

# Forecasting of instant coffee exports of India using transitional probability matrix

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#### Abstract

Coffee exporting of India is of high importance in order to alleviate poverty. However, Indian coffee prices fluctuate very randomly as a large number of factors like production, quality, market demands etc. have immense influence over it. Consequently, involvement of considerable risk and uncertainty in statistical modelling as well as forecasting becomes unavoidable. Hence, in the current investigation, an attempt has been made to forecast the instant coffee exports of India using transitional probability matrix. The share of instant coffee export is forecasted to be highest to Russian Federation for all 3 years but compared to last year, export share has been decreased. The export shares to Turkey, Finland and Indonesia are expected to rise but India's share to Malaysia, Ukraine, U.S.A and other countries is expected to fall. Where in case of Poland one and two-step forecasting showing decrease in export share but third step forecasting had increased significantly. Though the quantity of coffee exported to different countries has increased over the years, India has to capture new markets to sustain as also to increase the total coffee export.

Keywords: Coffee, forecasting, instant coffee, Markov chain, transitional probability matrix.

#### Introduction

Coffee is one of the vital non-alcoholic beverages in the world. Among the world's most popular beverages, coffee has placed in the second position after Tea. In recent years, coffee has become one of the most-profitable global commodities. The main reason for its popularity is its refreshing effect, which is due to the presence of 'Caffeine,' an alkaloid present in coffee<sup>1</sup>.

New products have been developed day by day by implementing various innovative ways of processing with a view to explore the beneficial properties of the specific chemical components of coffee. Coffee has become more popular than ever by mixing of compatible ingredients keeping the coffee as a base material<sup>2</sup>. Instant coffee is a beverage derived from brewed coffee beans, enabling people to prepare hot coffee quickly. Coffee exporting of India can play a vital role to alleviate poverty<sup>3</sup>. However, Indian coffee prices fluctuate very randomly as they are influenced by a large number of factors like production, demand of coffee in domestic and world level forces, quality of produce etc. As a consequence, involvement of considerable risk and uncertainty in statistical modelling as well as forecasting become inevitable<sup>4</sup>.

With the help of Markov chain analysis, the direction of trading of rice, wheat and mango was explained. It was seen that Maldives was one of the markets with most stability in case of rice with 41.54 percent retention probability. For all the four commodities Bangladesh was most stable market and the same is reflected in the probability matrix with the values 22.86, 45.40, 39.29 and 24.00 percent, respectively<sup>5</sup>. Results of the study on pomegranate prior to and after WTO era emanated from the Markov Chain analysis indicated U.A.E.as one of the stable importers of Indian pomegranate during both the periods<sup>6</sup>. The trade directions of basmati rice export from India was also analysed by transitional probability matrix during 2000-01 to 2012-13. UAE was the most stable market for Indian basmati rice among the major importers namely, Saudi Arabia, Kuwait, UK, UAE, Iran and Iraq<sup>7</sup>.

With these contexts, in the current investigation, an attempt has been made to forecast the instant coffee exports of India using transitional probability matrix.

#### Materials and methods

Ten years period from 2007-08 to 2016-17 was considered for the purpose of analysing the growth rate of instant coffee export. Secondary data were collected from database on coffee published by Coffee Board of India, Bengaluru. To study the structural change using Markov Chain model the ten years secondary data related to export of instant coffee and combined value added coffee from India to countries like Russian Federation, Turkey Malaysia, Ukraine, Finland, Poland, Indonesia and U.S.A. had been recorded from 2007-08 to 2016-17. The remaining importing countries where pooled under the category 'others' and considered for the analysis. In the current Research Journal of Mathematical and Statistical Sciences . Vol. 7(2), 13-20, May (2019)

study, the first order Markov chain model was employed to investigate the dynamic trading patterns<sup>8</sup>.

Let us consider a stochastic process { $X_n$ , n = 0, 1, 2, ...} which takes on countable number of possible values if  $X_n = i_n$ , then the process is termed in state I at the time point n. It is assumed that whenever the process is in state *i*, there exists a fixed probability  $P_{ij}$  such that in state *j* it will next be<sup>9, 10</sup>. It can be expressed mathematically as

$$\{X_{n+1} = j \mid X_n = i_n, X_{n-1} = i_{n-1}, \dots, \dots, 1 = i_1, X_0 = i_0\} = \{X_{n+1} = j \mid X_n = i_n\}$$
  
