Original Research Article

Identification of Mutation Point and Trend in Export of Indian Groundnut

ABSTRACT

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| The study aimed to identify structural mutation points and analyze long-term trends in India’s groundnut exports from 2005 to 2024 using time series data on export quantity and value sourced from Trade Map. Non-parametric methods, including Pettitt’s test, Buishand’s range test, and the Standard Normal Homogeneity (SNH) test, were applied to detect mutation points, while trend significance and magnitude were assessed using the Mann-Kendall test and Sen’s slope estimator. All three tests consistently identified 2010 as a major mutation year for both export quantity and value. Sen’s slope analysis indicated the highest growth during the full study period, with export quantity increasing by 23.84 thousand tonnes/year and value by 35.24 million USD/year. Trend models revealed that the quadratic model best explained the variation in exports. The findings highlight a structural shift post 2010 and emphasize the importance of strengthening trade strategies and infrastructure to sustain and enhance India’s groundnut export performance in the global market. |

*Keywords: Groundnut exports; Mutation point; Trend analysis; SNH test; Sen’s slope*

1. INTRODUCTION

Groundnut (*Arachis hypogaea L*.) is a self-pollinating allotetraploid legume crop that belongs to the Fabaceae family. Groundnut, also known as peanut, is recognized as the third most significant oilseed crop globally. It holds great significance due to its high-quality edible oil and protein content. Moreover, the crop’s byproducts, namely oilcake and haulms, play a crucial role as valuable animal feed, further enhancing its economic value in the agricultural industry. China is the largest groundnut producer in the world, followed by India and Nigeria (Sajindra et al.,2023). Groundnut is an immensely significant food and oil crop, cherished for its exceptional nutritional value. The kernels of groundnut are a nutritional powerhouse, boasting a remarkable composition of protein (approximately 25 per cent), oil (about 50 per cent), antioxidants, essential minerals, and vitamins. Beyond being a staple food, groundnut is vital to the oil industry due to its high oil content and heart-healthy fats. Rich in antioxidants like resveratrol, it offers numerous health benefits, including reducing oxidative stress and inflammation. Additionally, groundnut supports sustainable agriculture by improving soil fertility through nitrogen fixation and promoting biodiversity, making it an ideal rotational crop (ICRISAT, 2024). India showcased its agricultural prowess in the fiscal year 2022–2023 by exporting oilseeds valued at Rs. 673,525.23 lakhs (US$ 831.6 million), with groundnut production being a major contributor to this accomplishment. China is the largest groundnut producer in the world, followed by India and Nigeria. India exports groundnuts to more than 132 nations worldwide through a broad network. Significantly, countries like the Philippines, Vietnam, Malaysia, and Indonesia (Vignesh and Selvakumar, 2024). In recent years, the export performance of Indian groundnut has exhibited significant fluctuations influenced by domestic production variability, global market dynamics, trade policies, and climatic factors. Identifying long-term trends and critical structural changes known as mutation points in the export pattern is essential to understand these shifts and respond strategically. Mutation points reflect key turning points in the time series that may result from policy changes, economic events, or external shocks, and their identification can provide valuable insights into the stability and direction of trade flows and Identifying export trends helps businesses anticipate global demand shifts and optimize production and marketing strategies. It also enables policymakers to strengthen trade policies and boost economic growth through targeted support (Maheta and Rank, 2017; Ghadiya and Maheta, 2018; Bharodia et al., 2025; Maheta et al., 2025). Analysing these patterns is vital for exporters, policymakers, and stakeholders to evaluate the effectiveness of existing strategies and to anticipate future challenges. Therefore, this study aims to investigate the trend and detect mutation points in India’s groundnut export data using statistical methods such as trend analysis and structural break tests, thereby contributing to evidence-based decision-making for sustained export growth.

2. methodology

**2.1 Data**

The present study deals with identification of mutation point and trend in export of groundnut. To full fill the objectives of the study, a secondary data on export quantity and export value of groundnut from India for the period 2005 to 2024 have been obtained from Trade map. The time series data was analyzed using the XLSTAT trial version.

