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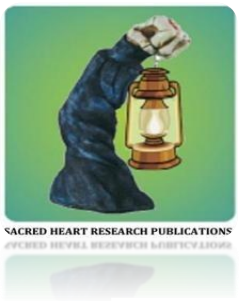


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# Marketing and Price Volatility of Turmeric in electronic National Agriculture Market (e-NAM) of Tamil Nadu

**A. Salaijayamani* and Dr. A. Xavier Susairaj****

## Abstract

*Turmeric is also known as "Indian saffron" and "Golden Spice" in India. Turmeric is considered as spice, medicine and herb. Turmeric is also used in Indian culture and traditions. The present study used secondary data as a major source for data. Sources such as Agricultural Statistics at a Glance, Government of India, Ministry of Agriculture and Farmers Welfare, Spice Board of India, Spice statistics at a glance. By using the daily price data of the Turmeric price volatility have been measured using ARCH and GARCH model. The study concludes that there is a direct relation between production of turmeric and price of turmeric in the market. The volatility results shows that price volatility is very high during the harvest period. This shows that there is high demand for turmeric only during the harvest period. The study suggests that government should initiate some awareness programmes for the farmers about the demand and supply of the market arrivals and government also should provide market information to the farmers trading in the market.*

***Keywords:*** *Turmeric, Production, Price, Volatility*

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**Introduction:**

The word Turmeric is derived from Latin word called terra merita, which refers to the colour of the ground turmeric, which resembles a mineral pigment (Willamson 2002). Major turmeric producers of turmeric are India, Pakistan, China, Malaysia, Vietnam, Philippines, Japan, Myanmar, Sri Lanka, Korea and Thailand (JRG 2011). Turmeric has been used for both cooking purpose and medicine for more than 6000 years. Turmeric belongs to the native of South and Southeast Asian countries and turmeric is also used as traditional dishes in India, China, Pakistan, Bangladesh, Taiwan, Malaysia, Nepal, Haiti, Jamaica and Indonesia (Krishnaswamy, 2006). Turmeric is also known as "Indian saffron" and "Golden Spice" in India. Turmeric is considered as spice, medicine and herb. Turmeric is also used in Indian culture and traditions. Spices are one of the major agriculture products that produced in India and account for exports to various countries (Seasonal Commodity Insights, 2015). India is one of the largest irrigated lands in the world, but its per-hectare water availability and per-capita ranks among the least. The Co-effective use of both water and fertilizer are the key factor for increasing the production and productivity of the agricultural product in our country (Sandeep 2021). India produces 78 percent of world turmeric and consumes 90 percent (Yogesh & Mokshapati, 2014). India's different climatic condition ensures accessibility of all varieties of spices. Major spices produced in India are pepper, turmeric, ginger, chillies, garlic, coriander, cumin, fennel, fenugreek, ajwan, cardamom, cinemon, nutmeg, clove, tamarind and saffron (Gawde 2019). There are 107 different variety of spices with 20 different countries which involved in production and Export of spices. Turmeric is grown as a the kharif crop in India due to high Curcumin content. Hence India is one of the leading exporters of turmeric to other countries, in 2019 India has exported 17000 tonnes worth of 57,371 lakh Indian rupees (Spice Statistics at a glance, 2021). Turmeric is cultivated on 218.7 '000 Ha with a production of 1166.8 '000 MT in Andhra Pradesh, Tamil Nadu, Odisha, Kerala, Maharashtra, West Bengal and north-eastern states of India (Anonymous 2013).

**Methodology:**

The present study used secondary data as a major source for data. Sources such as Agricultural Statistics at a Glance, Government of India, Ministry of Agriculture and Farmers Welfare, Spice Board of India, Spice statistics at a glance. By using the daily price data of the Turmeric price volatility have been measured using ARCH and GARCH model.

