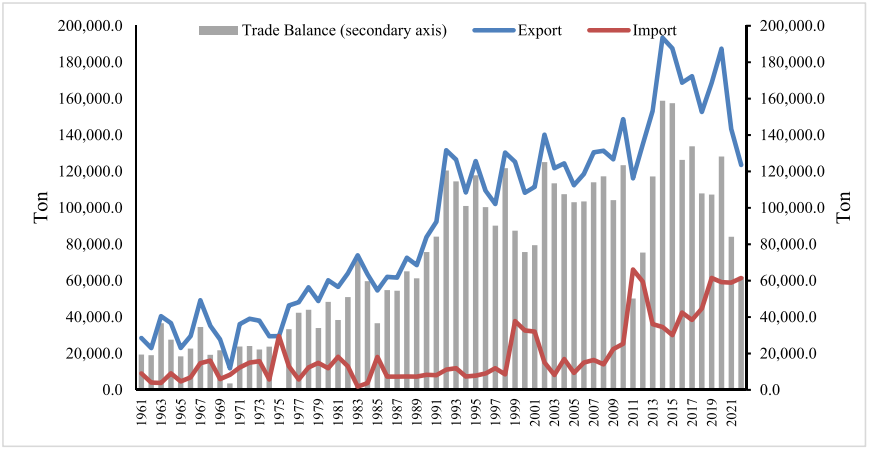
Fig. 1 shows Indonesia's spice trade in the world market by volume (Fig. 1a) and by value (Fig. 1b), illustrating this imbalance and the need to strengthen export competitiveness and domestic production capacity to meet both domestic and international demand, particularly from majorλdestination countries (Sulaiman et al., 2020). Previous studies also indicate that Indonesia's spice competitiveness remains concentrated in selected commodities (Anggrasari et al., 2021).

Recognizing these challenges, the Indonesian government has intensified its efforts to enhance the competitiveness of the spice sector. Previously, government attention toward spices was relatively limited compared with other plantation commodities, such as palm oil and rubber. To support the development of the spice industry, the government has introduced several policies and programs, including Indonesia Spice Up the World, Spice Gardens, the spice product certification program, the Love Indonesian Spices Program, the Sustainable Spices Initiative Indonesia, and the establishment of the National Spice Association. This association also supports the digital transformation of the Spice Route through the development of an Indonesian spice marketplace (Indriani, 2022).

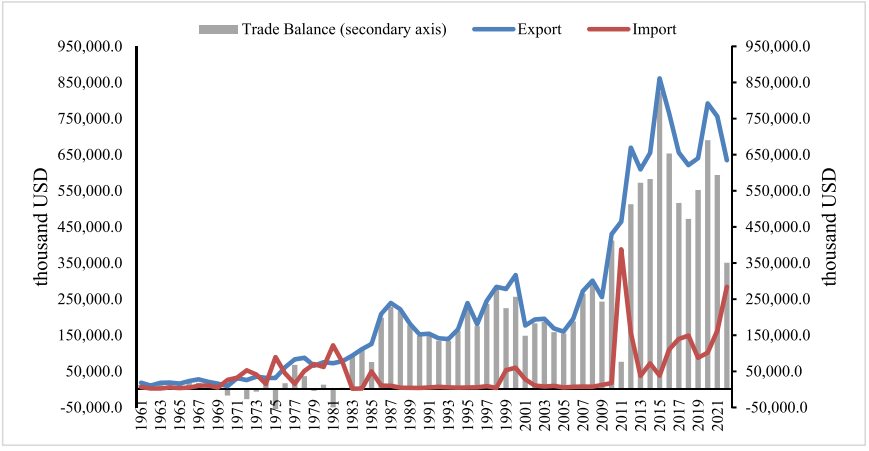
Based on the issues outlined above, this study aims to examine the competitiveness of Indonesian spices and the factors influencing it. This study differs from previous research in several ways. First, earlier studies did not adequately capture major global developments, including the 2008 food crisis, the COVID−19 pandemic in 2020, the 2013 food safety guidelines for spices and culinary herbs issued by the Codex Committee on Spices and Culinary Herbs, and the 2003 recognition of spices as part of intangible cultural heritage. Second, previous studies did not employ an integrated analytical framework combining Revealed Comparative Advantage (RCA), Export Product Dynamics (EPD), and Gravity Model estimation to comprehensively evaluate export competitiveness, market dynamics, and trade determinants. Finally, this study contributes to the renewed global discourse on agricultural trade and food systems.

2. Data and methods

Data were extracted from UN Comtrade, the Food and Agriculture Organization (FAO), the International Monetary Fund (IMF), the Ministry of Trade, and the Ministry of Agriculture. Spice commodities were



a. Indonesian spice trade in the world market by volume.



b. Indonesian spice trade in the world market by value.

Fig. 1. Indonesian spice trade in the world market 1960–2022.
Source: FAO, (2024) (Processed).

aggregated using four-digit HS codes to provide detailed commodity-level information: 0903 (mate), 0904 (pepper and chili), 0905 (vanilla), 0906 (cinnamon), 0907 (cloves), 0908 (nutmeg, mace, and cardamom), 0909 (seeds of anis, badian, fennel, coriander, cumin, caraway; juniper berries), and 0910 (ginger, turmeric, saffron, thyme, bay leaf, and curry leaves).

This study used time-series data for 2002–2021 to capture changes associated with the 2008 food crisis, the COVID−19 pandemic in 2020, the 2013 food-spice safety guidelines issued by the Codex Committee on Spices and Culinary Herbs, and the 2003 designation of intangible cultural heritage, which increased awareness of culturally embedded culinary practices. The scope of analysis was divided into two levels: (a) a global level covering 14 spice-exporting countries with the largest market shares, including Brazil, Argentina, Paraguay, India, Indonesia, Vietnam, China, Madagascar, France, Germany, Sri Lanka, Tanzania, Guatemala, and the Netherlands and (b) an Indonesia-specific level covering 30 main trading partners, including the Netherlands, Bulgaria, Australia, Brunei Darussalam, China, France, Hong Kong, Japan, Malaysia, Taiwan, Pakistan, Poland, Saudi Arabia, India, Singapore, Vietnam, Thailand, UAE, USA, Germany, Bangladesh, South Korea, Canada, Brazil, Russia, United Kingdom, Nigeria, Spain, Italy, and Egypt.

The Revealed Comparative Advantage (RCA) and Export Product Dynamic (EPD) were selected to align with the study's competitiveness objectives. RCA was used to assess whether Indonesian spices had a revealed comparative advantage in export markets by comparing their share of Indonesia's total exports with the share of the same commodities in global exports (Malau et al., 2022). An RCA value above 1 signifies a revealed comparative advantage, while a value below 1 suggests a comparative disadvantage. The RCA formula is shown in Eq. 1.

$$RCA = (X_{ij}/X_j)/(X_{iw}/X_w) \quad (1)$$

Where X_{ij} is an export of spice commodities i country j; X_j is the country's total spice exports j; X_{iw} is a world export of spice commodities i, and X_w is the total world spice exports.

EPD was then applied to capture dynamic changes in the competitiveness of Indonesian spice export products (Esterhuizen, 2006; Prasada & Masyhuri, 2019). The results of the EPD calculation were mapped into the EPD matrix, where market attractiveness, measured based on demand growth, is the horizontal axis or X-axis (Eq. 2), and business strength, measured based on market acquisition growth or market share, is the vertical axis or Y-axis (Eq. 3).

$$\text{X}-\text{axis}: \frac{\sum_{t=1}^{t}\left(\frac{X_{ca}}{W_{ca}}\right)t - \sum_{t=1}^{t}\left(\frac{X_{ca}}{W_{ca}}\right)t - 1x100\%}{T} \quad (2)$$

$$\text{Y}-\text{axis}: \frac{\sum_{t=1}^{t}\left(\frac{X_{ta}}{W_{ta}}\right)t - \sum_{t=1}^{t}\left(\frac{X_{ta}}{W_{ta}}\right)t - 1x100\%}{T} \quad (3)$$

Where X_{ca} is the export value of c products to country a, W_{ca} is the world export value of c products to country a, X_{ta} is the total value of exports of all Indonesian products to country a, W_{ta} is the total value of exports of all world commodities to country a, t is the number of years, a is the export destination country. After calculating the x and y axes, four position categories were obtained, namely, rising star, falling star, lost opportunity, and retreat (Table 1).

Furthermore, the Gravity Model was used to identify spice trade determinants based on macroeconomic factors and trade barriers. The model has been widely applied in trade studies since Tinbergen (1962) and Pulliainen (1963) and further developed by Linnemann (1966), and Abrams (1980), and Bergstrand (1985). Here, the Gravity Model was adjusted using relevant control variables, as shown in Eqs. 4 and 5.

Table 1
Competitiveness position matrix.

