Johansen Co-integration Test & VECM: Spatial Analysis Of Black Pepper Export Price Among Major Producers

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Pepper (*Piper nigrum*)

- originated from western ghats of India
- the oldest and most traded agricultural commodity across the globe
- highly adaptable in tropical countries
- used in various cuisine, medicine and cosmetics

Figure: Pepper on its vine

GLOBAL PRODUCTION

521,705 tones for the year 2022
(Department of Statistics Malaysia, 2023)

GLOBAL CONSUMPTION

224,309 tones for the year 2022
(Department of Statistics Malaysia, 2023)

GLOBAL CULTIVATED AREA

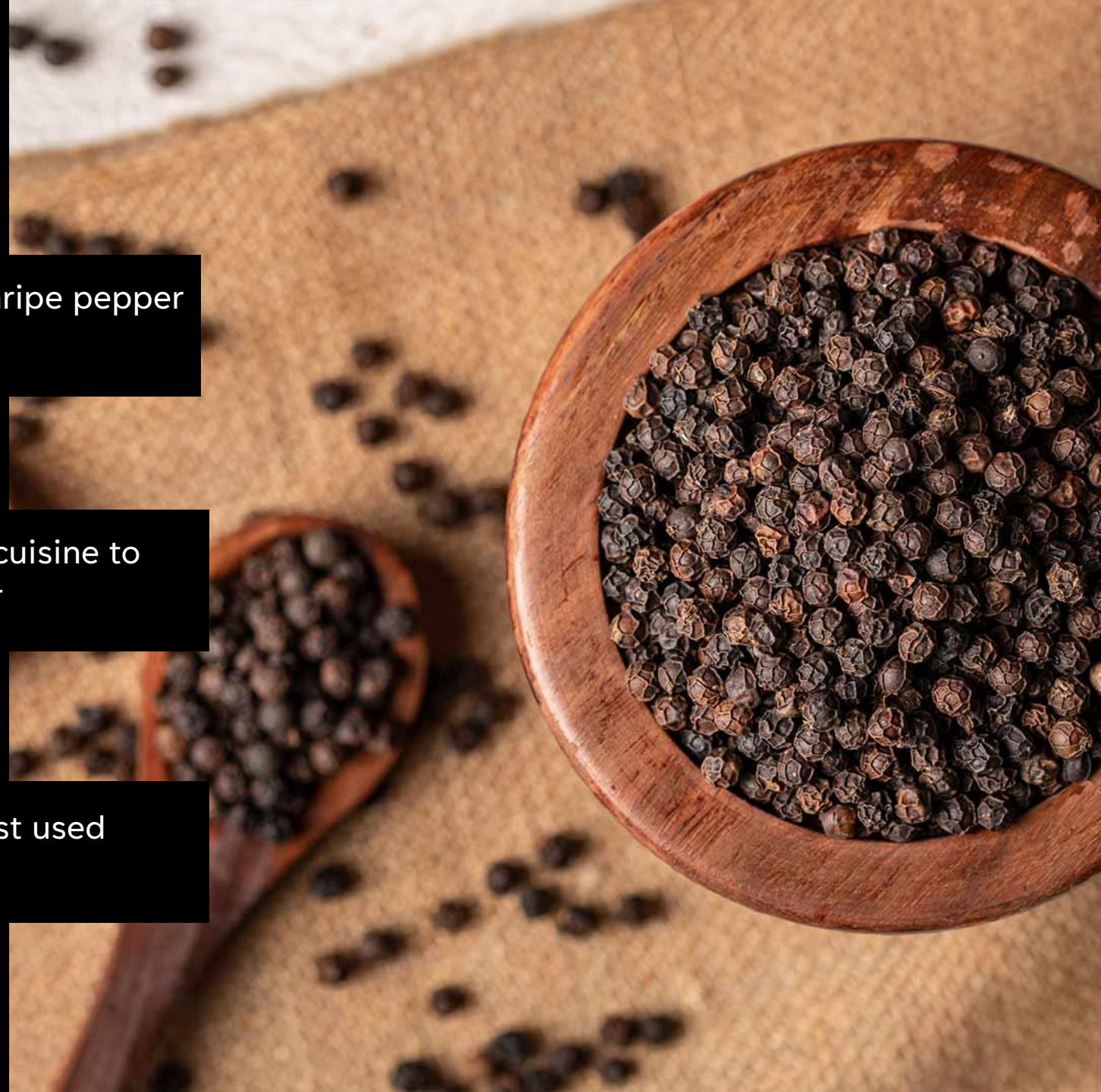
493,400 hectares for the year 2019
(International Pepper Community, 2019)