**2.2 Analytical Tools**

**2.2.1 Identification of mutation point**

The purpose of mutation point analysis, also known as change point analysis, is to detect significant structural shifts or turning points in the time series data of groundnut exports. Identifying these change points is essential for understanding the impact of external factors such as policy changes, trade agreements, climatic conditions, or market disruptions that may alter the export performance over time (Oganja *et al.,* 2024). Various researchers have employed different statistical techniques to identify such structural breaks in agricultural and trade-related time series data. In this study, appropriate statistical methods have been employed to detect mutation points in the groundnut export time series. This helps in identifying periods of significant change and understanding the underlying causes, thereby assisting policymakers and stakeholders in framing effective export strategies.

***2.2.1.1 Pettitt test***

Pettitt test method is a non parametric test method based on the rank to detect abrupt changes in the mean of the variables. This method is commonly applied to detect single change point in time series data.

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Test statistic K and the associated confidence level (ρ) for the sample length (n) may be described as

When ρ is smaller than the specific confidence level, the null hypothesis is rejected. The approximate significance probability (p) for a change-point is defined as given below:

It is obvious that where a significant change point exists, the series is segmented at the location of the change point into two subseries. The test statistic K can also be compared with standard values at different confidence level for detection of change point in a series (Pettitt, 1980).

***2.2.1.2 Buishand range test***

The adjusted partial sum (Sk), that is the cumulative deviation from mean for kth observation of a series x1, x2, x3 ….xk…. xn with mean can be computed using following equation:

The significant breakpoint can be computed by the method of rescaled adjusted range (R) if the ≅ 0, in this case, R is defined by

Here, R denotes change point value (Buishand, 1982).

***2.2.1.3. Standard Normal Homogeneity (SNH) test***

Test statistic () is used to compare the mean of first n observations with the mean of the remaining (n-k) observations with n data points

Z1 and Z2 can be computed as:

Where, and are the mean and standard deviation of the series. The year k can be considered as change point and consist a break where the value of Tk attains the maximum value. To reject the null hypothesis, the test statistic should be greater than the critical value, which depends on the sample size (n) is given.

For confirmation of mutation point, the result of at least two tests of three tests should be same. That point will be considered as the true mutation point. The significance will be tested for 1 per cent and 5 per cent probability levels (Alexandersson, 1986).

**2.2.2 Trend analysis**

The presence of a significant trend in the time series was tested using the Mann-Kendall test, and its magnitude was subsequently estimated using Sen’s slope estimator.

***2.2.2.1 Mann-Kendall test***

The main task in trend analysis is to assess the monotonic fluctuations in long-period data sets, which can be well performed through a non-parametric linear trend test, i.e., the Mann-Kendall test. The test statistic of the Mann-Kendall test (S) is expressed as

Where, n is the total length of data, xi and xj are two generic sequential data values, and function sign(xi–xj) assumes the following values

Under this test, the statistic S is approximately normally distributed with the mean E(S) and the variance Var(S) can be computed as follow:

Where, n is the length of time series, and t is the extent of any given tie and Σt denotes the summation over all tie number of values. The standardized statistics Z for this test can be computed by the following equation:

Here, the detection of a trend depends on the value of Z. For example, if the Z value is zero, it means that the data does not follow any trend; if the value of Z is positive, it means that the trend is in an upward direction; and if the value of Z is negative, it means that the trend is in a downward direction (Mann 1945; Kendall 1975).

***2.2.2.2 Sen’s slope estimator***

Assuming that the time series data exhibits a significant trend, i.e., either a positive or a negative trend, then the Sen’s slope estimator can be estimated. It means the slope of the trend line or the average rate of change of the trend. The slope of the trend is estimated using the following test statistic:

**Ti =** for i= 1,2,3… N

Here, yj and yk are the data values at time j and k (j > k), respectively. The median of these N values of Ti is the Sen’s slope estimator, which is defined as follows:

β

Here, if the value of β is positive, it means that the trend is in a rising pattern, and if the value of β is negative, it means that the trend is in a declining pattern (Sen, 1968).