		Share of the country's exports in world trade	
		Falling (Non-competitive)	Rising (Competitive)
Share of product in world trade	Rising (Dynamic)	Lost opportunity	Rising stars
	Falling (Stagnant)	Retreat	Falling stars

Source: Nabi & Luthria, 2002.

$$\exp_{ijt} = \alpha_0 + \alpha_1 lggdpo_{it} + \alpha_2 lggdpp_{jt} + \alpha_3 ldistk_{ij} + \alpha_4 d08 + \alpha_5 dcov + \alpha_6 dcac + \alpha_7 dich + \alpha_8 due + \varepsilon \quad (4)$$

$$\exp_{zjt} = \beta_0 + \beta_1 lggdp_{zt} + \beta_2 lggdpp_{jt} + \beta_3 ldistk_{zj} + \beta_4 lrer_{zjt} + \beta_5 d08 + \beta_6 dcov + \beta_7 dcac + \beta_8 dich + \beta_9 due + \varepsilon \quad (5)$$

Where exp_{ijt} and exp_{zjt} denote spice exports from country i and Indonesia (z) to country j in year t, respectively; the logarithmic variables represent GDP, distance, and exchange rate measures, while *d08*, *dcov*, *dcac*, *dich*, and *due* are dummy variables; α_0 and β_0 are intercepts; α_{1-8} and β_{1-9} are estimated parameters; and ε is the error term. Table 2 provides detailed variable descriptions, units, and data sources.

Eqs. (4) and (5) were estimated using Poisson pseudo-maximum likelihood (PPML) to accommodate zero trade flows. This study applied the Ramsey test to assess model specification and employed

Table 2
Detailed variables, their descriptions, units of variables, and data sources used in estimating the Gravity model.

No.	Variable notation	Variable description	Variable units	Data sources
Dependent variables:				
1.	exp_{ijt}	Spice export from country i to country j in year t	000 USD	UN Comtrade
2.	exp_{zjt}	Spice export from Indonesia (z) to country j in year t	000 USD	UN Comtrade
Independent variables:				
3.	$gdpo_{it}$	GDP of country i in year t	USD	World Bank
4.	$gdpp_{zt}$	GDP of Indonesia (z) in year t	USD	World Bank
5.	$gdpp_{jt}$	GDP of destination country j in year t	USD	World Bank
6.	$distk_{ij}$	Distance between countries i and country j	km	Distancecalculator.net
7.	$distk_{zj}$	Distance between Indonesia (z) and country j	km	Distancecalculator.net
8.	rer_{zjt}	Exchange rate of Indonesia (z) against country j in year t	Rp/USD	World Bank
9.	*d08*	Dummy for the 2008 food crisis	Dummy	FAO
10.	*dcov*	Dummy for the Covid−19 pandemic	Dummy	WHO
11.	*dcac*	Dummy for the 2013 Codex Committee on Spices and Culinary Herbs	Dummy	FAO
12.	*dich*	Dummy for the 2003 Intangible Cultural Heritage	Dummy	FAO and UNESCO
13.	*due*	Dummy for the European Union membership	Dummy	European Union

Fixed Effect (FE), Random Effect (RE), and Generalized Least Squares (GLS) estimations for robustness checks.

3. Results and discussion

3.1. Development of the Indonesian spice trade

Indonesia's spice trade generally increased over time, although several periods experienced contraction. Exports reached their highest level in 2014/2015, reflecting stronger global demand, particularly from developing countries and emerging markets such as China and India (Parappurathu & Mathur, 2015). This was due to the post−2008 recovery in food-related trade and domestic efforts to strengthen agricultural production through technology and innovation.

In 2022, FAO data showed that Indonesia accounted for 6.2 % of global spice exports and 2.6 % of imports, while UN Comtrade recorded lower shares of 2.8 % and 0.7 %, respectively, due to differences in commodity classification and HS-code-based reporting (FAO, 2024; UN Comtrade, 2024). Commodity-level data further indicate that nutmeg, cinnamon, and cloves remained Indonesia's leading spices in global trade, with export shares of 20–26.7 %, 12.7 %, and 9.1 %, respectively (Appendix Fig. A.1).

Nutmeg, mace, and cardamom are Indonesia's primary spice commodities and are widely exported to China, India, and Vietnam. Even the share of Indonesian nutmeg, mace, and cardamom exports to China reached 39 % of the total exports of these commodities in 2022. The same condition occurs in cinnamon, where its exports to the United States have a share of 52.93 %. In addition to the United States, Indonesia's other cinnamon trading partners are the Netherlands and Vietnam. Meanwhile, the pepper trade is exported with almost an even share to Vietnam, the United States, and China.

Apart from these three primary commodities, the export value of mate (HS 0903), vanilla (HS 0905), anise seeds, fennel, coriander (HS 0909), and ginger (HS 0910) are relatively small. This reflects strong domestic demand, particularly for ginger and cloves; product quality issues, such as vanilla; and limited production scale, such as mate (Nurhayati et al., 2018; Lestari et al., 2022). Demand, market prices, and production characteristics therefore shape Indonesian spice exports in the world market. For example, Indonesia's ginger production fluctuates due to weather factors (Choerunnisa et al., 2021), but despite reaching 307,242 tons in 2021 (Appendix Fig. A.2), it was mostly absorbed by domestic consumption. Meanwhile, nutmeg, anise, and cardamom were produced in smaller quantities than ginger, cloves, cinnamon, and pepper. Yet a much larger proportion of their output entered export markets, reaching 90.5 per cent of total production in 2021.

3.2. Development of Indonesian spice competitiveness

The value and volume of Indonesian spice exports fluctuate, and some spices are experiencing a downward trend, highlighting the urgency of assessing Indonesian spice competitiveness for development strategy (Rahmawati et al., 2019). The RCA estimation results confirm that the competitiveness of Indonesian spices has been dynamic for almost two decades across 30 trading partner countries. Indonesian spices are relatively highly competitive in the United States and the Netherlands for several spice commodities. In general, the competitiveness declined in almost all countries during 2002–2021, except for cloves (HS 0907), nutmeg, mace, and cardamom (HS 0908), and ginger (HS 0910) in the Dutch market and cinnamon (HS 0906) in the United States market.

Regarding mate trading (HS 0903), although Indonesia is not a significant producer, it once had a high competitiveness in the Indian market in 2002–2005 (Appendix Fig. B.1a). Since 2006, Indonesia has never had a competitive mate in the international market. The world's top mate producers are Argentina, Brazil, and Paraguay, where Brazil has a 65 % share of world mate production and a smaller crop area than Argentina (Heimann et al., 2021). In the pepper trade (HS 0904), Indonesia was still competitive in Singapore and the United States markets in 2002, then began to decline its competitiveness in 2016 (Appendix Fig. B.1b). Some of the factors that affect it are high transportation costs and complicated regulations. On the other hand, pepper cultivation involves many small-scale smallholder farmers with limited access to resources (Amorita & Daryanto, 2021).

In vanilla trade (HS 0905), although Indonesia's vanilla production is not large, Indonesia is competitive, especially in the United States market (Appendix Fig. B.1c). Meanwhile, Indonesia's vanilla competitiveness tends to decline in the German and Indian markets due to instability in export demand and increased competition with other exporting countries. According to Hermawan (2015), Vanilla remains one of the spices where Indonesia is potentially trading in other markets, such as ASEAN. Conditions are almost the same as the cinnamon trade (HS 0906). The competitiveness of cinnamon in the United States market can be maintained until 2021 (Appendix Fig. B.1d). This study's results align with research by Rambe and Malau (2023) and Rochdiani and Wulandari (2023), which stated that Indonesian cinnamon is competitive in the United States market.

In the clove trade (HS 0907), Indonesia is recorded to be competitive in several markets, such as the Netherlands, Bulgaria, Australia, Brunei Darussalam, and France in 2021 (Appendix Fig. B. 1e). These results align with the findings of Zuhdi et al. (2020) and Nurhayati et al. (2018). However, in 2021, the competitiveness of Indonesian cloves tends to decline in the international market in line with the competitiveness of the main competitors, namely Madagascar and Comoro (Pratama et al., 2020; Zuhdi & Rambe, 2021). Nutmeg, mace, and cardamom (HS 0908) are not much different from the competitiveness of cloves. Indonesian nutmeg, mace, and cardamom are competitive in the markets of the Netherlands, Bulgaria, Australia, and Brunei Darussalam (Appendix Fig. B.1 f).

In the trade of anise, fennel, and coriander seeds (HS 0909), competitiveness followed a different pattern from other commodities, increasing in the United States market in 2006–2009 but not reaching a highly competitive level (Appendix Fig. B.1 g). Indonesian ginger (HS 0910) was competitive in the Brazilian market in 2014 (Appendix Fig. B.1 h), but its competitiveness has declined across all trading partner countries since then, partly due to strong competition from China (Kaneya & Firdaus, 2014; Rusnaldi et al., 2023).

Building on the RCA results, the EPD matrix further maps Indonesia's competitive position in the world spice market (Anggrasari et al., 2021). The results capture dynamic shifts across commodities and trading partner countries, supporting previous evidence that Indonesian spice export competitiveness varies by commodity and destination market (Pratama et al., 2020; Purba et al., 2021).