MARKET VALUE

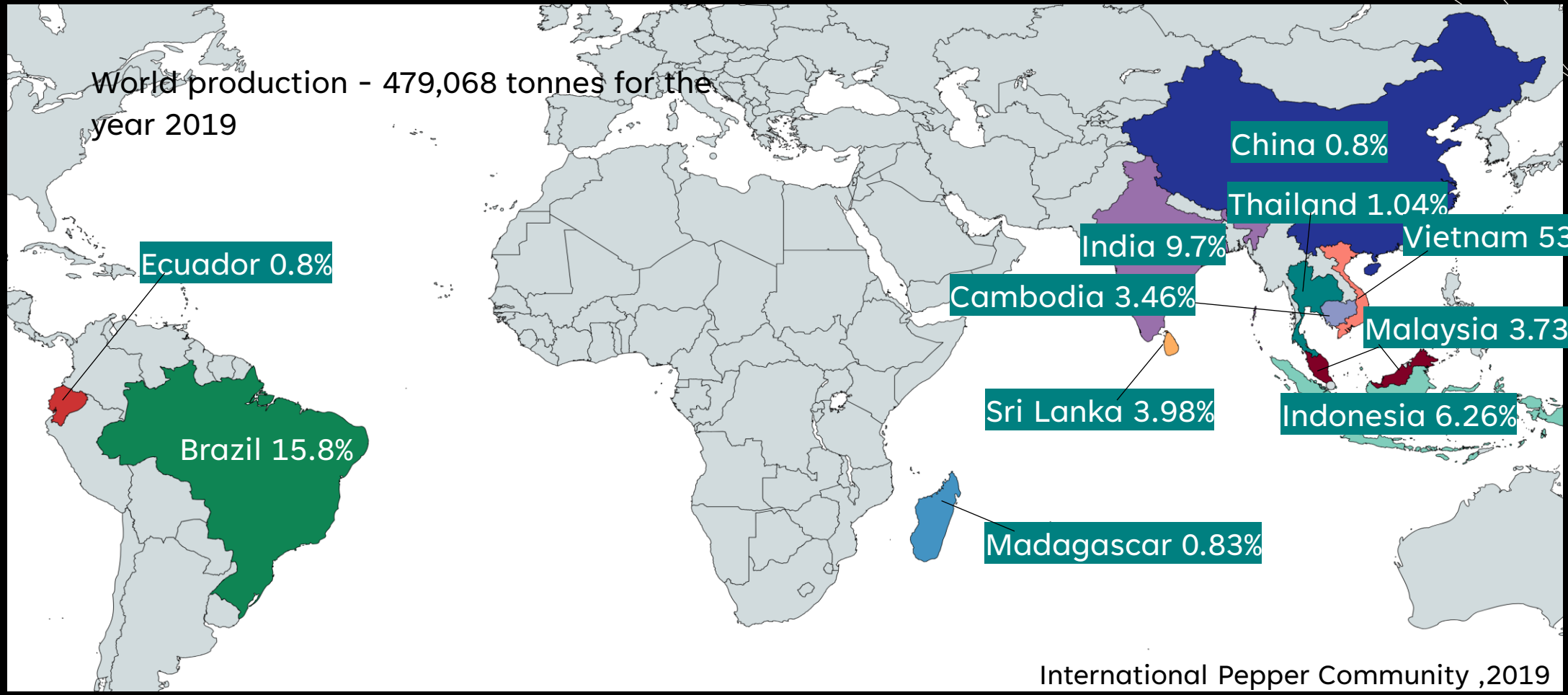
5.43 billion USD for the year 2022
(Global Market Insights, 2023)