**Result and Discussion:**

**Table 1: Area, Production and Productivity of Turmeric in Tamil Nadu**

| Year | State | Area (in '000) Ha | Production in ('000) MT | Productivity Rate in % |
|---|---|---|---|---|
| 2013 | Tamil Nadu | 76.98 | 461.99 | |
| | % Distribution of Tamil Nadu | 33.08 | 38.82 | 6 |
| | India | 232.67 | 1189.89 | 5.11 |
| 2014 | Tamil Nadu | 31.97 | 117.42 | |
| | % Distribution of Tamil Nadu | 17.33 | 14.14 | 3.76 |
| | India | 184.44 | 830.39 | 4.5 |
| 2015 | Tamil Nadu | 34.73 | 132.4 | |
| | % Distribution of Tamil Nadu | 18.68 | 14.03 | 3.81 |
| | India | 185.9 | 943.3 | 5.07 |
| 2016 | Tamil Nadu | 29.31 | 112.59 | |
| | % Distribution of Tamil Nadu | 13.21 | 10.66 | 3.84 |
| | India | 221.78 | 1056.1 | 4.76 |
| 2017 | Tamil Nadu | 30 | 116 | |
| | % Distribution of Tamil Nadu | 12.60 | 10.24 | 3.87 |
| | India | 237.96 | 1132.72 | 4.76 |
| 2018 | Tamil Nadu | 23.35 | 92.36 | |
| | % Distribution of Tamil Nadu | 8.91 | 9.64 | 3.9 |
| | India | 261.92 | 957.13 | 3.6 |
| 2019 | Tamil Nadu | 18.43 | 96.25 | |
| | % Distribution of Tamil Nadu | 6.22 | 8.16 | 5.2 |
| | India | 296.18 | 1178.75 | 3.9 |
| 2020 | Tamil Nadu | 20.89 | 86.51 | |
| | % Distribution of Tamil Nadu | 7.13 | 7.69 | 4.14 |
| | India | 292.88 | 1123.86 | 3.84 |
| 2021 | Tamil Nadu | 24.22 | 104.4 | |
| | % Distribution of Tamil Nadu | 6.93 | 7.82 | 4.31 |
| | India | 349.43 | 1334.31 | 3.82 |

*Source: Compiled from various Agricultural Statistics at a Glance Reports*

Table 1 shows the area, production and productivity of turmeric and percentage distribution of turmeric in Tamil Nadu. Highest percentage of distribution of area was in 2013 with 33.08 percent followed by 2015 with 18.68 percent and 2014 with 17.33 and the lowest area of distribution was in the year 2019 with 6.22 percent. In the year 2013 highest production percentage distribution was recorded with 38.82 percent followed by 2014 with 14.14 percent and 2015 with 14.03 percent and lowest was in the year 2020 with 7.69 percent. Productivity rate was high in the 2013 with 6 percent followed by 2019 with

5.2 and 2021 with 4.31 percent and the lowest was in the year 2014 with 3.76. The data reveals that area, production and productivity of turmeric in Tamil Nadu was in a negative trend.