Regarding mate (HS 0903), Indonesia's competitiveness was generally positioned in the rising stars and falling stars quadrants, indicating market-share gains in several trading partners despite Indonesia not being a major mate producer (Appendix Fig. B.2). In contrast, pepper (HS 0904), vanilla (HS 0905), cinnamon (HS 0906), cloves (HS 0907), nutmeg, mace, and cardamom (HS 0908), and ginger (HS 0910) were generally positioned in the lost opportunity and retreat quadrants, reflecting declining market shares in several destination markets (Appendix Figs. B.3–B.7 and B.9). Meanwhile, anise, fennel, and coriander seeds (HS 0909) were distributed across all four quadrants. However, rising stars and falling stars were relatively more frequent (Appendix Fig. B.8).

These results indicate that no spice commodity maintained a consistent competitive position over time, reflecting intense competition across Indonesia's destination markets. Although RCA results suggest a general decline in competitiveness, the 2021 EPD positions indicate some improvement, particularly through the dominance of rising stars and the loss of opportunities, except for mate. It suggests that Indonesia still has momentum to strengthen spice competitiveness in selected markets.

3.3. Determinants of spice trade in the world market

To provide a comprehensive picture of the world spice trade performance, its determinants were examined using a trade model with 3640 observations (Table 3). Descriptive statistics show that world spice exports averaged USD 8 million, with a standard deviation of USD 28.4 million, indicating substantial variation in export values across observations. In contrast, GDP growth and distance show relatively lower variation across origin and destination countries.

In terms of the determinant parameters of the world spice trade, the results indicate that the GDP of the destination country or the economic size of the destination country, distance, the food crisis in 2008, the Covid−19 pandemic, and the presence of intangible cultural heritage in 2003 had a significant effect on the world spice trade based on the Pseudo Maximum Likelihood Fixed Effects (PPML FE) approach. Meanwhile, the GDP of the country of origin is considered robust because the sign of the estimated parameters is consistent in the four models, even though the significance is different (Table 4). This finding aligns with the study of Panchalingam et al. (2014), where the size of economies between countries positively affects trade flows, and the distance between countries negatively affects trade flows. The larger economy of the destination country will enhance purchasing power, thereby stimulating increased spice exports. These results also confirm that distance significantly and negatively affects the world spice trade by increasing transportation and other trade costs.

The 2008 food crisis negatively affected the world spice trade, whereas the Covid−19 pandemic had a positive effect. During the 2008 crisis, consumers prioritized staple foods such as rice, corn, and wheat, whose prices rose sharply, thereby reducing demand for spices, ceteris paribus. In contrast, spice export values rose during the COVID−19 pandemic despite mobility restrictions and lockdowns (Sadiyah, 2021; Sarni & Sidayat, 2020; Wahdiana et al., 2023). This increase was driven by rising demand for health- and immunity-related spices, such as turmeric and ginger, more home cooking, and the growth of food and culinary industries across countries (Massabuau, 2021; Onyeaghala et al., 2023; Pancawati, 2021; Putra, 2020). These patterns are consistent with studies showing increased attention to spices and herbs during the COVID−19 pandemic due to perceived health benefits and shifts in food-related consumption (Özen et al., 2022; Singh et al., 2021).

In addition, the existence of intangible cultural heritage since 2003 by UNESCO in various culinary sectors in many countries has helped increase spice exports in the world. Some examples included food and culinary activities that are emerging again and increasingly popular with the existence of intangible cultural heritage such as Rendang from Indonesia, Pizza from Italy, Kimchi from South Korea, Lavash from Armenia, and Dolma from Azerbaijan. In the case of Indonesia, intangible cultural heritage embedded in several foods encourages more intensive efforts to develop culinary, including culinary tourism, so that it will also encourage the need for spices (Wibawati & Prabhawati, 2021).

3.3.1. Determinants of Indonesian spice trade in the world market

The performance of the Indonesian spice trade in the world market shows a pattern similar to that of the global spice trade. The model of the Indonesian spice trade was built using 600 observations (Table 5). Indonesian spice exports averaged USD 15.5 million, with a standard deviation of USD 31.6 million, indicating high dispersion. The average GDP of destination countries (6.5) was slightly higher than Indonesia's GDP (6.4), while distance and exchange rate variables showed relatively limited variation.

The estimation results with the PPML FE approach show that Indonesia's GDP, the destination country's GDP, existed intangible cultural heritage (food/culinary) in 2003, and the country's membership in the European Union significantly affected Indonesia's spice exports. The significant influence of Indonesia's GDP and destination countries is also confirmed in the RE and GLS Models (Table 6). These results are aligned with research by Humaira and Rochdiani (2021) and Novidayanti et al. (2019), which shows that Indonesia's GDP significantly affects Indonesia's spice exports in international trade. Although distance is not significant in the PPML, RE, and FE models, its negative and significant coefficient in the GLS model suggests a potential adverse effect on Indonesian spice exports, consistent with Inayah et al. (2015).

Even though the food crisis of 2008 did not affect the flow of Indonesian spice exports to the world market, the Covid−19 pandemic, intangible cultural heritage (food/culinary), and membership of destination countries in the European Union were determinants of Indonesian spice exports in the world market. For Indonesia, the Covid−19 pandemic has contracted spice exports to the world market, at least in the short term. According to Ing and Vadila (2022), Indonesia's exports to world markets generally decreased during the COVID−19 pandemic. Indonesian spice exports also indicated a decline when initially responding to the outbreak of the COVID−19 pandemic because the lockdown had disrupted the distribution chain and also caused a build-up of export goods at ports (Sucahyo, 2022; Wicaksono, 2021). The same condition also happened in India, the center of the largest spice producer in the world (Fredenburgh, 2020).

The membership variable of countries in the European Union also influences the flow of Indonesian spice exports to the European Union region. It is because buyers from the European Union generally set mandatory requirements for spices exported by Indonesia by the provisions, including (a) Regulation (EC) 178/2002 concerning general principles and requirements for European Union food legislation, (b) Regulation (EC) 852/2004 concerning general provisions for food business actors, including food hygiene, (c) Regulation (EEC) 315/93 concerning the regulation of the presence of contaminants in food, (d) Regulation (EU) 2023/915 concerning determining maximum levels of

Table 3
Description of statistical variables in the world spice trade model.

No.	Variable	Obs.	Mean	Max.	Min.	SD.
1.	exp_{ijt}	3640	8004.906	645,223.000	0.000	28,405.960
2.	$l\exp_{ijt}$	3640	0.387	13.377	−11.513	9.028
3.	$lggdpo_{it}$	3640	5.719	9.783	1.622	2.072
4.	$lggdpp_{jt}$	3640	5.719	9.783	1.622	2.072
5.	$ldistk_{ij}$	3640	8.934	9.868	6.059	0.755
6.	*d08*	3640	0.100	1.000	0.000	0.300
7.	*dcov*	3640	0.100	1.000	0.000	0.300
8.	*dcac*	3640	0.050	1.000	0.000	0.218
9.	*dich*	3640	0.050	1.000	0.000	0.218
10.	*due*	3640	0.214	1.000	0.000	0.410

Source: World Bank, 2023; UN Comtrade, 2023 (Processed).
Note: Obs.: observations; SD: standard deviation; exp_{ijt}: spice exports from country *i* to country *j* in year *t*; $l\exp_{ijt}$: logarithm of spice exports from country *i* to country *j* in year *t*; $lggdpo_{it}$: logarithm of gross domestic product of country *i* in year *t*; $lggdpp_{jt}$: logarithm of GDP of destination country *j* in year *t*; $ldistk_{ij}$: logarithm of distance between country *i* and country *j*; *d08*: dummy for the 2008 food crisis; *dcov*: dummy for the Covid−19 pandemic; *dcac*: dummy for the 2013 Codex Committee on Spices and Culinary Herbs; *dich*: dummy for the 2003 Intangible Cultural Heritage designation; *due*: dummy for European Union membership.

Table 4
Estimation of world spice trade determinants.

Variable	PPML FE		Random Effect		Fixed Effect		GLS	
	exp_{ijt}	Std. Err.	l exp $_{ijt}$	Std. Err.	l exp $_{ijt}$	Std. Err.	lex_{pijt}	Std. Err.
$lggdpo_{it}$	0.096	0.076	0.983****	0.134	0.691****	0.209	1.419****	0.054
$lggdpp_{jt}$	0.365****	0.089	1.733****	0.139	1.819****	0.209	2.042****	0.060
$ldistk_{ij}$	−0.587****	0.162	−2.166****	0.550	-	-	−2.054****	0.148
d08	−1.091****	0.186	−0.454***	0.219	−0.488***	0.219	−0.333	0.371
dcov	0.277****	0.041	0.111	0.227	0.204	0.228	−0.227	0.373
dcac	−0.421	0.205	−0.061	0.301	0.002	0.301	−0.286	0.508
dich	−1.415****	0.170	0.089	0.319	−0.081	0.324	0.704	0.512
due	0.174	0.461	3.948****	1.066	-	-	3.344****	0.306
_*cons*	-	-	3.392	5.056	−13.932****	0.888	−1.737	1.442
Obs.	3640.000		3640.000		3640.000		3640.000	
R^2	0.144		0.455		0.393		0.462	
Wald chi^2			604.640				3136.880	
Prob. > chi^2			0.000				0.000	
F					66.240			
Prob. > F					0.000			
Chi^2	6.980							
Prob. > chi^2	0.008							

Source: World Bank, 2023; UN Comtrade, 2023 (Processed).
Note: PPML FE: Poisson pseudo-maximum likelihood with fixed effects; RE: random effects; FE: fixed effects; GLS: generalized least squares; Std. Err.: standard error; Obs.: observations; exp_{ijt} and l exp $_{ijt}$ denote spice exports and their logarithmic form from country *i* to country *j* in year *t*, respectively; $lggdpo_{it}$, $lggdpp_{jt}$, and $ldistki_{ij}$ denote the logarithms of origin-country GDP, destination-country GDP, and bilateral distance; *d08*, *dcov*, *dcac*, *dich*, and *due* denote dummies for the 2008 food crisis, Covid−19 pandemic, 2013 Codex Committee on Spices and Culinary Herbs, 2003 Intangible Cultural Heritage designation, and European Union membership, respectively; *, **, ***, and **** indicate significance at the 15%, 10%, 5%, and 1% levels, respectively.