BLACK PEPPER

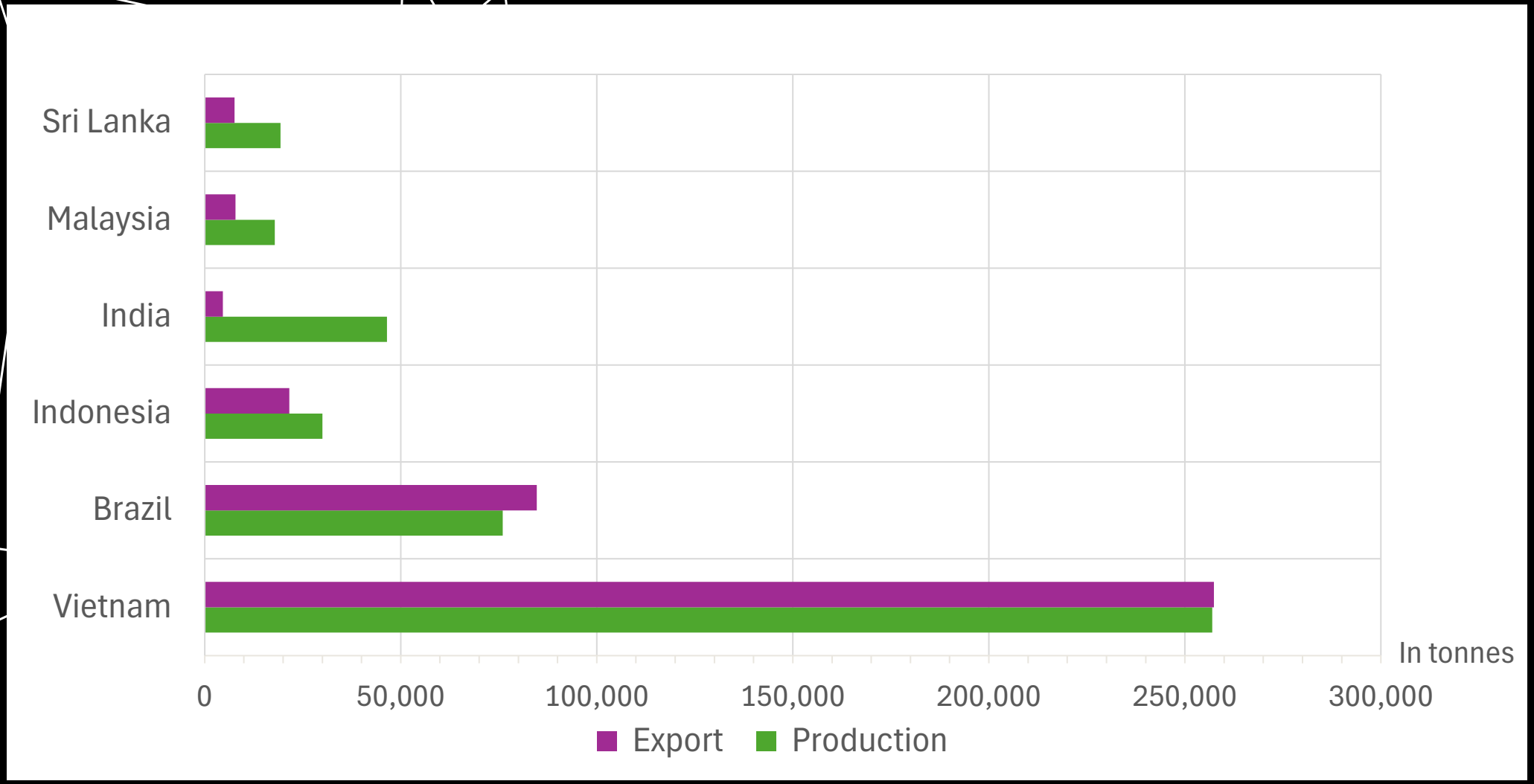
- Made from unripe pepper berries
- Immature berries are harvested and sundried without additives
- Use in various cuisine to amp up flavour
- Gives a pungent spice to dishes
- Known as most used spice



Major Black Pepper Producers



Black Pepper Production and Export for the Year 2019



Black Pepper Price Variation In Markets

- Differences in *geographical positions* of the countries, the *market price* of a commodity may *vary* from one place to another and is a natural market phenomenon (Rashid, Minot, & Behute, 2010).

- This could be due to the *difference in government policy*, *service tax*, *transportation cost*, *competition*, and other variable *cost in production* and *supply chain*.

- Due to *variability in price*, *market integration* across different countries is *essential* to prevent any form of *exploitation or unfair competition* (Rashid et al., 2010).