**Table-2, District-wise Production of Turmeric (in Tonnes) in Tamil Nadu**

| District | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|
| Ariyalur | 51 | 57580 | 30283 | 19849 | 17746 | 90 | 65 |
| Coimbatore | 2815 | 159 | 64 | 48 | 40 | 2546 | 2479 |
| Cuddalore | 502 | 3956 | 1564 | 1304 | 1108 | 1085 | 544 |
| Dharmapuri | 17181 | 4328 | 2247 | 1308 | 3525 | 37747 | 14891 |
| Dindigul | 12 | 44 | 8 | 0 | 0 | 37 | 20 |
| Erode | 33240 | 49593 | 12331 | 11786 | 9668 | 46397 | 15030 |
| Kancheepuram | 12 | 548 | 292 | 224 | 157 | 0 | 0 |
| Kanniyakumari | 0 | 5 | 0 | 15 | 0 | 0 | 0 |
| Karur | 562 | 77 | 30 | 29 | 60 | 20 | 367 |
| Krishnagiri | 1551 | 9495 | 5279 | 3899 | 2775 | 2201 | 1162 |
| Madurai | 18 | 121 | 61 | 11 | 0 | 37 | 32 |
| Nagapattinam | 1 | 55 | 45 | 55 | 68 | 0 | 0 |
| Namakkal | 7677 | 0 | 4 | 0 | 0 | 10932 | 10893 |
| Perambalur | 1960 | 5 | 133 | 4 | 0 | 2278 | 3424 |
| Pudukottai | 51 | 22 | 11 | 11 | 16 | 34 | 97 |
| Ramanathapuram | 0 | 11 | 8 | 15 | 24 | 0 | 0 |
| Salem | 11553 | 11 | 0 | 0 | 0 | 10612 | 7482 |
| Sivaganga | 19 | 9207 | 6806 | 3190 | 1720 | 19 | 32 |
| Thanjavur | 28 | 192 | 76 | 48 | 24 | 25 | 69 |
| The Nilgiris | 45 | 10274 | 6481 | 5040 | 4590 | 47 | 69 |
| Theni | 3 | 6826 | 8136 | 2559 | 1697 | 18 | 4 |
| Thoothukudi | 18 | 9992 | 4709 | 4713 | 2154 | 12 | 20 |
| Tiruchirapalli | 558 | 11057 | 4603 | 2703 | 2848 | 855 | 3034 |
| Tirunelveli | 13 | 49 | 23 | 18 | 20 | 23 | 28 |
| Tiruppur | 1146 | 0 | 11 | 0 | 16 | 1453 | 1167 |
| Tiruvallur | 28 | 27931 | 8271 | 6472 | 6066 | 29 | 28 |
| Tiruvannamalai | 1958 | 65108 | 46727 | 40641 | 35035 | 2828 | 2274 |
| Tiruvarur | 12 | 384 | 80 | 66 | 608 | 14 | 8 |
| Vellore | 3419 | 641 | 186 | 59 | 48 | 3126 | 1927 |
| Villupuram | 7926 | 80426 | 30969 | 10645 | 13066 | 7090 | 7984 |
| Virudhunagar | 2 | 20316 | 5337 | 2704 | 1923 | 8 | 4 |
| State | 92361 | 368413 | 174775 | 117416 | 105002 | 129563 | 73134 |

*Source: Compiled from Statistical Handbook of Tamil Nadu, Government of Tamil Nadu*

Table 2 shows the district wise production of Turmeric in Tamil Nadu. In the year 2012 Erode has the highest production of 33240 tonnes of turmeric followed by

Dharmapuri with 17181 tonnes and Salem with 11553 tonnes and the lowest turmeric producing district in Tamil Nadu is Nagapattinam with 1 Tonne. In overall production of Turmeric was in 2013 had the highest production rate with 368413 tonnes followed by 174775 tonnes in 2014 and 129563 tonnes in 2017. The lowest production of turmeric was recorded in the year 2018 with 73134 tonnes.

**Table-3, District-wise Productivity (Tonnes/Ha) of Turmeric in Tamil Nadu**

| District | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|
| Ariyalur | 4210 | 3510 | 3190 | 3430 | 3620 | 4045 | 3955 |
| Coimbatore | 5480 | 3760 | 3690 | 4000 | 1993 | 4721 | 6842 |
| Cuddalore | 5480 | 3790 | 3670 | 4030 | 2352 | 2256 | 2252 |
| Dharmapuri | 5480 | 8740 | 4900 | 1211 | 4774 | 2811 | 2989 |
| Dindigul | 5500 | 4000 | 0 | 0 | 3620 | 4045 | 3955 |
| Erode | 8660 | 4920 | 5740 | 4380 | 4898 | 4892 | 5898 |
| Kancheepuram | 5480 | 3790 | 3670 | 4030 | 3620 | 0 | 3955 |
| Kanniyakumari | 5000 | 0 | 3750 | 0 | 0 | 0 | 0 |
| Karur | 5500 | 3750 | 3630 | 4000 | 88 | 2624 | 3955 |
| Krishnagiri | 4460 | 3680 | 3280 | 3150 | 3307 | 2363 | 2179 |
| Madurai | 5500 | 3590 | 3670 | 0 | 3620 | 4045 | 3955 |
| Nagapattinam | 5500 | 3750 | 3670 | 6800 | 0 | 0 | 3955 |
| Namakkal | 0 | 4000 | 0 | 0 | 3253 | 5985 | 3595 |
| Perambalur | 5000 | 3800 | 4000 | 0 | 2814 | 6071 | 3541 |
| Pudukottai | 5500 | 3670 | 3670 | 4000 | 3620 | 4045 | 3955 |
| Ramanathapuram | 5500 | 4000 | 3750 | 6000 | 0 | 0 | 0 |
| Salem | 5500 | 0 | 0 | 0 | 1612 | 2816 | 2750 |
| Sivaganga | 3950 | 4410 | 3240 | 3740 | 3620 | 4045 | 3955 |
| Thanjavur | 5490 | 3800 | 3690 | 4000 | 3620 | 4045 | 3955 |
| The Nilgiris | 2630 | 2170 | 2240 | 2150 | 3620 | 4045 | 3955 |
| Theni | 5480 | 8510 | 4010 | 4450 | 3620 | 4045 | 3955 |
| Thoothukudi | 5480 | 4140 | 6380 | 4730 | 3620 | 4045 | 3955 |
| Tiruchirapalli | 5480 | 3500 | 2870 | 3740 | 1340 | 9755 | 1896 |
| Tirunelveli | 5440 | 3830 | 3600 | 4000 | 3620 | 4045 | 3955 |
| Tiruppur | 0 | 3670 | 0 | 4000 | 1769 | 4650 | 3955 |
| Tiruvallur | 11380 | 6050 | 5380 | 6920 | 3620 | 4045 | 3955 |
| Tiruvannamalai | 5060 | 4280 | 4970 | 5570 | 6870 | 6571 | 5217 |
| Tiruvarur | 5490 | 3810 | 3670 | 4030 | 3620 | 4045 | 3955 |
| Vellore | 5480 | 3800 | 3690 | 4000 | 5646 | 5139 | 6926 |
| Villupuram | 5740 | 2900 | 1850 | 2560 | 2840 | 4269 | 3852 |
| Virudhunagar | 6500 | 3120 | 2670 | 3710 | 3620 | 4045 | 3955 |
| State | 161350 | 120740 | 102540 | 174730 | 94236 | 117508 | 115172 |