Table 5
Variable statistics description on the Gravity model of Indonesian spice trade in the world market.

No.	Variable	Obs.	Mean	Max.	Min.	SD.
1.	exp_{ijt}	600	15,497.200	214,770.000	0.000	31,576.870
2.	l exp $_{ijt}$	600	8.080	12.277	−9.903	2.533
3.	$lggdpp_{zt}$	600	6.441	7.078	5.276	0.573
4.	$lggdpp_{jt}$	600	6.477	10.057	1.765	1.543
5.	$ldistk_{zj}$	600	8.730	9.702	6.795	0.756
6.	$lrer_{zjt}$	600	9.288	9.546	9.058	0.117
7.	*d08*	600	0.100	1.000	0.000	0.300
8.	*dcov*	600	0.100	1.000	0.000	0.300
9.	*dcac*	600	0.050	1.000	0.000	0.218
10.	*dich*	600	0.050	1.000	0.000	0.218
11.	*due*	600	0.233	1.000	0.000	0.423

Source: World Bank, 2023; UN Comtrade, 2023 (Processed).
Note: Obs.: observations; SD: standard deviation; exp_{ijt} and l exp $_{ijt}$ denote Indonesian spice exports to country *j* in year *t* and their logarithmic form, respectively; $lggdpp_{zt}$, $lggdpp_{jt}$, $ldistk_{zj}$, and $lrer_{zjt}$ denote the logarithms of Indonesia's GDP, destination-country GDP, distance between Indonesia and country *j*, and Indonesia's exchange rate against country *j*, respectively; *d08*, *dcov*, *dcac*, *dich*, and *due* denote dummies for the 2008 food crisis, Covid−19 pandemic, 2013 Codex Committee on Spices and Culinary Herbs, 2003 Intangible Cultural Heritage designation, and European Union membership, respectively.

contaminant content, (e) labeling of spice products, and (f) European Union standardization. It could become a trade barrier or Non-Tariff Measures (NTMs) for Indonesian spice exporters.

In addition, the results indicate that food-related intangible cultural heritage positively affects Indonesian spice exports. This suggests that culturally embedded food practices can stimulate demand for Indonesian spices in terms of quantity, quality, and originality, as products associated with intangible cultural heritage are closely linked to cultural identity (Zhang et al., 2023). Culinary heritage can also enhance the value and attractiveness of local food products, creating opportunities for origin-based differentiation (Ossowska et al., 2024). Nutmeg from the Banda Islands and cloves from North Maluku exemplify how regional spices linked to cultural identity and culinary heritage can support production development and export potential.

4. Conclusions and policy implications

Exports of Indonesian spices on the world market continue to increase, especially of nutmeg, anise, cardamom, pepper, and cinnamon. However, the competitiveness of Indonesian spices has fluctuated and generally weakened over the past two decades, although several commodities, particularly vanilla, cinnamon, cloves, nutmeg, mace, and cardamom, have maintained relatively strong competitive positions in selected markets. The RCA and EPD results indicate that Indonesia's spice competitiveness is not uniform across commodities and destination countries, reflecting intense competition and changing market dynamics in the global spice trade.

The determinants of the spice trade differ between the global and Indonesia-specific models. At the global level, economic size, distance,

Table 6
The estimation results of the PPML FE, RE, and the GLS model of Indonesian spice trade determinants in the world market.

Variable	PPML FE		Random Effect		Fixed Effect		GLS	
	exp_{ijt}	Std. Err.	l exp $_{ijt}$	Std. Err.	l exp $_{ijt}$	Std. Err.	l exp $_{ijt}$	Std. Err.
$lggdpp_{zt}$	0.677****	0.164	0.992****	0.192	1.302****	0.221	0.744****	0.238
$lggdpp_{jt}$	0.544**	0.279	0.762****	0.168	0.255	0.246	1.166****	0.063
$ldistk_{zj}$	−0.392	0.396	−0.636	0.458	-	-	−1.115****	0.138
$lrer_{zjt}$	0.230	0.446	1.934****	0.724	1.978****	0.720	1.899**	1.046
d08	−0.114	0.097	0.097	0.196	0.155	0.196	0.051	0.283
dcov	−0.060	0.170	−0.362*	0.221	−0.357*	0.219	−0.366	0.319
dcac	0.046	0.053	0.176	0.262	0.188	0.260	0.166	0.378
dich	0.224****	0.064	0.056	0.279	0.017	0.277	0.087	0.402
due	−2.969****	0.808	−0.099	0.741	-	-	0.111	0.209
_cons	-	-	−15.612****	8.419	−20.319****	7.470	−12.174	10.899
Obs.	600		600		600		600	
R^2	0.838		0.397		0.236		0.402	
Wald chi^2			168.990				418.100	
Prob. > chi^2			0.000				0.000	
F					21.520			
Prob. > F					0.000			
Chi^2	3.040							
Prob > chi^2	0.081							

Source: World Bank, 2023; UN Comtrade, 2023 (Processed).
Note: PPML FE: Poisson pseudo-maximum likelihood with fixed effects; RE: random effects; FE: fixed effects; GLS: generalized least squares; Std. Err.: standard error; Obs.: observations; exp_{ijt} and l exp $_{ijt}$ denote Indonesian spice exports to country *j* in year *t* and their logarithmic form, respectively; $lggdpp_{zt}$, $lggdpp_{jt}$, $ldistk_{zj}$, and $lrer_{zjt}$ denote the logarithms of Indonesia's GDP, destination-country GDP, distance between Indonesia and country j, and Indonesia's exchange rate against country j, respectively; *d08*, *dcov*, *dcac*, *dich*, and *due* denote dummies for the 2008 food crisis, Covid−19 pandemic, 2013 Codex Committee on Spices and Culinary Herbs, 2003 Intangible Cultural Heritage designation, and European Union membership, respectively; *, **, ***, and **** indicate significance at the 15%, 10%, 5%, and 1% levels, respectively.

the 2008 food crisis, the Covid−19 pandemic, and food-related intangible cultural heritage were important factors shaping spice trade flows. For Indonesian spice exports, the main determinants were Indonesia's economic size, the destination country's economic size, Covid−19-related disruptions, food-related intangible cultural heritage, and European Union membership. These findings show that Indonesian spice competitiveness is influenced not only by production capacity and market demand, but also by external shocks, cultural drivers of food consumption, and increasingly stringent market requirements.

Therefore, strengthening Indonesia's spice competitiveness requires policies that improve both domestic supply capacity and export readiness. Given commodity-specific differences in competitiveness, government support should prioritize training and assistance in implementing good agricultural practices (GAPs) and good handling practices (GHPs), especially for spices with strong export potential but unstable production or quality constraints. Export training for small business actors should also focus on standards compliance, product documentation, labeling, traceability, and market information, particularly for the European Union market. Stronger farmer institutions are needed to improve collective marketing, quality control, and coordination among producers, exporters, and government programs. Finally, policy interventions should align with Indonesia's Spice Down streaming Roadmap 2025–2045 by strengthening value-added processing and export-market access for strategic spices.

This study is limited to data through 2022 and Indonesia's primary export destinations. Future research could update the analysis with more recent data and broader destination-country coverage to better map Indonesia's competitive position, identify potential new markets, and assess the role of free trade agreements (FTAs) in boosting spice exports.

Informed consent statement

Not applicable.