**2.2.3 Statistical models for trend analysis**

In order to analyze the trend pattern in export of groundnut, the trend values will be computed by fitting linear, exponential and quadratic models (Arunachalam and Balakrishnan, 2012).

***2.2.3.1 Linear Model***

**yt = a + bt**

Where yt denotes the time series value at time 𝑡. The values of constants 𝑎 and 𝑏 are obtained by using the principle of least squares on solving the following normal equations:

Where, n represent the number of observed values.

***2.2.3.2 Exponential model***

**Yt= aebt**

Taking natural log on both sides of above equation, we have

loge yt = loge a + bt logee

where,

Yt = loge yt ,

A=loge a, and logee = 1

The normal equations for estimating the values of 𝐴and 𝑏 are as follows:

Finally, the value of 𝑎is obtained on using

a = antilog (A)

***2.2.3.3 Quadratic model***

**Yt = b0 +b1t + b2t2**

Where,

Yt = the value of the data at time t

b0 = A constant

b1 and b2 = Coefficients for time

3. RESULT AND DISCUSSION

The data of groundnut exports from India procured from the Trade Map website covering the period from 2005 to 2024, was collected and summarized in Table 1. This table presents the descriptive statistics for two key export variables, quantity and value. The quantity of groundnuts exported, measured in tonnes, ranges from a minimum of 180,851 tonnes to a maximum of 760,764 tonnes, with an average export volume of 517,134.45 tonnes. The standard deviation of 181,845.63 tonnes reflects noticeable variability in the quantity exported each year, likely influenced by changes in domestic production, global demand, pricing, and policy interventions. The value of groundnut exports, measured in thousand USD, shows a wide range from a low of 109,447 thousand USD to a high of 941,047 thousand USD. The mean export value stands at 569,546.60 thousand USD, with a substantial standard deviation of 260,103.40 thousand USD, indicating significant annual fluctuations. These fluctuations may be attributed to variations in international market prices, currency exchange rates, and trade agreements. Overall, the data highlights considerable variability in both the quantity and value of groundnut exports from India over the years, pointing to the dynamic nature of the export market and its sensitivity to multiple external and internal factors.

**Table 1. Summary statistics of groundnut exports during 2005 to 2024 from India**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable** | **Minimum** | **Maximum** | **Mean** | **Std. deviation** |
| **Quantity(tones)** | 180851.000 | 760764.000 | 517134.450 | 181845.633 |
| **Value (thousand**  **USD)** | 109447.000 | 941047.000 | 569546.600 | 260103.404 |

In the current study, the three non-parametric tests Pettitt’s, SNH and Buishand’s range tests have been applied to identify the mutation point for year wise export quantity and export value of groundnut from 2005 to 2024. From Table 2, the result exhibits for the export quantity variable, Pettitt’s test, Buishand range tests detected a significant change point around 2010, and SNH test showed 2009 as mutation point with all tests showing statistically significant result at the 1 per cent level. The year 2010 thus appears to mark a notable structural shift in the quantity of groundnut exported from India. This turning point could be attributed to a combination of factors such as favorable trade policies, increased international demand, or improvements in production and processing technology. Additionally, a significant depreciation of the Indian rupee around that period might have enhanced export competitiveness. Similarly, for export value, all three tests pointed to 2010 as a significant mutation year. Pettitt’s test revealed a significant change point at the 1% level (*P = .004*), whereas the Buishand and SNH tests both showed significance at the 1% level (*p = .001* and *P = .000* respectively). The alignment of mutation points in export value and quantity suggests that the underlying drivers affected both dimensions of trade. This structural break around 2010 may reflect a realignment in global market positioning of Indian groundnut exports, possibly due to quality improvements, entry into new markets, or policy incentives such as export subsidies and minimum support price mechanisms.