=  $P_{ij}$ 

For all the states,  $i_0$ ,  $i_1$ , ...,  $n_{-1}$ , i, jand all  $n \ge 0$ . A stochastic process like this is called as a Markov chain. If the conditional distribution of any future state  $X_{n+1}$  given the past states  $X_0, X_1, X_2, ..., X_{n-1}$  and the present state  $X_n$ , does not depends on the past states but only on the present state, is termed as first order Markov chain<sup>11</sup>. The matrix of first order or one-step transition probability P is denoted by

to a specific country was a variable assumed to be random, which is dependent only on its lag values<sup>12</sup>, is mathematically denoted as

$$E_{jt} = \sum_{i=1}^{n} [E_{it} - 1]P_{ij} + e_{jt}$$

Where,  $E_{jt}$ = Exports in the year *t*to  $j^{th}$  country,  $E_{it-1}$  = Exports during the year (t - 1) to  $i^{th}$  country,  $P_{ij}$  = Probability of exports switching from country '*i*' to country '*j*' over time,  $e_{jt}$  = Error term, n = Number of importing countries.

During t<sup>th</sup> period, the expected export share of each country can be computed by multiplying the transitional probability matrix with the past exports to these countries.

MS Excel-2013, LINGO-17.0 and R Studio were used for the purpose of statistical computation.

#### **Results and discussion**

Switching behaviour of instant coffee among the major importing countries was explained by the transitional probabilities matrix presented in table-1. In order to compute the transitional probabilities, actual proportions of export shares were utilised. Information regarding the extent of loss and gains in trade, on account of competing countries were indicated by the row and column elements of the matrix, respectively. However, retention

Export probability shifting from one country (i) to another country probability of the matrix, respectively. However, retention (j) over time is indicated by  $P_{ij}$ . However, it measures the countries were implied by diagonal elements<sup>13</sup>.

		Loss													
D	Destination		Turkey	Malaysia	Ukraine	Finland Poland		Indonesia	U.S.A.	Others					
	Russian Fed.	0.6794	0.0000	0.0000	0.0000	0.0800	0.0000	0.0000	0.0000	0.2407					
	Turkey	0.0000	0.7089	0.0000	0.0000	0.0000	0.1999	0.0912	0.0000	0.0000					
	Malaysia	0.0000	0.3212	0.0060	0.0000	0.0000	0.0000	0.0000	0.1411	0.5317					
	Ukraine	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000					
Gain	Finland	0.1578	0.0000	0.0000	0.4938	0.3484	0.0000	0.0000	0.0000	0.0000					
	Poland	0.0000	0.1571	0.0000	0.0000	0.0000	0.4832	0.0000	0.3597	0.0000					
	Indonesia	0.0000	0.3325	0.0338	0.0000	0.0000	0.0000	0.6337	0.0000	0.0000					
	U.S.A.	0.0000	0.0075	0.0244	0.5722	0.1689	0.0000	0.2270	0.0000	0.0000					
	Others	0.0391	0.0000	0.1922	0.0140	0.0000	0.0170	0.0000	0.0573	0.6805					

Table-1: Transition probability matrix for shifts in behaviour of instant coffee export from India.

The actual and the estimated values of instant coffee exports along percent (2010-11). The country Poland had actual export share with the foreseen share are provided in the Table-2. From the ranging from 1.63 percent (2010-11) to 8.93 percent (2016-17) Table-2 it is clear that actual instant coffee export to Russian and similar range was seen for predicted export shares too where it Federation has highest export shares for the following study years. had varied from 1.96 percent (2010-11) to 7.88 percent (2016-17). Even though Russian federation and Ukraine has non-significant Actual export shares for Indonesia had varied from 0 percent growth rate, there is a variation in the export shares. The actual (2007-08) to 10.43 percent (2013-14) and the predicted export export shares for Russian federation had varied from 16.65 percent shares had varied from 0.82 percent to 8.81 percent (2013-14). For (2013-14) to 41.24 percent (2009-10). Similar trend was found in U.S.A. the actual export shares had varied from 1.22 percent the case predicted values where it had varied from 20.32 percent (2008-09) to 5.36 percent (2010-11) and for predicted export (2013-14) to 35.80 percent (2009-10). For Ukraine, the actual shares it had varied from 3.30 percent (2007-08) to 5.84 percent export shares varied from 3.56 percent (2015-16) to 12.54 percent (2016-17). Graphical representation of the same for Turkey, (2008-09), whereas for predicted export shares had varied from Malaysia, Poland, Indonesia and U.S.A. is provided in Figure-2, 4.19 percent (2016-17) to 8.15 percent (2007-08). The same is Figure-3, Figure-6, Figure-7 and Figure-8, respectively. reflected in the Figure-1 and Figure-4, respectively.