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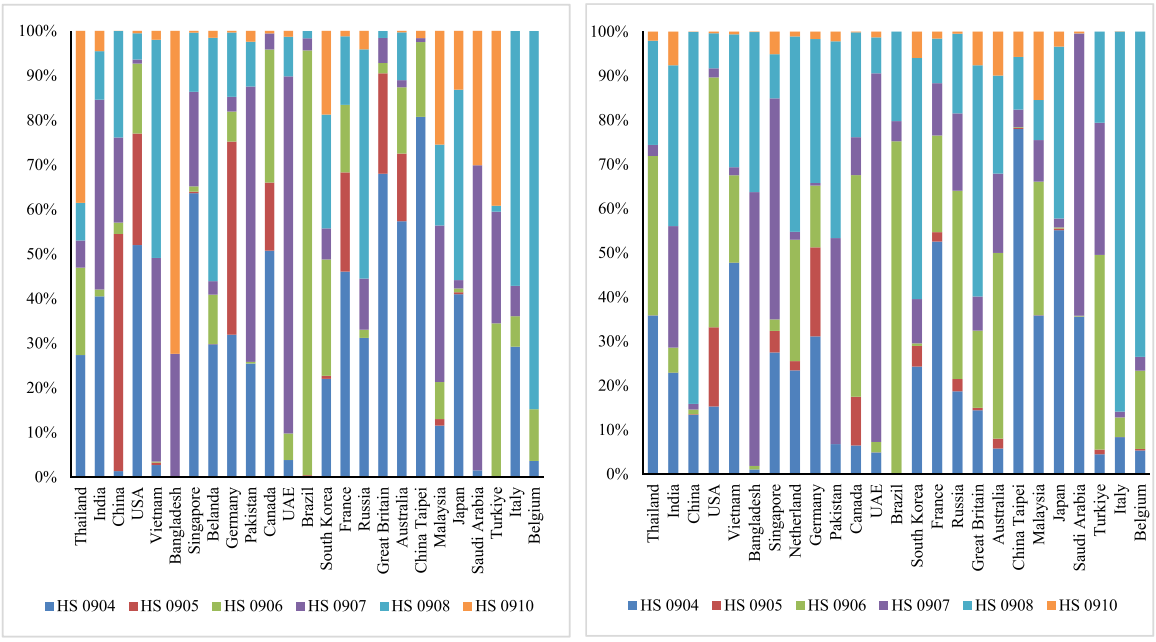
CRediT authorship contribution statement

Khoiru Rizqy Rambe: Writing – original draft, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Iwan Hermawan:** Writing – original draft, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Maria Widyarini:** Writing – original draft, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Carunia Mulya Firdausy:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Formal analysis, Data curation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Indonesian spices production and export to major countries



a. Year 2002 b. Year 2022

Fig. A.1. Share of export value of Indonesian spices to major countries in 2002 and 2022
Source: ITC-Trademap, 2023 (Processed).

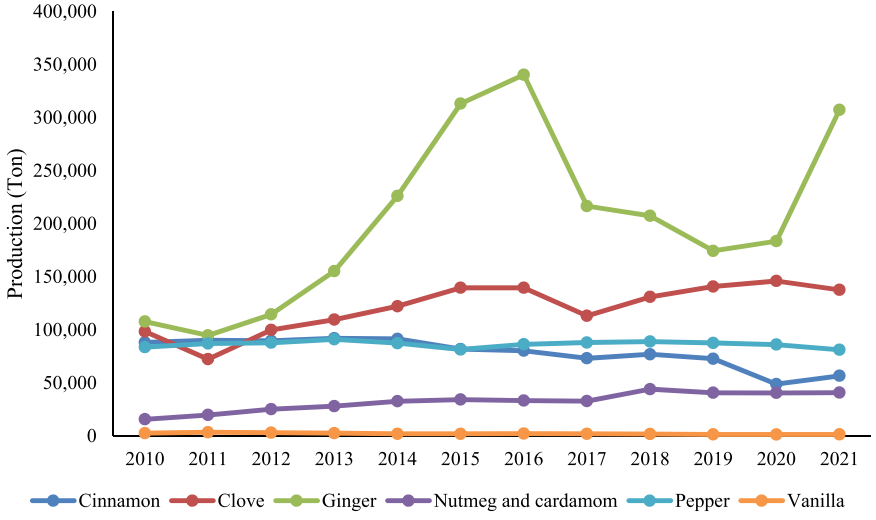


Fig. A.2. Indonesian spice production 2010–2021
Source: FAO, 2023 (Processed).

Appendix B. Indonesian spices competitiveness

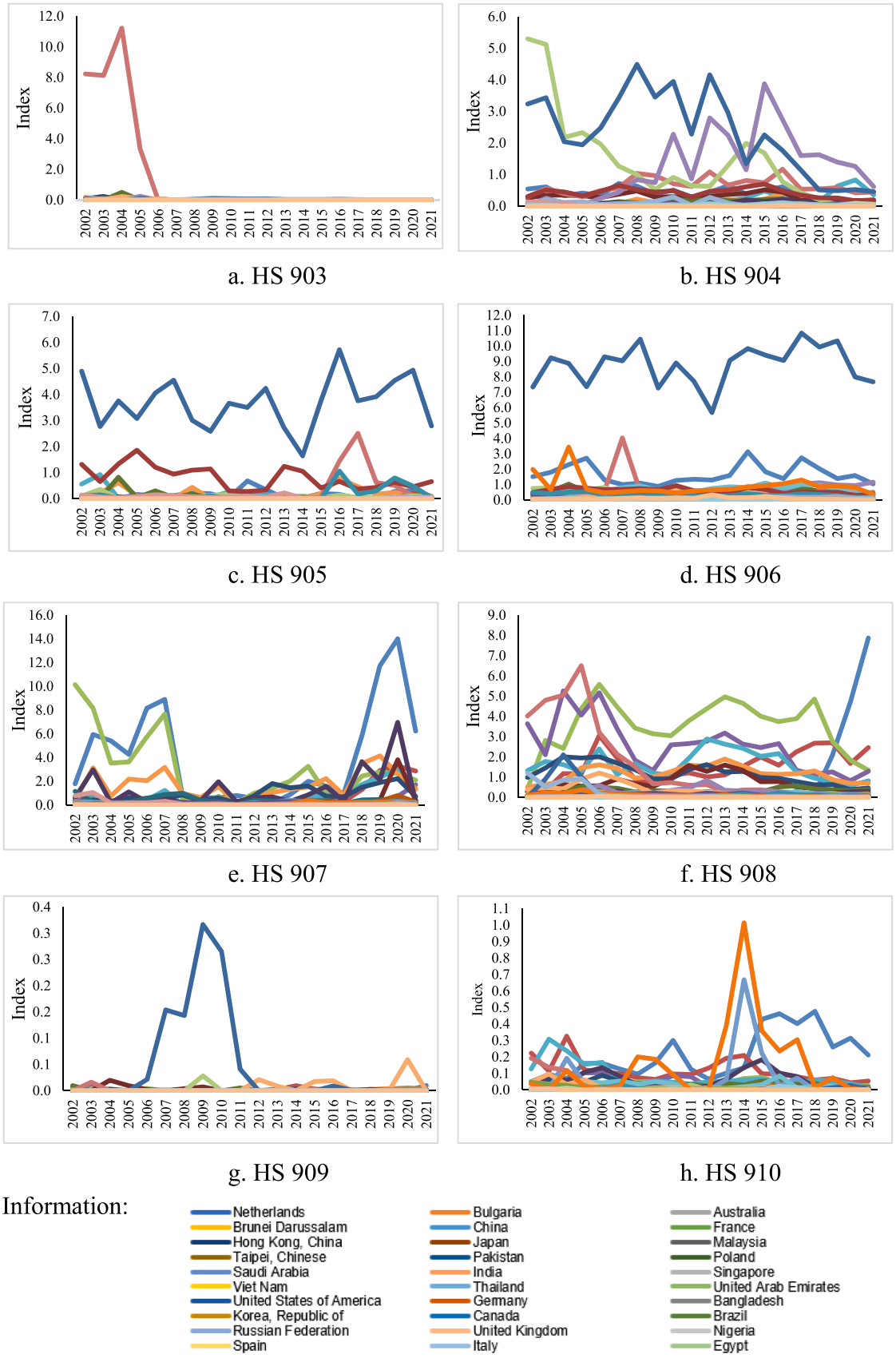


Fig. B.1. Development of Indonesian spice competitiveness in the international market, 2002–2021
Source: UN Comtrade 2023 (Processed).