**Table 2 Analysis of mutation point of groundnut exports during 2005 to 2024 from India**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Variable | Pettitt’s test | | Buishand range test | | SNH test | |
| Change point | *P*-value | Change point | *P*-value | Change point | *P*-value |
| Export quantity | 2010\*\*\* | .006 | 2010\*\*\* | <.0001 | 2009\*\*\* | .001 |
| Export value | 2010\*\*\* | .004 | 2010\*\*\* | .001 | 2010\*\*\* | .000 |

Note: *\*, \*\* and \*\*\* indicate significance at 10%, 5% and 1% level of significance respectively.*

After, identification of mutation point, the whole time series (2005-2024) were divided into three parts i.e., first-time series (before mutation point), second-time series (after mutation point) and whole time series (2005-2024). For segmentation period of groundnut export quantity, mutation point was identified as 2010. Mutation point for both export quantity and export value of groundnut was observed as 2010. Hence, the time series 2005-2009 and 2010-2024 were identified as first-time series and second- time series, respectively as shown in table 3. Sen’s slope estimators have been used to compute the degree of monotonic trends. Further, the trend analysis was extended based on segmentation time period. Here, the M-K test has been applied to analysis the significant monotonic trends for indicator wise and segmentation period wise for groundnut exports.

From the MK-test and Sen’s slope estimator analysis, it is observed that statistically significant (p < .01) growth in export quantity and export value of groundnut was experienced during the overall time series of 2005–2024. The highest significant increase in export quantity was 23,837.53 tonnes/year, while export value increased at 35,235.98 thousand USD/year during the same period. However, the trends in the sub-periods 2005–2009 and 2010–2024 were statistically non-significant (p > .05), indicating fluctuations and instability in the export pattern during those segments. During the first sub-period (2005–2009), export quantity and value increased at the rate of 17,028.50 tonnes/year and 48,026.50 thousand USD/year, respectively, but the trends were not statistically significant. Similarly, during the second sub-period (2010–2024), export quantity and value increased at a much lower rate of 6,205.71 tonnes/year and 16,493.50 thousand USD/year, respectively, also statistically non-significant as shown in Table 3.

**Table 3 Mann-Kendall test and Sen’s slope estimators of groundnut exports during 2005-2024 from India**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable** | **Segmentation**  **year** | **MK-test** | **Kendall’s**  **Tau** | ***P*-value** | **Sen’s**  **slope** |
| Export quantity  (tonnes) | 2005-2009 | 4 | 0.400 | .462 | 17028.500 |
| 2010-2024 | 19 | 0.181 | .373 | 6205.714 |
| 2005-2024 | 98 | 0.516*\*\*\** | .002 | 23837.531 |
| Export value  (thousand USD) | 2005-2009 | 6 | 0.600 | .221 | 48026.500 |
| 2010-2024 | 23 | 0.219 | .276 | 16493.500 |
| 2005-2024 | 104 | 0.547*\*\*\** | .001 | 35235.976 |

The whole-time series result showed an upward and significant (p < .01) trend in both export quantity and export value, highlighting long-term growth potential in groundnut exports from India. Thus, export value showed a relatively higher increasing trend as compared to export quantity during all three segments. The statistical analysis showed that both export quantity and value experienced an overall positive growth trend during the study period, although the segmented periods showed variations. Overall, the data indicate significant and consistent increases in groundnut export quantity and value over the past two decades, especially during the full-time series. The trends reflect improvements in export performance, global demand, and trade facilitation policies favouring India’s groundnut sector.

Table 4 presents the coefficient of determination (R²) values for linear, exponential, and quadratic models fitted to the data on export quantity and export value of groundnut from India. The R² values serve as indicators of how well each model explains the variability in the respective export parameters over time. For export quantity, the quadratic model achieves the highest R² value of 0.660, suggesting that approximately 66 per cent of the variation in groundnut export quantity can be explained by a quadratic trend. In terms of export value, the quadratic model again performs best with an R² of 0.614, indicating that around 61.4 per cent of the variability in export value is accounted for by the quadratic equation. Overall, the quadratic model consistently provides the best fit for both export quantity and export value, as indicated by the highest R² values among the three models.