- *Market integration* is defined as the *similar pattern of movement* in price across different *markets over a long period of time*.

OBJECTIVE/AIM

- It is essential to compare one market price with the other to ensure that the markets are competitive and efficient in the long run.
- The aim of this paper is to determine whether the prices of various black pepper markets with lion shares are parallel to each other.
- To evaluate the equilibrium of export prices of pepper among four countries – India, Indonesia, Malaysia and Vietnam.

LITERATURE REVIEW

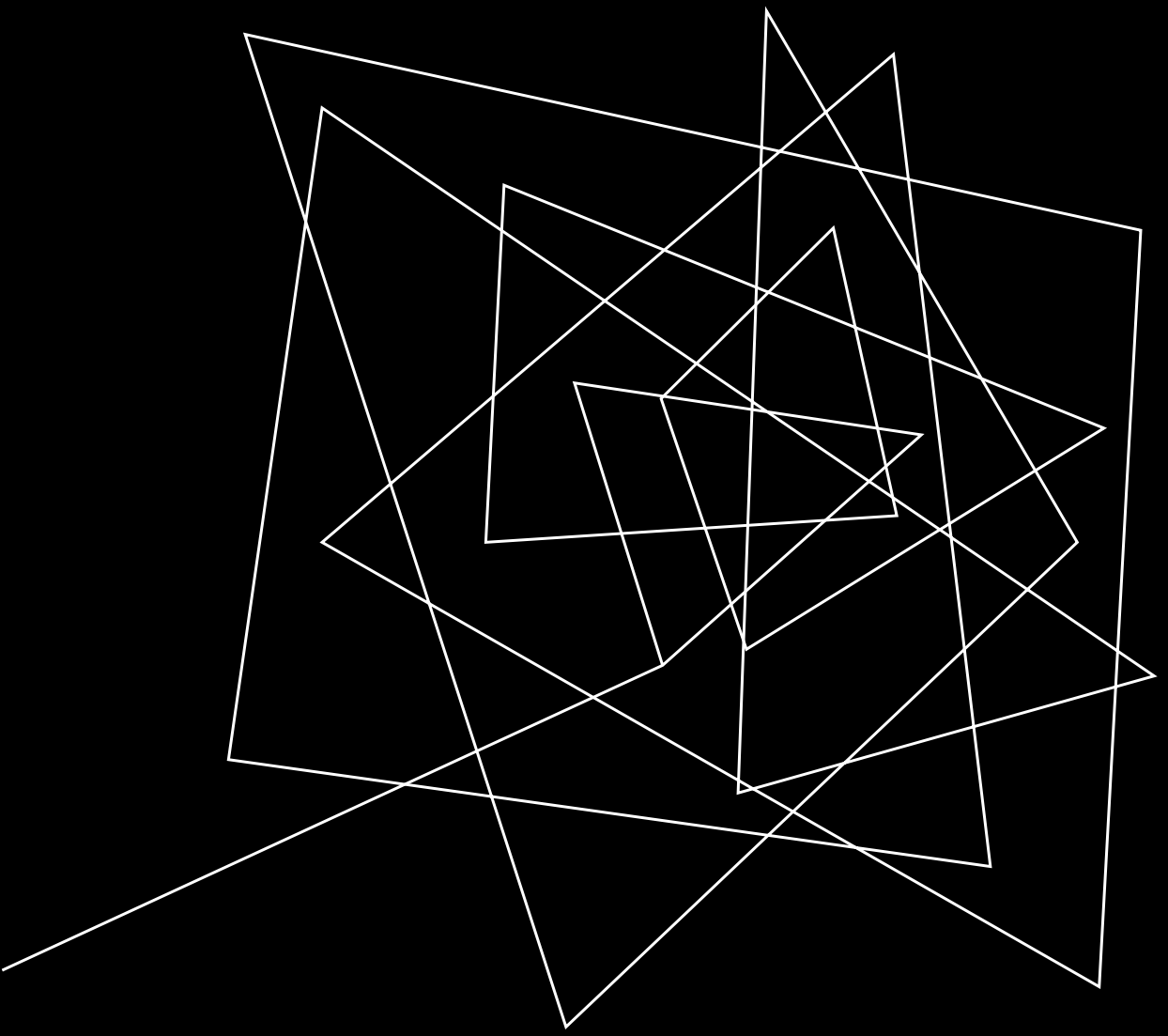
1. Prabha, Sivakumar, Murugananthi, and Palanichamy (2022)
   - studied the market integration of India coffee (Arabica and Robusta) by comparing two significant worldwide markets, New York (for Arabica) and London (for Robusta), as well as three significant Indian local markets, Bangalore, Chennai, and Hyderabad,. The Johansen Cointegration Test and the Vector Error Correction Model (VECM) were used. From the study it was found that only Robusta markets were integrated in the long run.
2. Sivasankari & Vasanthi (2015)
   - studied black pepper domestic and international market from the year 2000 to 2012 using monthly prices data. The Engle-Granger Test was utilised as only 2 variables were tested. From the results, the domestic and international market were at unison suggesting that the markets are efficient and effective in mitigating price instability.
3. Khatkar, Singh, Karwasra, & Bhatia (2013)
   - study the market integration of domestic mustard markets in India using Johansen Cointegration Test and VECM. From the result, among four market tested only two were found to be cointegrated.
4. Pardhi, Singh, Tingre, and Potdar (2022)
   - studied the market integration of mango prices between Varanasi, India (major producing state) and international market. Johansen Cointegration Test and VECM were used to analyse the markets. From the results, both markets were found to be cointegrated.