The Finland had shown a negative growth rate in export of instant The Turkey, Malaysia, Poland, Indonesia and U.S.A. were shown coffee (figure-5) and there was a decrease in trend for the study positive significant growth rate in export of instant coffee and period. It had ranged from 12.88 percent (2008-09) to 2.12 percent there was increase in trend for the study period. For turkey, the (2016-17) whereas predicted values had ranged from 7.46 percent actual export shares had ranged from 1.68 percent (2007-08) to (2007-08) to 3.42 percent (2010-11). The actual and predicted 15.46 percent (2014-15) and for predicted export shares had export shares for the other countries was found to be have up and ranged from 2.74 percent (2007-08) to 16.87 percent (2014-15). down trend for the present study period. The actual export shares The actual export shares had varied from 3.69 percent (2007-08) have varied from 30.76 percent (2014-15) to 37.82 percent (2010to 10.16 percent (2012-13) for Malaysia whereas for predicted 11) and predicted shares had varied from 29.41 percent (2014-15) export share it had ranged from 6.26 percent (2015-16) to 7.42 to 37.26 percent (2010-11). The same is reflected in the Figure-9.

Voor	Russian Fed.		Turkey		Malaysia		Ukraine		Finland		Poland		Indonesia		U.S.A.		Others	
1 cai	А	Р	А	Р	А	Р	А	Р	А	Р	А	Р	А	Р	А	Р	А	Р
2007-	22.27	22.10	1.08	1.76	2.37	4.39	4.89	5.23	7.67	4.78	1.38	1.26	0.00	0.54	1.97	2.12	22.50	21.93
08	(34.73)	(34.48)	(1.68)	(2.74)	(3.69)	(6.84)	(7.62)	(8.15)	(11.96)	(7.46)	(2.15)	(1.97)	(0.00)	(0.85)	(3.06)	(3.30)	(35.09)	(34.20)
2008-	11.31	14.39	0.94	1.90	2.88	2.82	5.28	3.18	5.43	2.88	0.83	0.83	0.53	0.54	0.52	1.53	14.41	14.06
09	(26.85)	(34.15)	(2.24)	(4.52)	(6.84)	(6.69)	(12.54)	(7.54)	(12.88)	(6.84)	(1.97)	(1.98)	(1.26)	(1.28)	(1.22)	(3.63)	(34.20)	(33.37)
2009-	11.98	10.40	0.75	1.18	1.65	1.89	1.57	1.54	1.99	1.78	0.69	0.65	0.00	0.24	0.74	1.04	9.67	10.34
10	(41.24)	(35.80)	(2.59)	(4.05)	(5.67)	(6.50)	(5.40)	(5.31)	(6.84)	(6.11)	(2.39)	(2.24)	(0.00)	(0.82)	(2.56)	(3.57)	(33.31)	(35.61)
2010-	27.88	24.84	2.05	2.97	4.02	5.70	4.07	4.90	4.34	4.44	1.25	1.51	0.00	1.12	4.12	2.68	29.03	28.60
11	(36.33)	(32.36)	(2.67)	(3.87)	(5.24)	(7.43)	(5.31)	(6.39)	(5.65)	(5.78)	(1.63)	(1.96)	(0.00)	(1.46)	(5.36)	(3.49)	(37.82)	(37.26)
2011-	28.60	25.67	1.74	4.08	6.05	5.66	4.34	4.42	4.93	4.47	3.06	2.32	1.19	1.54	2.76	3.60	28.72	29.64
12	(35.14)	(31.54)	(2.14)	(5.01)	(7.43)	(6.96)	(5.33)	(5.43)	(6.05)	(5.49)	(3.76)	(2.85)	(1.46)	(1.89)	(3.39)	(4.42)	(35.28)	(36.42)
2012-	15.04	15.39	4.29	5.38	5.53	3.48	4.02	3.26	2.99	2.70	1.52	1.89	0.92	1.59	2.69	2.32	17.42	18.41
13	(27.65)	(28.28)	(7.88)	(9.89)	(10.16)	(6.39)	(7.38)	(5.99)	(5.49)	(4.96)	(2.79)	(3.47)	(1.69)	(2.91)	(4.95)	(4.27)	(32.01)	(33.84)
2013-	14.18	17.31	11.50	13.17	5.44	6.04	5.80	4.80	4.68	3.38	1.83	3.68	8.89	7.50	3.63	3.10	29.23	26.20
14	(16.65)	(20.32)	(13.50)	(15.46)	(6.39)	(7.09)	(6.80)	(5.63)	(5.49)	(3.96)	(2.15)	(4.32)	(10.43)	(8.81)	(4.27)	(3.64)	(34.32)	(30.76)
2014-	19.70	21.81	15.56	16.98	7.14	6.38	6.62	4.41	3.81	3.52	4.35	5.74	8.87	7.87	3.66	4.34	30.96	29.61
15	(19.57)	(21.67)	(15.46)	(16.87)	(7.09)	(6.34)	(6.57)	(4.38)	(3.79)	(3.50)	(4.32)	(5.70)	(8.81)	(7.82)	(3.64)	(4.31)	(30.76)	(29.41)
2015-	24.83	21.82	13.78	13.75	5.95	5.82	3.31	4.23	3.25	3.77	5.29	5.80	3.63	4.44	3.88	4.40	28.96	28.85
16	(26.73)	(23.49)	(14.84)	(14.80)	(6.41)	(6.26)	(3.56)	(4.55)	(3.50)	(4.06)	(5.70)	(6.25)	(3.91)	(4.78)	(4.18)	(4.74)	(31.18)	(31.06)
2016-	25.17	22.69	16.26	16.84	6.45	6.73	3.93	4.49	2.27	3.66	9.57	8.44	5.13	5.88	5.07	6.26	33.27	32.13
17	(23.49)	(21.18)	(15.18)	(15.73)	(6.02)	(6.28)	(3.67)	(4.19)	(2.12)	(3.42)	(8.93)	(7.88)	(4.78)	(5.49)	(4.74)	(5.84)	(31.06)	(30.00)