**Table 4 Model equations for linear, exponential and quadratic trends and value of R2 of export quantity and export value of groundnut from India**

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable** | **Model name** | **Y** | **R2** |
| Export quantity  (tonnes) | Linear model | y = 276631.8+22905.01t | 0.555 |
| Exponential model | y = 12.48·e0.4462t | 0.589 |
| Quadratic model | y = 127326.16 + 63624.73t− 1939.03t² | 0.660 |
| Export value  (thousand USD) | Linear model | y = 232528.93+32096.92t | 0.533 |
| Exponential model | y = 12.25·e0.0812t | 0.594 |
| Quadratic model | y = 45063.81 + 83223.77t − 2434.61t² | 0.614 |

4. CONCLUSION

The study highlights significant variability and long-term growth trends in groundnut exports from India during 2005–2024. Using nonparametric tests, a major structural shift was identified in 2010, likely influenced by trade policies, global demand, and currency movements. Trend analysis showed a statistically significant increase in both export quantity and value during the overall period. Export quantity increased by 23.84 thousand tonnes/year and value by 35.24 million USD/year, with the quadratic model best capturing the export dynamics. The findings emphasize the importance of strengthening trade strategies and export infrastructure to sustain India’s upward trajectory in groundnut exports.

References

Alexandersson, H. (1986). A homogeneity test applied to precipitation data. *The International Journal of Climatology,* 6, 661-675.

Arunachalam, R. & Balakrishnam, V. (2012). Statistical modeling for wheat crop production. *International Journal of Statistics and Appilication, 2*(4),40-46

Bharodia, C. R., Lakhlani, C. D., Maheta, H. Y. & Kumar, K. (2025). Market integration and price transmission in fruits price export from India. *Plant Archives*, 25(Special Issue), 627-632.

Buishand, T. A. (1982). Some methods for testing the homogeneity of rainfall records. *Journal of Hydrology*, *58*(1–2), 11-27.

Ghadiya, M. & Maheta, H. Y. (2018). Trend of area, production and productivity of groundnut in Gujarat. *AGRES – An International e. Journal*, 7(3), 355-360.

ICRISAT (2024). Groundnut crop. The International Crops Research Institute for the Semi-Arid Tropics.

Kendall, M. G. (1975). Rank Correlation Methods. 4th ed., Charles Grifin*,* London.

Mann, H. B. (1945). Non-parametric tests against trend. *Econometrica*, *13*, 245-259.

Maheta, H.Y. & Rank, H. D. (2017). Trend analysis of rainfall using mann-kendall test in Karmal watershed of Bhadar basin. *An International E. Journal*, 6(3), 435-441.

Maheta, H.Y., Rank, H. D., Parajapati, G. V., Kumar, K. & Bharodia, C. R. (2025). Regional rainfall frequency analysis of Bhadar basin using L-moment approach. *Plant Archives*, 25(Special Issue), 633-640.

Oganja, Y. H., Maheta, H. Y., Kumar, K., & Bharodia, C. R. (2024). Identification of mutation point and trend analysis of area, production, and yield of wheat crop in Gujarat, India. *Asian Research Journal of Agriculture*, *17*(4), 150-156. DOI: https://doi.org/10.9734/arja/2024/v17i4510

Pettitt, A. N. (198). A non-parametric approach to the change point problem. *Journal of Applied Statistics*, *28*(2), 126-135.

Sajindra, H., Abekoon, T., Wimalasiri, E. M., Mehta, D. & Rathnayake, U. (2023). An artificial neural network for predicting groundnut yield using climatic data. *AgriEngineering*,*5*(4), 1713-1736.

Sen, P. K. (1968). Estimates of the regression coefficient based on Kendall’s tau. *Journal of the American Statistical Association,* *63*, 1379-1389.

Vignesh, M. & Selvakumar, R. (2024). Export performance of Groundnut and its value added products in the study area. *Indian Journal of Applied and Pure Biology, 39*(3), 1921-1924.