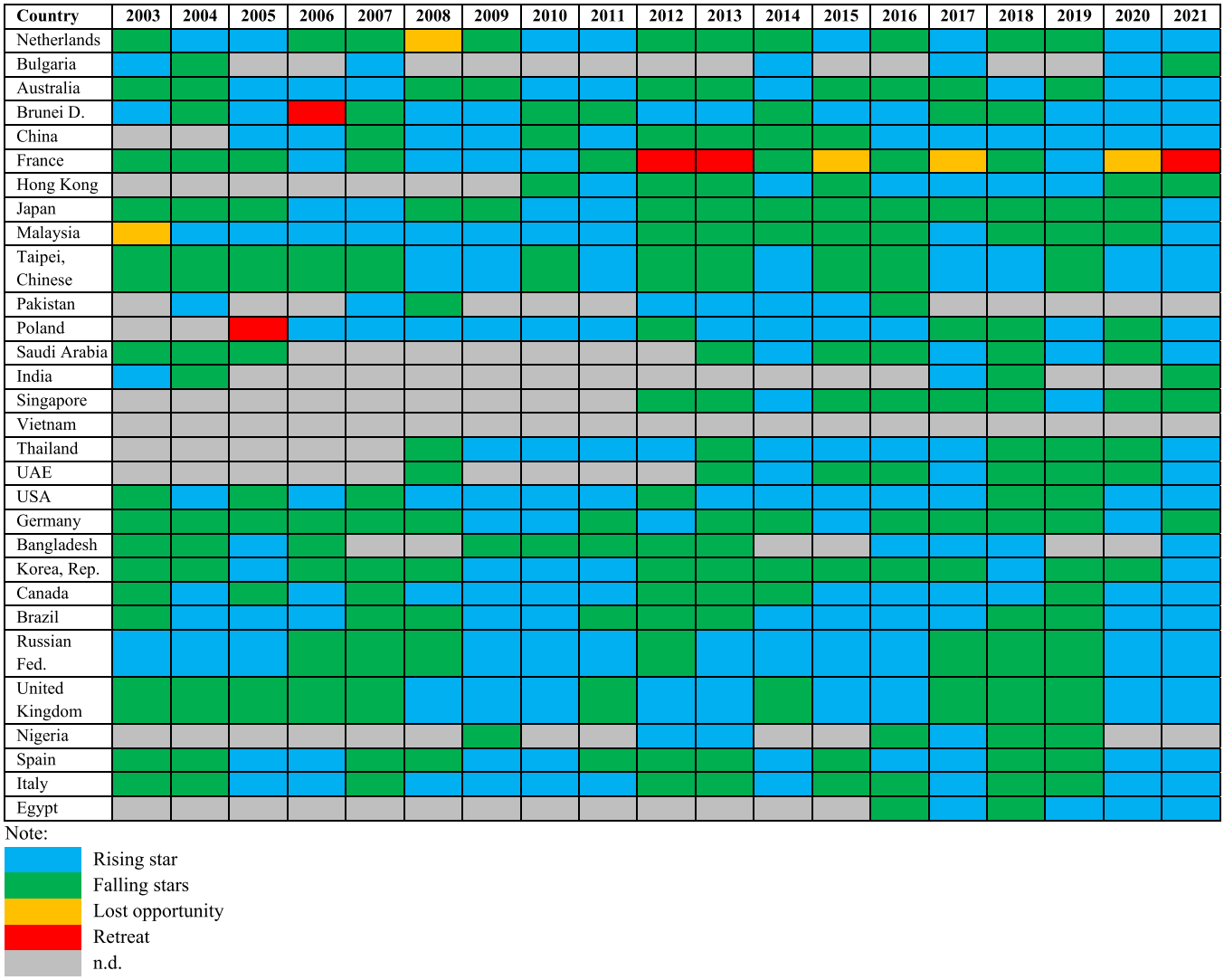


Fig. B.2. Development export product dynamics of Indonesian spices (HS 0903) in the world market, 2003–2021.
Source: UN Comtrade, 2023 (Processed).

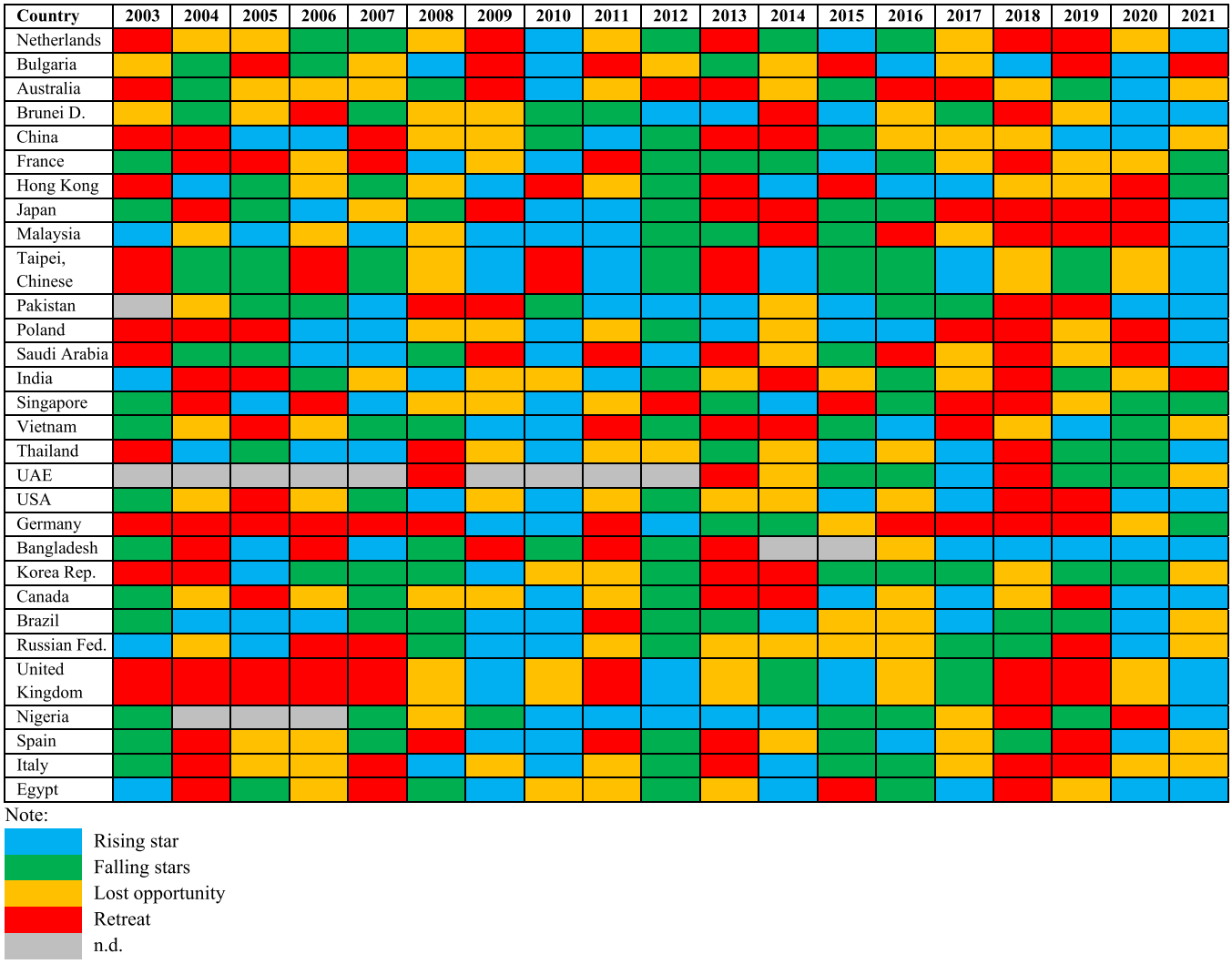


Fig. B.3. Development export product dynamics of Indonesian spices (HS 0904) in the world market, 2003–2021
Source: UN Comtrade, 2023 (Processed).