METHODOLOGY

- Data Collection
  - monthly export price data from 2010 to 2019 were collected from IPC

- Multivariate Johansen Cointegration Test
  - -to investigate the existence of a long-term equilibrium
  - -all time-series integrated in the same order, tested with following unit root test
    - -Augmented Dickey-Fuller
    - -Phillips-Perron
    - -Kwiatkowski–Phillips–Schmidt–Shin

- Vector Error Correction Model
  - -to explore the dynamic (short-run and long-run) cointegration relationship among variables.



RESULT & DISCUSSION

a) Graphical Illustration for the Time Series

- The stationarity of the four different series is being predicted by plotting the graphs in the linear form.
- The plotted time series suggested that there are *stochastic and random walk* trends in the series, indicating to be *non-stationary at level*.

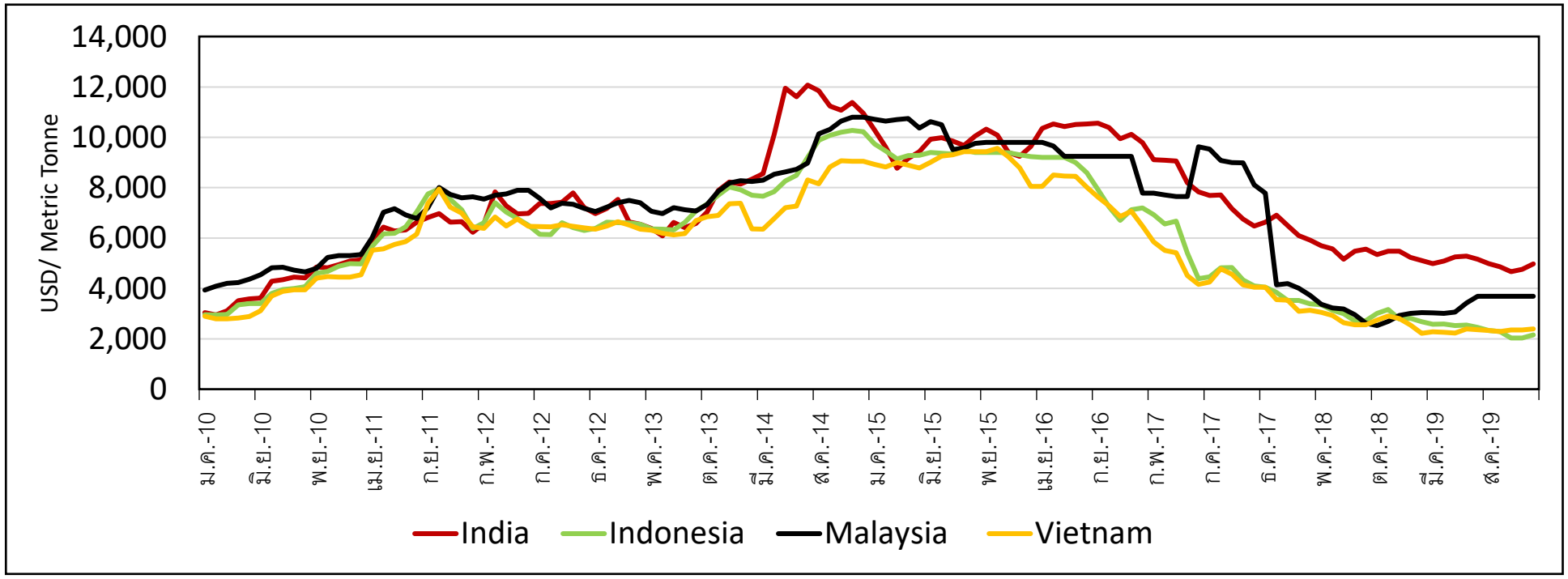


Figure: Black Pepper Export Price for India, Indonesia, Malaysia & Vietnam in USD/Metric Tonne for the year 2010 to 2019.

b) Testing for Unit Root

- All the series has proven to *have a unit root at level* through the test performed. Meanwhile, at *first difference* all the series has indicated to be *stationary at 1 percent significance*.
- Hence, the cointegration test can be carried out, furthering with Vector Error Correction Model (VECM).

Table 1: Unit Root Test for Export Black Pepper Price Series

		ADF		PP		KPSS
Series		**Probability**	**Statistics**	**Probability**	**Statistics**	**LM Statistic**
Vietnam	Level	0.766	−1.651	0.769	−1.643	0.304 ***
	First Difference	0.000	−9.034 ***	0.000	−8.932 ***	0.091
India	Level	0.691	−1.815	0.690	−1.816	0.303 ***
	First Difference	0.000	−9.286 ***	0.000	−9.286 ***	0.061
Indonesia	Level	0.767	−1.649	0.860	−1.385	0.311 ***
	First Difference	0.000	−8.689 ***	0.000	−8.027 ***	0.077
Malaysia	Level	0.816	−1.523	0.766	−1.651	0.277 ***
	First Difference	0.000	−9.431 ***	0.000	−9.565 ***	0.060

*** statistically significant at 1 percent level.

c) Multivariate Cointegration Interpretation