**Table-2:** Observed and predicted share of instant coffee exports from India to various destination.

A - Actual values, P - Predicted values, values in parentheses indicates percent export shares.



Figure-1: Export proportions of Instant coffee to Russian Federation.



Figure-2: Export proportions of Instant coffee to Turkey.



Figure-3: Export proportions of Instant coffee to Malaysia.







Figure-5: Export proportions of Instant coffee to Finland.



Figure-6: Export proportions of Instant coffee to Poland.







Figure-8: Export proportions of Instant coffee to U.S.A.



Figure-9: Export proportions of Instant coffee to others country.

Year	Russian Fed.		Turkey		Malaysia		Ukraine		Finland		Poland		Indonesia		U.S.A		Others	
	А	Р	А	Р	А	Р	А	Р	А	Р	А	Р	А	Р	А	Р	А	Р
2015-16	24.83	21.82	13.78	13.75	5.95	5.82	3.31	4.23	3.25	3.77	5.29	5.8	3.63	4.44	3.88	4.4	28.96	28.85
2016-17	25.17	22.69	16.26	16.84	6.45	6.73	3.93	4.49	2.27	3.66	9.57	8.44	5.13	5.88	5.07	6.26	33.27	32.13
2017-18	-	21.74	-	17.43	-	6.57	-	5.84	-	4.15	-	7.99	-	6.68	-	5.82	-	30.9
2018-19	-	22.47	-	17.99	-	6.35	-	5.81	-	4.17	-	7.87	-	7.15	-	5.57	-	29.75
2019-20	-	22.9	-	18.44	-	6.13	-	5.66	-	4.19	-	7.9	-	7.43	-	5.43	-	29.03

Table-3: Forecasted Export shares of instant coffee to major importing countries.

A – Actual values, P – Predicted values.

The export shares of instant coffee was forecasted for next three years from 2017-18 to 2019-20 and represented in Table-3. The one-step transitional probabilities are used to forecast the export shares for three years from 2017-18. For the next three years the forecasted exports of instant coffee to Russian Federation was found to be highest compared to other countries, but when it is compared to last year (2016-17) the export has been decreased. The export shares to Turkey is found to be increased for next three years and when compared to last year the export has increased considerably.

For counties like Malaysia, Ukraine and U.S.A there will be decrease in the export shares for next three years. For Malaysia, the forecasted export shares for the year 2017-18 will be higher than last year and found to be decrease for next two years. Export shares of Ukraine and U.S.A are higher than last year for all the three years, but there will be decrease in the export shares from year to year for these two countries.

Finland and Indonesia are showing increase in the export shares and their shares had been increased compared to last year. For Poland the export shares has been decreased from last year and there will be up and down in the export shares for next three years.

Findings of study emphasizing on similar topic also reported that countries denoted as 'Others' are importer of Indian coffee having highest stability with retention probability of 83 percent followed by Italy (69 %) and Germany (58 %) while Spain (6 %) was the least stable importer compared to rest of countries<sup>14</sup>.

# Conclusion

The export share of instant coffee is forecasted to be highest to Russian Federation for all 3 years but compared to last year, export share has been decreased. The export shares to Turkey, Finland and Indonesia are expected to rise but India's share to Malaysia, Ukraine, U.S.A and other countries is expected to fall. Where in case of Poland one and two-step forecasting showing decrease in export share but third step forecasting had increased significantly. Though the quantity of coffee exported to different countries has increased over the years, India has to capture new markets to sustain as also to increase the total coffee export.

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Research Journal of Mathematical and Statistical Sciences \_ Vol. 7(2), 13-20, May (2019)

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