*Source: Compiled from Statistical Handbook of Tamil Nadu, Government of Tamil Nadu*

Table 3 shows the district wise productivity of turmeric in Tamil Nadu. In 2013 Tiruvallur has the highest productivity rate of 11380 tonnes/Ha followed by Erode with

8660 tonnes/Ha and Virudhunagar with 6500 tonnes/Ha and the least productivity of turmeric was recorded in Nilgiris with 2630 tonnes/Ha. In the year 2018 Vellore has the highest productivity rate with 6926 tonnes/Ha followed by Coimbatore with 6842 tonnes/Ha and Erode with 5898 tonnes/Ha and the lowest rate of productivity was in Tiruchirappalli with 1896 tonnes/Ha. And the total productivity of Tamil Nadu was high in the year 2015 with 174730 tonnes/Ha followed by 2012 with 161350 tonnes/Ha and 2013 with 120740 tonnes/Ha and lowest productivity of turmeric was in 2016 with 94236 tonnes/Ha.

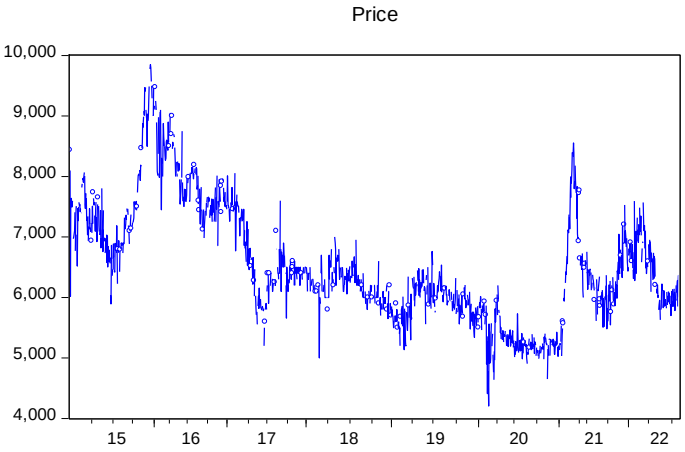
**Table 4: Turmeric Traded in eNAM**

| | **Arrived lot (No. of Farmers)** | **Arrived Qty (100 kg)** | **e trade** | **Traded Qty (100 kg)** | **Traded value (Rs)** |
|---|---|---|---|---|---|
| **2017-18** | 1 | 1.5 | 1 | 1.43 | 4576 |
| **2018-19** | 252 | 2501.82 | 90 | 1501.49 | 9914958 |
| **2019-20** | 1075 | 8109.67 | 771 | 6518.9 | 41080393.45 |
| **2020-21** | 48 | 145.55 | 9 | 17.66 | 73527.4 |
| 2021-22 | 88 | 298.55 | 58 | 174.93 | 1526350.6 |