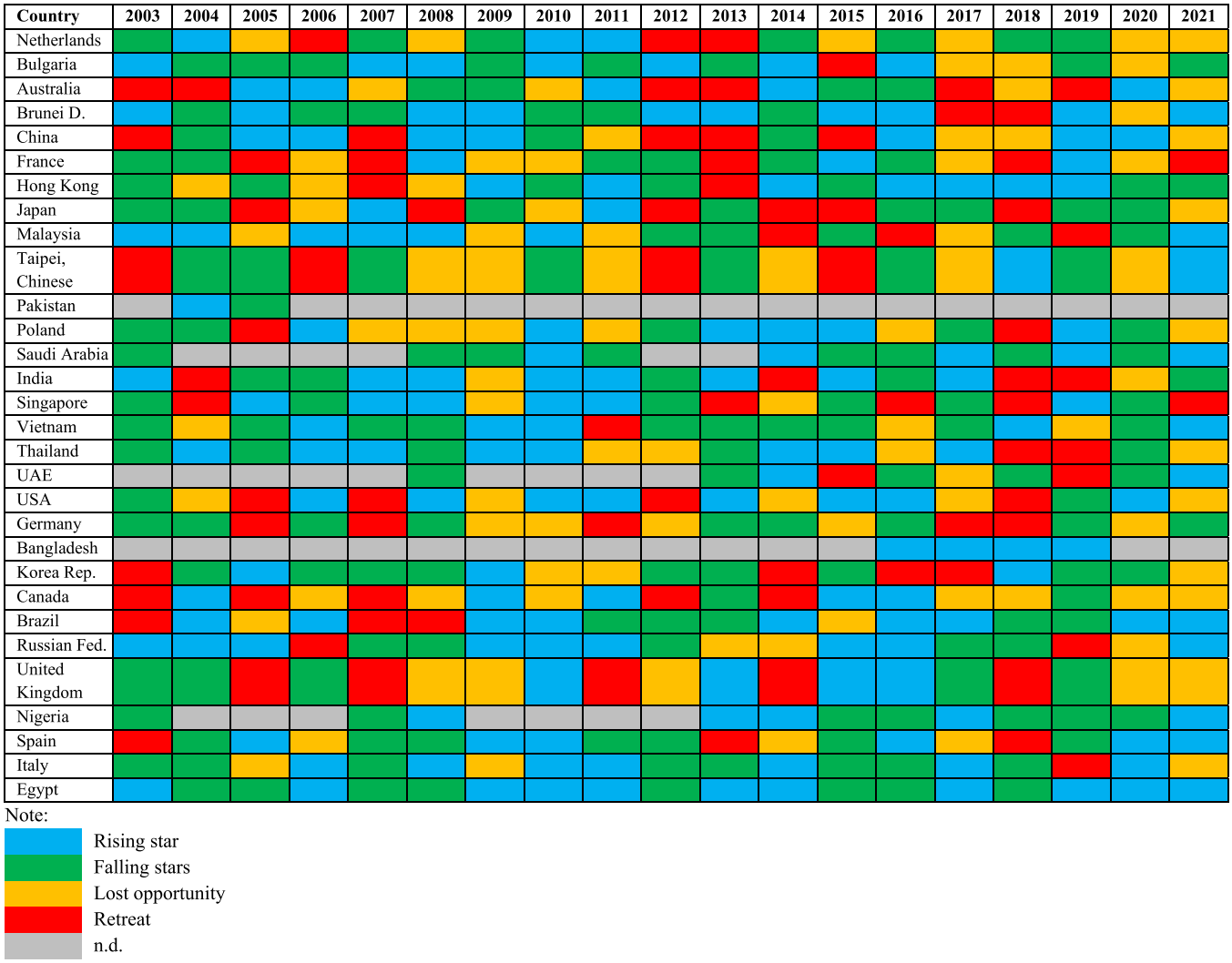


Fig. B.4. Development export product dynamics of Indonesian spices (HS 0905) in the world market, 2003–2021
Source: UN Comtrade, 2023 (Processed).

Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Netherlands																			
Bulgaria																			
Australia																			
Brunei D.																			
China																			
France																			
Hong Kong																			
Japan																			
Malaysia																			
Taipei, Chinese																			
Pakistan																			
Poland																			
Saudi Arabia																			
India																			
Singapore																			
Vietnam																			
Thailand																			
UAE																			
USA																			
Germany																			
Bangladesh																			
Korea Rep.																			
Canada																			
Brazil																			
Russian Fed.																			
United Kingdom																			
Nigeria																			
Spain																			
Italy																			
Egypt																			

Note:

- Rising star
- Falling stars
- Lost opportunity
- Retreat
- n.d.

Fig. B.5. Development export product dynamics of Indonesian spices (HS 0906) in the world market, 2003–2021
Source: UN Comtrade, 2023 (Processed).

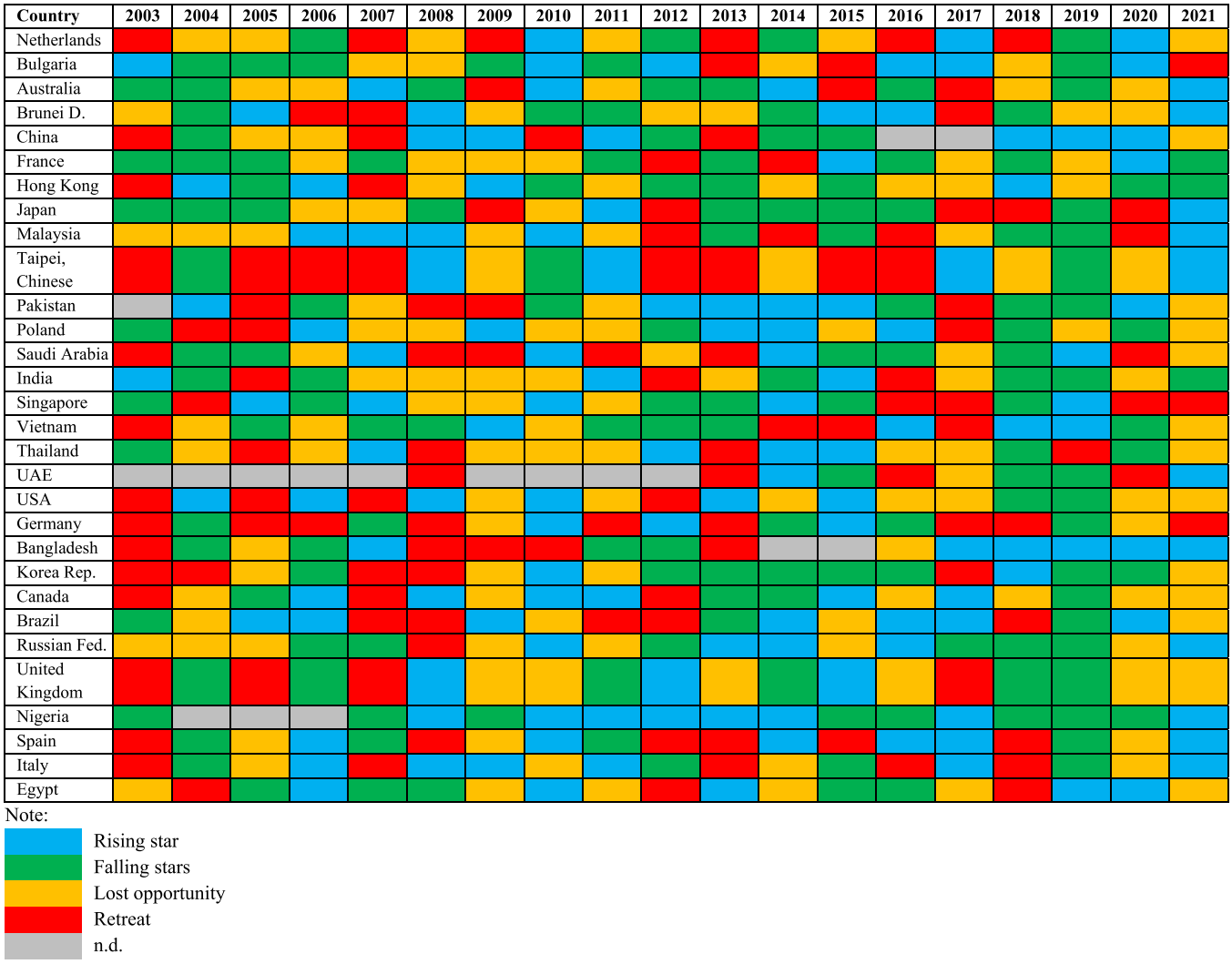


Fig. B.6. Development export product dynamics of Indonesian spices (HS 0907) in the world market, 2003–2021
Source: UN Comtrade, 2023 (Processed).

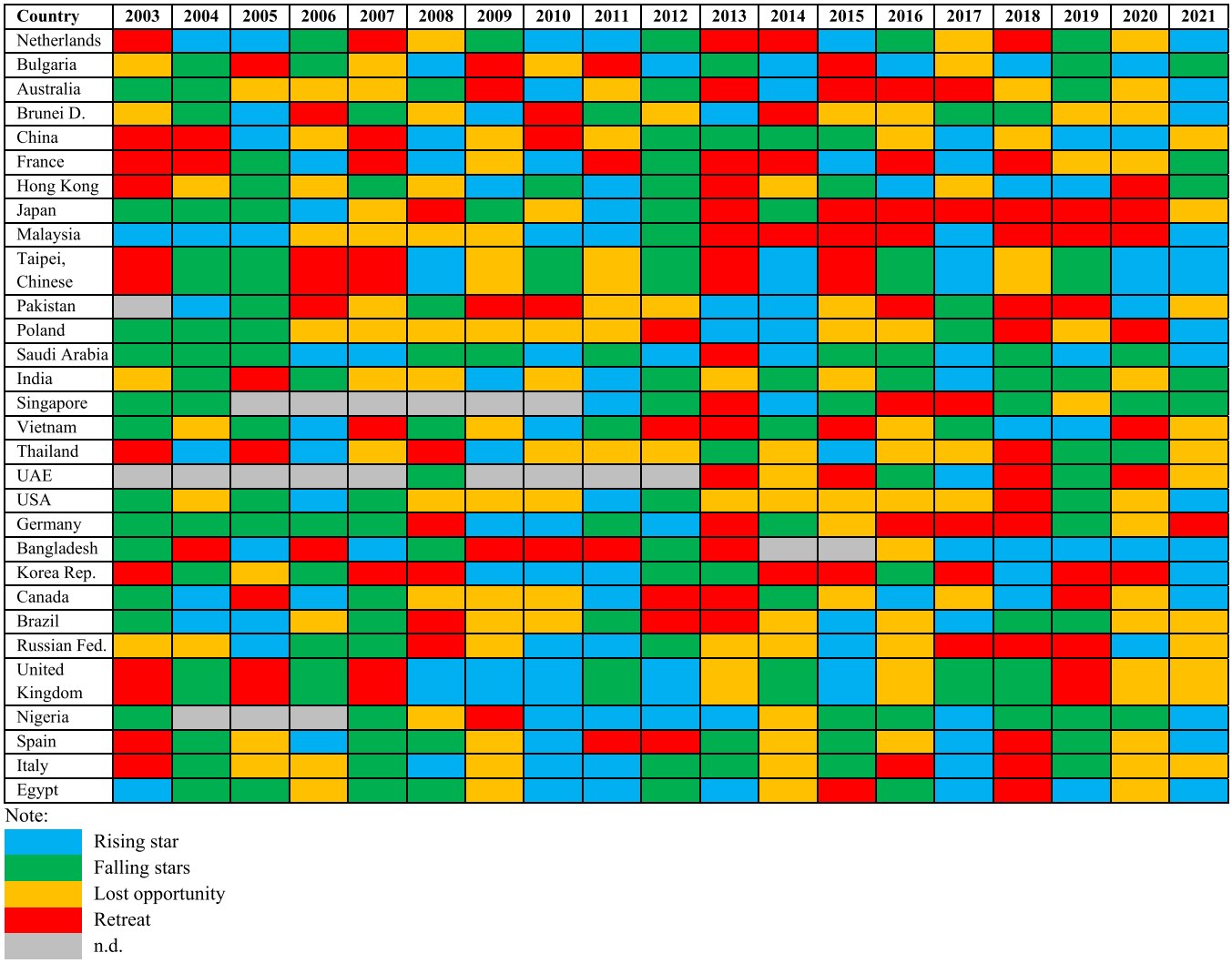


Fig. B.7. Development export product dynamics of Indonesian spices (HS 0908) in the world market, 2003–2021
Source: UN Comtrade, 2023 (Processed).