Based on the results in the Table 2, it can be concluded that all the series has at least one or two cointegrating vectors. Yet only the target variable, which is the main producer and exporter (key player) will be focused.

Table 2: Cointegration Test for Export Black Pepper Price Series.

Series	Test Specification	Null Hypothesis (Trace Test)
Vietnam/Indonesia/India/ Malaysia	None	Fail to Reject
	Restricted Constant	Fail to Reject
	Linear Trend	Rejected (r = 1)
	Restricted Linear Trend	Rejected (r = 2)
	Quadratic Trend	Rejected (r = 1)

Note: H_o: Trace test indicates no cointegrating equation at 0.05 level (r = 0); H_1: Trace test indicates 1 cointegrating equation at 0.05 level (r = 1); H_2: Trace test indicates 2 cointegrating equation at 0.05 level (r =2).

d) Multivariate Vector Error Correction Model Result

The VECM dynamics of long-run and short-run coefficient are stated in the table for each series. As described by Juselius (2006), any variables can be selected to form a cointegrating equation as the ratio of the coefficients are the same disregard of the variables chosen. Hence, Vietnam was chosen due to its role as the key producer and exporter of black pepper.

Table 3: VECM for Export Black Pepper Price Series

Series	Long-Run Relationship	Short-Run Relationship	
	Normalized Cointegrating Coefficients	**Error Correction Term (ECT)**	***p*-Value**
ECT Coefficient (CoInt.Eq)	-	−0.187 ***	0.004
Vietnam	1.000	0.253 *	0.062
Indonesia	−1.280	−0.027	0.853
India	0.360	0.064	0.574
Malaysia	0.098	−0.031	0.672
Intercept	−0.685	−0.000	0.820

*** statistically significant at 1 per cent level, * statistically significant at 10 per cent level.

Cointegrating equation:

1.000 × Vietnam − 1.280 × Indonesia + 0.360 × India + 0.098 × Malaysia

e) Post-Estimation Diagnostic Analysis

The validity of each model has been tested using the residuals. Post estimation of the series includes test for serial correlation, heteroskedasticity, normality of disturbance and specification error. The results of the tests for the series are shown in Table 4.