Table 4 shows the turmeric traded in eNAM in Tamil Nadu. The traded value of turmeric in eNAM was higher in the year 2019-20 with 41080393.45 followed by 2018-19 with 9914958 and 2021-22 with 1526350.6 and the least amount of turmeric was traded in the year 2017-18 with 4576. This shows that farmers are willing to trade in eNAM because of various reasons like transparency in transaction, No intermediaries, high price for their produce etc.

**Price Volatility of Turmeric Bulb**

Non-Stationary Prices



## Unit Root Test for Prices: Result shows non-stationary

Null Hypothesis: PRICE has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on SIC, maxlag=23)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | 2.550062 | 0.1039 |
| Test critical values: | 1% level | -3.434502 | |
| | 5% level | -2.863261 | |
| | 10% level | -2.567735 | |

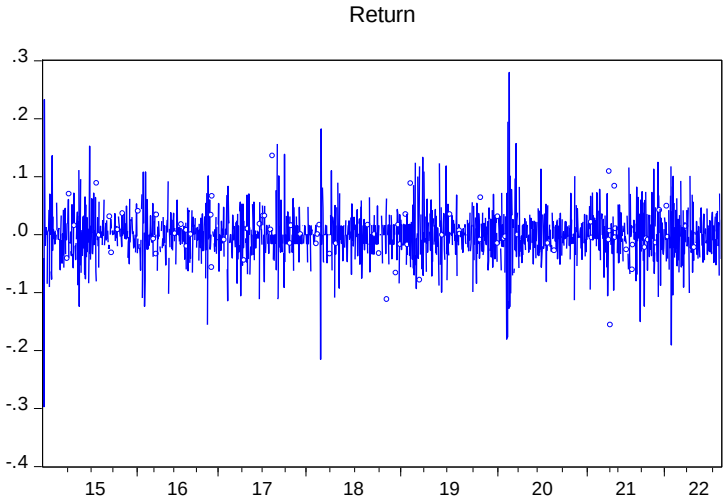
*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PRICE)
Method: Least Squares
Date: 12/22/22 Time: 13:35
Sample (adjusted): 1/08/2015 7/29/2022
Included observations: 1500 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| PRICE(-1) | -0.016507 | 0.006473 | -2.550062 | 0.0109 |
| D(PRICE(-1)) | -0.479312 | 0.025890 | -18.51360 | 0.0000 |
| D(PRICE(-2)) | -0.305116 | 0.026948 | -11.32252 | 0.0000 |
| D(PRICE(-3)) | -0.139782 | 0.024901 | -5.613445 | 0.0000 |
| C | 106.2325 | 42.71983 | 2.486727 | 0.0130 |

| | | | |
|---|---|---|---|
| R-squared | 0.207124 | Mean dependent var | -0.956667 |
| Adjusted R-squared | 0.205003 | S.D. dependent var | 266.5411 |
| S.E. of regression | 237.6550 | Akaike info criterion | 13.78284 |
| Sum squared resid | 84437446 | Schwarz criterion | 13.80056 |
| Log likelihood | -10332.13 | Hannan-Quinn criter. | 13.78944 |
| F-statistic | 97.63529 | Durbin-Watson stat | 2.013959 |
| Prob(F-statistic) | 0.000000 | | |

## Stationary Return Prices




## Unit Root Test for Return Price Series: Result shows Stationary

Null Hypothesis: RETURN has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on SIC, maxlag=23)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -33.07624 | 0.0000 |
| Test critical values: | 1% level | -3.434502 | |
| | 5% level | -2.863261 | |
| | 10% level | -2.567735 | |