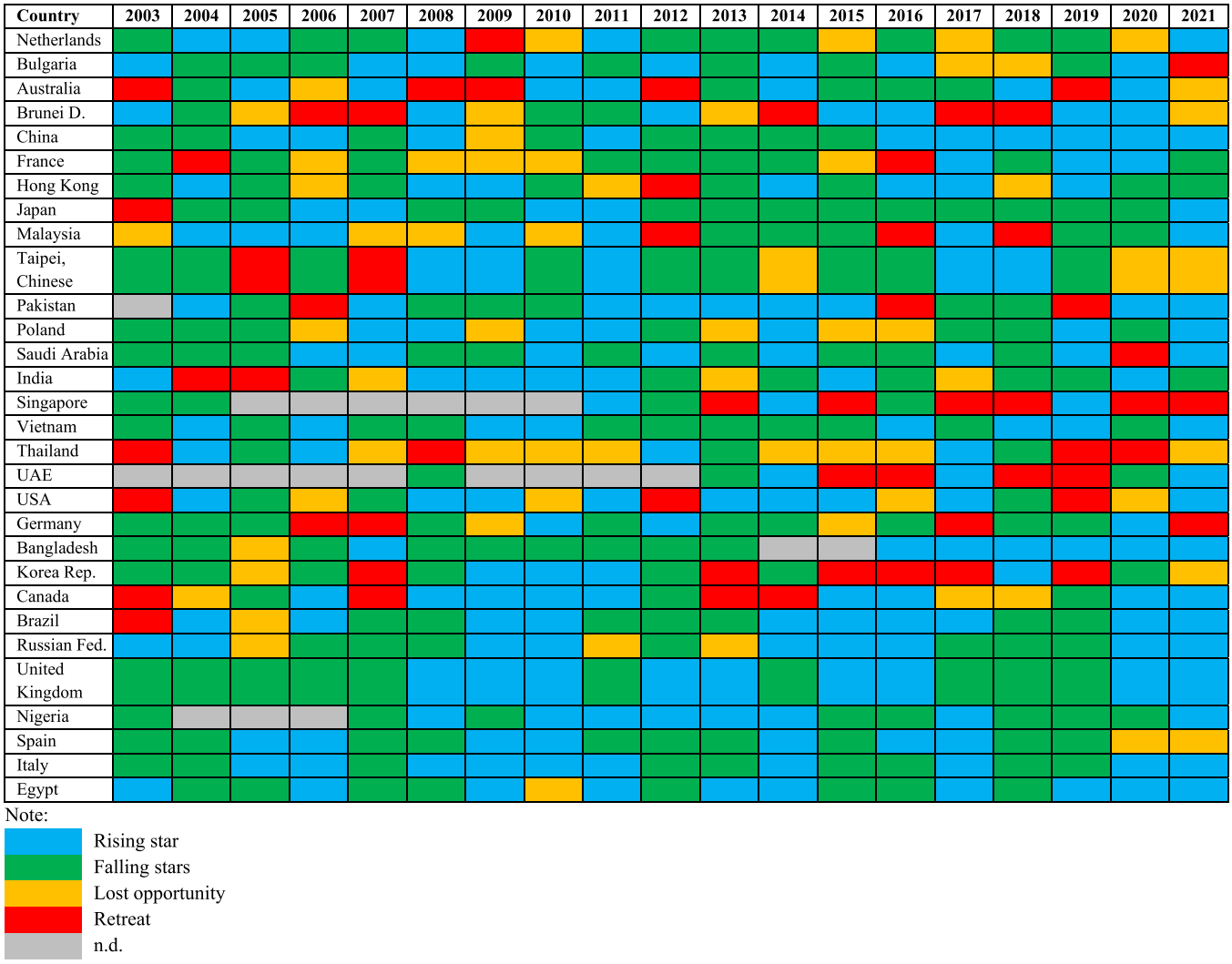


Fig. B.8. Development export product dynamics of Indonesian spices (HS 0909) in the world market, 2003–2021
Source: UN Comtrade, 2023 (Processed).

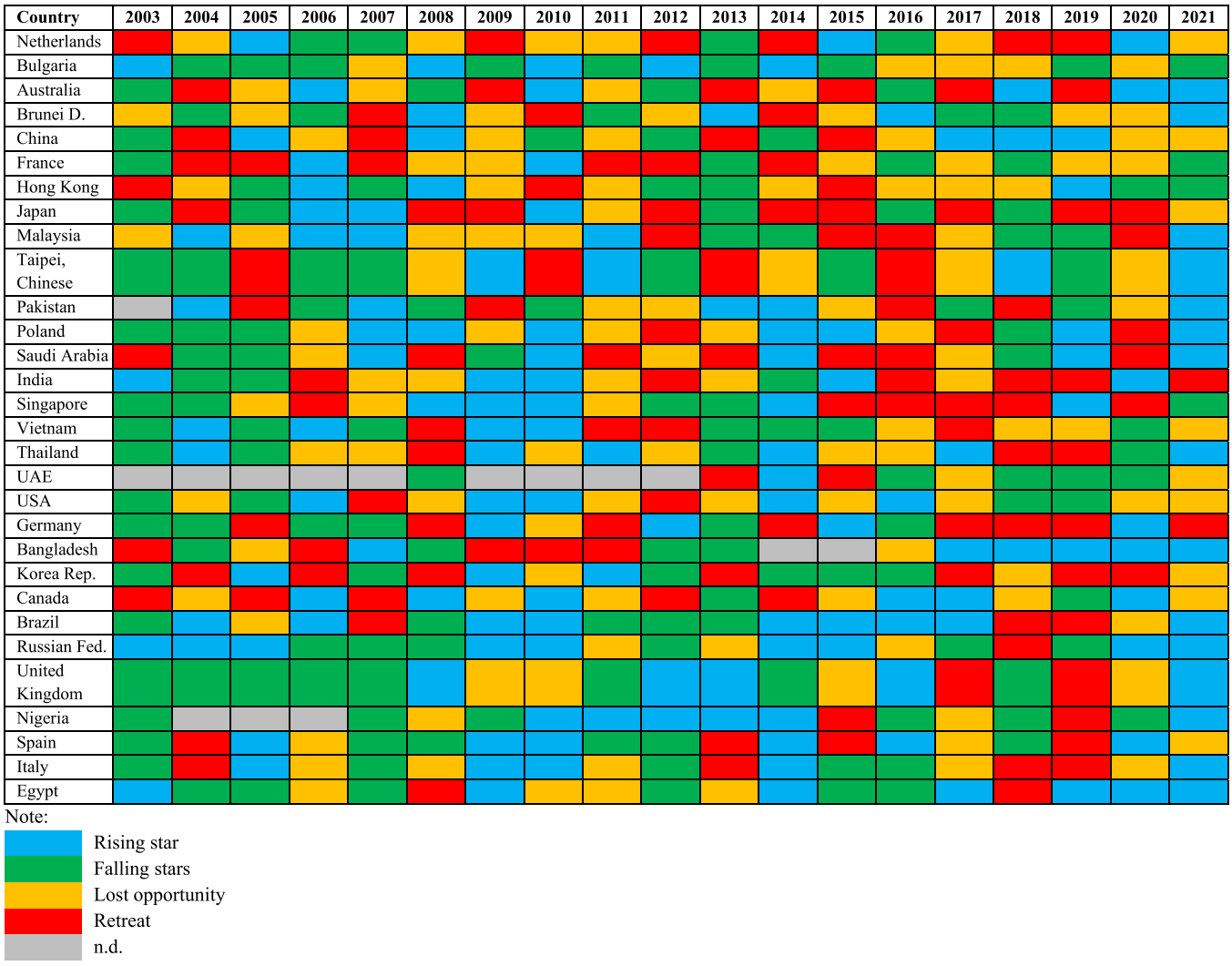


Fig. B.9. Development export product dynamics of Indonesian spices (HS 0910) in the world market, 2003–2021
Source: UN Comtrade, 2023 (Processed).

Data availability

Data will be made available on request.

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