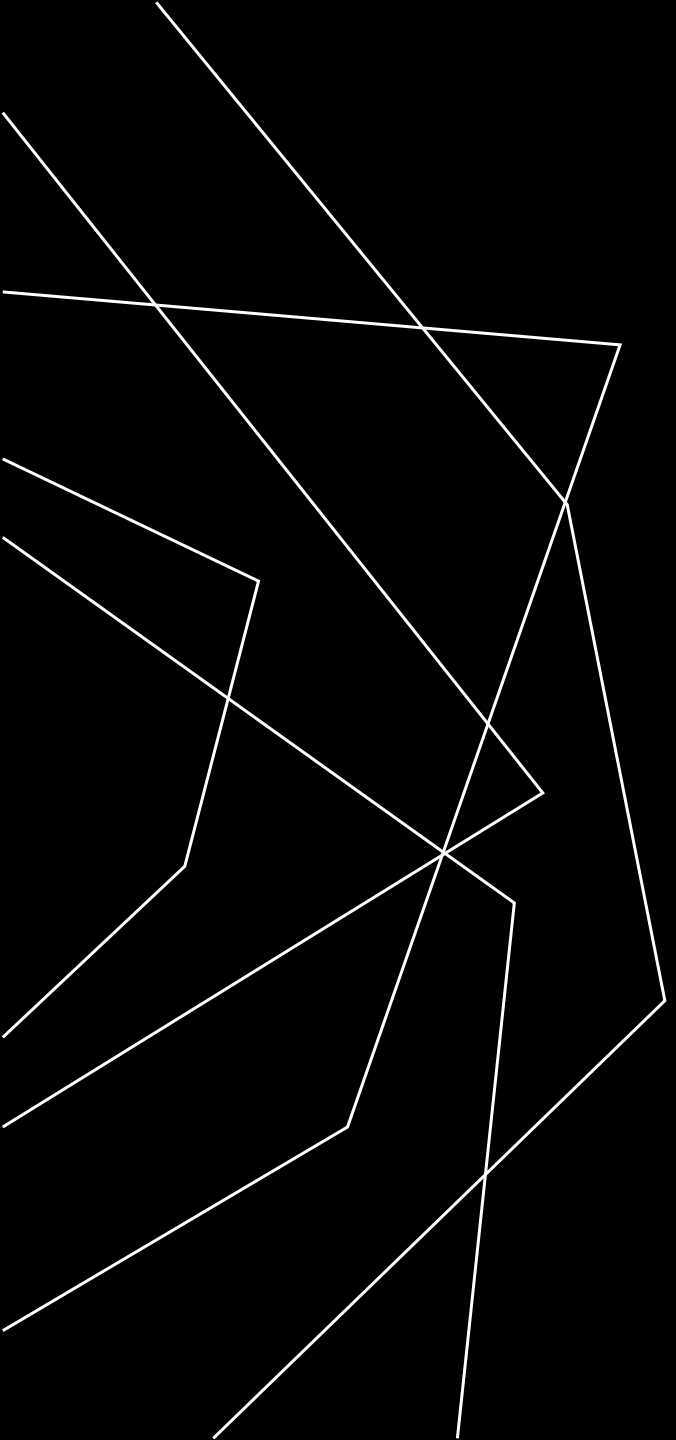
Table 4: Post-Estimation Analysis for Black Pepper Export Price.

Diagnostic Test	**Null**	***p*-Value**	**Conclusion**
Breusch-Godfrey Serial Correlation LM Test Chi-Square Probability	No serial correlation	0.7934	Null Accepted
Autoregressive Conditional Heteroskedasticity (ARCH) Test	No conditional heteroskedasticity	0.2901	Null Accepted
Jarque–Bera Normality Test Probability	Disturbance is normally distributed	0.0012	Null Rejected
Ramsey's Regression Equation Specification Error Test	No specification error	0.0511	Null Accepted

CONCLUSION

From the analysis conducted, the price series have revealed that there is presence of mutual interaction among the selected pepper markets despite an obvious diversification in prices among them. The co-movement amongst the market have proved that the goal or hypothesis of ‘cointegrated market’ has been achieved.

The study also supports the previous by Sivasankari and Vasanthi (2015), Sinharoy and Nair (1994), Hema et al. (2007) and Sabu et al. (2019).



THANK YOU