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RETURN)
Method: Least Squares
Date: 12/22/22 Time: 13:36
Sample (adjusted): 1/08/2015 7/29/2022
Included observations: 1500 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| RETURN(-1) | -1.989897 | 0.060161 | -33.07624 | 0.0000 |
| D(RETURN(-1)) | 0.464823 | 0.044622 | 10.41681 | 0.0000 |
| D(RETURN(-2)) | 0.145669 | 0.024987 | 5.829845 | 0.0000 |
| C | -0.000228 | 0.000946 | -0.240774 | 0.8098 |

| | | | |
|---|---|---|---|
| R-squared | 0.723182 | Mean dependent var | -0.000138 |
| Adjusted R-squared | 0.722627 | S.D. dependent var | 0.069559 |
| S.E. of regression | 0.036634 | Akaike info criterion | -3.773005 |
| Sum squared resid | 2.007730 | Schwarz criterion | -3.758836 |
| Log likelihood | 2833.754 | Hannan-Quinn criter. | -3.767727 |
| F-statistic | 1302.759 | Durbin-Watson stat | 2.017149 |
| Prob(F-statistic) | 0.000000 | | |

## ARCH Model: Null Hypothesis rejected

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 84.00293 | Prob. F(1,1499) | 0.0000 |
| Obs*R-squared | 79.65140 | Prob. Chi-Square(1) | 0.0000 |

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 12/22/22 Time: 13:41
Sample (adjusted): 1/07/2015 7/29/2022
Included observations: 1501 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.001183 | 9.23E-05 | 12.81443 | 0.0000 |
| RESID^2(-1) | 0.186978 | 0.020401 | 9.165312 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.053066 | Mean dependent var | 0.001469 |
| Adjusted R-squared | 0.052434 | S.D. dependent var | 0.003455 |
| S.E. of regression | 0.003363 | Akaike info criterion | -8.550523 |
| Sum squared resid | 0.016955 | Schwarz criterion | -8.543442 |
| Log likelihood | 6419.167 | Hannan-Quinn criter. | -8.547885 |
| F-statistic | 84.00293 | Durbin-Watson stat | 1.992254 |
| Prob(F-statistic) | 0.000000 | | |

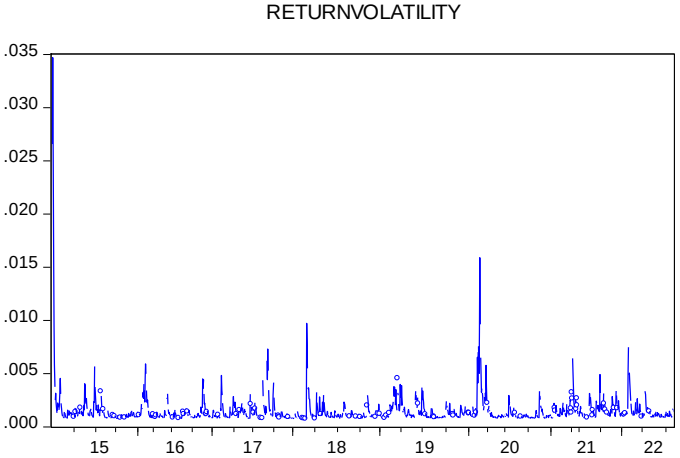
## GARCH Model: Past Return have strong impact on current return

Dependent Variable: RETURN
Method: ML ARCH - Normal distribution (Marquardt / EViews legacy)
Date: 12/22/22 Time: 13:44
Sample (adjusted): 1/06/2015 7/29/2022
Included observations: 1502 after adjustments
Convergence achieved after 17 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | -0.000539 | 0.000820 | -0.658071 | 0.5105 |
| RETURN(-1) | -0.383974 | 0.026369 | -14.56141 | 0.0000 |
| | Variance Equation | | | |
| C | 0.000322 | 4.19E-05 | 7.680291 | 0.0000 |
| RESID(-1)^2 | 0.193920 | 0.029668 | 6.536409 | 0.0000 |
| GARCH(-1) | 0.582428 | 0.050087 | 11.62828 | 0.0000 |

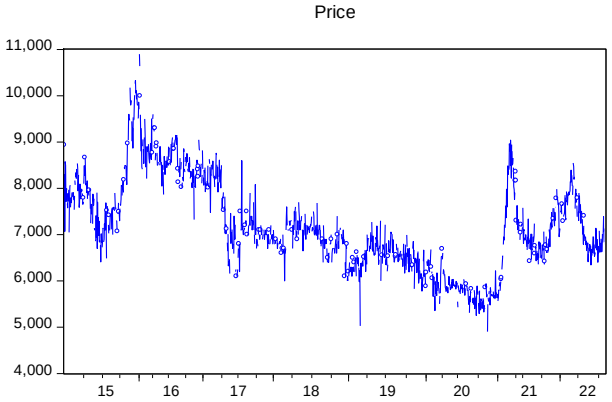
| | | | |
|---|---|---|---|
| R-squared | 0.154831 | Mean dependent var | -0.000182 |
| Adjusted R-squared | 0.154267 | S.D. dependent var | 0.042614 |
| S.E. of regression | 0.039189 | Akaike info criterion | -3.798356 |
| Sum squared resid | 2.303702 | Schwarz criterion | -3.780665 |
| Log likelihood | 2857.566 | Hannan-Quinn criter. | -3.791766 |
| Durbin-Watson stat | 2.179596 | | |

## Return Volatility Graph

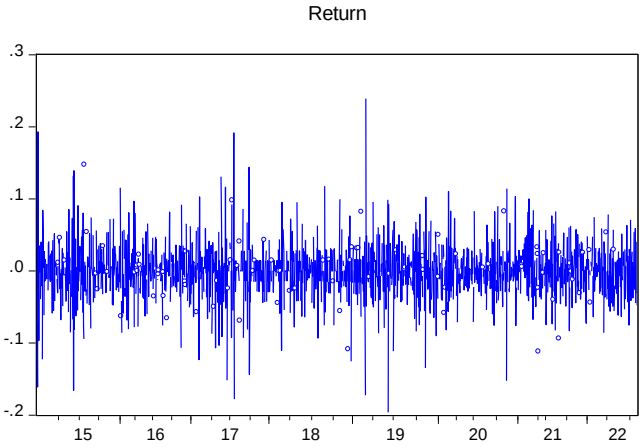


## Finger

### Non- Stationary




### Stationary




Null Hypothesis: PRICE has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on SIC, maxlag=23)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -2.803049 | 0.0580 |
| Test critical values: | 1% level | -3.434502 | |
| | 5% level | -2.863261 | |
| | 10% level | -2.567735 | |

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PRICE)
Method: Least Squares
Date: 12/22/22 Time: 14:16
Sample (adjusted): 1/08/2015 7/29/2022
Included observations: 1500 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| PRICE(-1) | -0.018697 | 0.006670 | -2.803049 | 0.0051 |
| D(PRICE(-1)) | -0.444702 | 0.025949 | -17.13772 | 0.0000 |
| D(PRICE(-2)) | -0.262826 | 0.027243 | -9.647433 | 0.0000 |
| D(PRICE(-3)) | -0.111046 | 0.025302 | -4.388773 | 0.0000 |
| C | 132.5436 | 48.31360 | 2.743401 | 0.0062 |

| | | | |
|---|---|---|---|
| R-squared | 0.184296 | Mean dependent var | -1.220000 |
| Adjusted R-squared | 0.182114 | S.D. dependent var | 275.3297 |
| S.E. of regression | 249.0001 | Akaike info criterion | 13.87611 |
| Sum squared resid | 92691557 | Schwarz criterion | 13.89382 |
| Log likelihood | -10402.08 | Hannan-Quinn criter. | 13.88271 |
| F-statistic | 84.44330 | Durbin-Watson stat | 2.011946 |
| Prob(F-statistic) | 0.000000 | | |

Null Hypothesis: RETURN has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on SIC, maxlag=23)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -31.53535 | 0.0000 |
| Test critical values: | 1% level | -3.434502 | |
| | 5% level | -2.863261 | |
| | 10% level | -2.567735 | |

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RETURN)
Method: Least Squares
Date: 12/22/22 Time: 14:17
Sample (adjusted): 1/08/2015 7/29/2022
Included observations: 1500 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| RETURN(-1) | -1.875686 | 0.059479 | -31.53535 | 0.0000 |
| D(RETURN(-1)) | 0.396822 | 0.044490 | 8.919325 | 0.0000 |
| D(RETURN(-2)) | 0.120061 | 0.025343 | 4.737367 | 0.0000 |
| C | -0.000222 | 0.000891 | -0.248945 | 0.8034 |

| | | | |
|---|---|---|---|
| R-squared | 0.707484 | Mean dependent var | -0.000134 |
| Adjusted R-squared | 0.706897 | S.D. dependent var | 0.063771 |
| S.E. of regression | 0.034525 | Akaike info criterion | -3.891608 |
| Sum squared resid | 1.783187 | Schwarz criterion | -3.877439 |
| Log likelihood | 2922.706 | Hannan-Quinn criter. | -3.886329 |
| F-statistic | 1206.083 | Durbin-Watson stat | 2.014773 |
| Prob(F-statistic) | 0.000000 | | |

## ARCH

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 111.8534 | Prob. F(1,1499) | 0.0000 |
| Obs*R-squared | 104.2255 | Prob. Chi-Square(1) | 0.0000 |

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 12/22/22 Time: 14:21
Sample (adjusted): 1/07/2015 7/29/2022
Included observations: 1501 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.000953 | 7.65E-05 | 12.46565 | 0.0000 |
| RESID^2(-1) | 0.251467 | 0.023777 | 10.57608 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.069437 | Mean dependent var | 0.001281 |
| Adjusted R-squared | 0.068817 | S.D. dependent var | 0.002807 |
| S.E. of regression | 0.002708 | Akaike info criterion | -8.983631 |
| Sum squared resid | 0.010995 | Schwarz criterion | -8.976551 |
| Log likelihood | 6744.215 | Hannan-Quinn criter. | -8.980993 |
| F-statistic | 111.8534 | Durbin-Watson stat | 2.054929 |
| Prob(F-statistic) | 0.000000 | | |

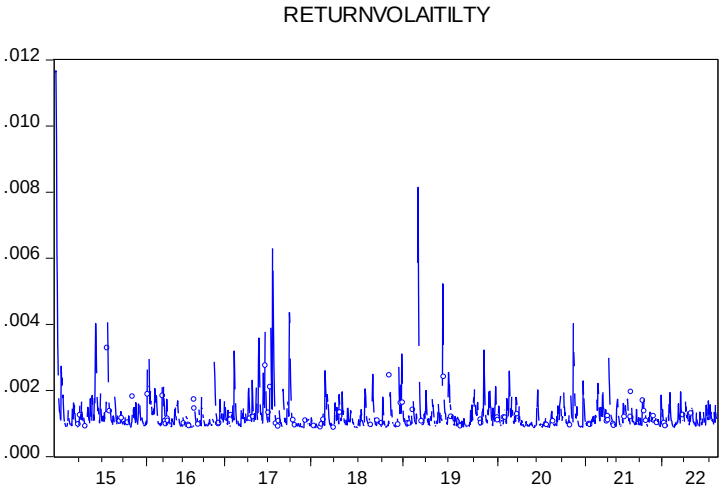
## GARCH

Dependent Variable: RETURN
Method: ML ARCH - Normal distribution (Marquardt / EViews legacy)
Date: 12/22/22 Time: 14:22
Sample (adjusted): 1/06/2015 7/29/2022
Included observations: 1502 after adjustments
Convergence achieved after 14 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | -0.000155 | 0.000839 | -0.185130 | 0.8531 |
| RETURN(-1) | -0.344088 | 0.025103 | -13.70699 | 0.0000 |
| | Variance Equation | | | |
| C | 0.000385 | 5.15E-05 | 7.468569 | 0.0000 |
| RESID(-1)^2 | 0.139073 | 0.023806 | 5.842030 | 0.0000 |
| GARCH(-1) | 0.556186 | 0.047917 | 11.60717 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.136506 | Mean dependent var | -0.000139 |
| Adjusted R-squared | 0.135930 | S.D. dependent var | 0.038890 |
| S.E. of regression | 0.036150 | Akaike info criterion | -3.871532 |
| Sum squared resid | 1.960222 | Schwarz criterion | -3.853841 |
| Log likelihood | 2912.521 | Hannan-Quinn criter. | -3.864942 |
| Durbin-Watson stat | 2.204042 | | |

## Return Volatility Graph




## Conclusion:

The study concludes that there is a direct relation between production of turmeric and price of turmeric in the market. The volatility results shows that price volatility is very high during the harvest period. This shows that there is high demand for turmeric only during the harvest period. The study suggests that government should initiate some awareness programmes for the farmers about the demand and supply of the market arrivals and government also should provide market information to the farmers trading in the market.

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