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Vinay Kumar
Department of Business Management, CCS Haryana Agricultural University, Hisar, Haryana India

SK Goyal
Department of Business Management, CCS Haryana Agricultural University, Hisar, Haryana India

Nirmal Kumar
Department of Agricultural Economics, CCS Haryana Agricultural University, Hisar, Haryana India

Amita Girdhar
Department of Business Management, CCS Haryana Agricultural University, Hisar, Haryana India

Manoj Kumar
Department of Mathematics and Statistics, CCS Haryana Agricultural University, Hisar, Haryana India

Corresponding Author:
Vinay Kumar
Department of Business Management, CCS Haryana Agricultural University, Hisar, Haryana India

Stability analysis of Indian cotton exports using Markov Chain analysis

Vinay Kumar, SK Goyal, Nirmal Kumar, Amita Girdhar and Manoj Kumar

Abstract
The study was conducted on the cotton exports of India using Markov Chain analysis technique. The cotton export data from 2011-12 to 2020-21 was used for the research study. Top major cotton importing countries like- China, Bangladesh, Indonesia, Thailand, Turkey and Korea were selected and total of the cotton imports of rest of the countries was labelled as "Others". The trade directions of Indian cotton exports were analysed using the Markov Chain analysis approach. Transitional probability matrix was formed to know the share of export to each country. The results revealed China as the most stable market as it retained majority of its cotton imports from India followed by Bangladesh.

Keywords: Markov Chain, imports, trade directions, transitional probability matrix

Introduction
Cotton (*Gossypium* spp.), "the King of fibres" is a multipurpose crop grown under various agro-climatic conditions. Cotton belongs to the mallow family Malvaceae and is distinguished botanically as *Gossypium* spp. The most suitable soil for cotton cultivation is medium to deep black clayey soil, but is also grown in sandy and sandy loam soil through supplemental irrigation by farmers. Cotton is grown both under rain-fed and irrigated conditions. Nearly 36 per cent of cotton is cultivated under irrigated conditions in the country.

The crop has a global significance majorly grown for its lint and seed. Cotton is used for a number of products in the textile industry. It is also used in fishing nets, coffee filters, tents, explosive manufacturers, cotton paper and in bookbinding. The cotton seed which remains after the cotton is ginned and is fed to cattle and crushed to produce oil. This oil is used for cooking and in products like soap, emulsifiers, cosmetics pharmaceuticals, rubber and plastics. Linters are the short fibres that remain on the cotton seed after ginning and are used for producing goods like bandages, cotton buds, banknotes and x-rays.

India exported 7.8 million bales of cotton in 2020–21, a significant increase over the 4.7 million bales it exported in 2019–20. India exported cotton to more than 159 countries in 2021–2022. Between April 2021 and February 2022, India's top cotton importers were Bangladesh, China, and Vietnam. The three countries together accounted for almost 60% of all exports from India. The export of cotton and cotton yarn from India has continued despite the COVID-19 outbreak. After Bangladesh, China is the second-largest importer of cotton from India together accounting for over 80% of cotton imports. Over 15% of India's cotton exports go to Vietnam and Indonesia (Cotton corporation of India, 2021-22).

Cotton is an important cash crop in many developing countries supporting the livelihoods of millions of households. Among the countries in which cotton is an important contributor to rural households are India, China and Pakistan. India is the largest producer of cotton accounting for about 23 per cent of the world's cotton production. The other major cotton-producing countries in the world are the United States, Pakistan, Brazil, Australia, Turkey etc.

Materials and Methods
Markov chain model
The major cotton importing countries from India are Bangladesh, Malaysia, U Arab Emirates, Sri Lanka and Nepal. Annual export data of cotton were used for analysing the direction of trade and changing pattern of Indian cotton export. The trade directions of Indian cotton exports were analysed using the first order Markov chain approach. The lingo software was adopted to study the transition probability matrix.

Central to Markov chain analysis is the estimation of the transitional probability matrix 'P' whose elements, P_{ij} indicate the probability of exports switching from country 'i' to country 'j' over time. The diagonal element P_{ij} where i=j, measures the probability of a country retaining its market share or in other words, the loyalty of an importing country to a particular country's exports. Annual export data for the period 2011-12 to 2020-21 were used to analyse the direction of trade and changing pattern of Indian cotton export. In this context, major cotton importing countries *viz.*, Bangladesh, Malaysia, U Arab Emirates, Sri Lanka, Nepal and the remaining countries denoted as other countries. The average exports to a particular country were considered to be a random variable which depends only on the past exports to that country, which can be denoted algebraically as

$$E_{jt} = \sum_{i=0}^{n} E_{it-1} * P_{ij} + e_{jt}$$

Where,
E_{jt} = exports from India to the j^{th} country in the year t
E_{it-1} = exports of i^{th} country during the year t-1
P_{ij} = the probability that exports will shift from i^{th} country to j^{th} country
e_{jt} = the error term which is statistically independent of E_{it-1}
n = the number of importing countries
The transitional probabilities P_{ij}, which can be arranged in a (c x n) matrix, have the following properties

$$\sum_{i=1}^{n} P_{ij} = 1 \text{ and } 0 \le P_{ij} \le 1 = 1,$$

Thus, the expected export share of each country during period 't' is obtained by multiplying the exports to these countries in the previous period (t-1) with the transitional probability matrix. The probability matrix was estimated for the period 2011-12 to 2020-21. Thus, transitional probability matrix (T) is estimated using linear programming (LP) framework by a method referred to as minimization of Mean Absolute Deviation (MAD).

Min. OP* + I e
Subject to

X P* + V = Y
GP* = 1
P* ≥ 0

Where
P* is a vector of the probabilities P_{ij}
O is the vector of zeros
I is an appropriately dimensioned vector of area.
e is the vector of absolute errors
Y is the proportion of exports to each country.
X is a block diagonal matrix of lagged values of Y
V is the vector of errors
G is a grouping matrix to add the row elements of P arranged in P* to unity.

Results and Discussion

Direction of trade of Indian cotton export

The Markov chain analysis was used to examine the structural variations in the percentage of Indian cotton exported to the main markets. For cotton export, the transitional probability matrix was calculated. Over the study period (2011–2012 to 2020–21) of cotton exports as shown in Table 1 and 2, the transitional probability matrix provided a general indication of changes in the direction of cotton export from India. Using the actual ratio of exports to various importing nations, the transitional probability matrix for the research period was created. The changing patterns of trade among the importing nations are explained by this matrix.

Table 1: Country-wise export data on cotton exports from India

Year/Country	China		Bangladesh		Indonesia		Thailand	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
2011-12	1708046	1835118	265165.6	273714	26695.61	27991	15907.24	16104
2012-13	984278.9	968089	317094.4	343889	28889.8	19121	12503.16	13944
2013-14	1101952	1267905	367317.5	444002	55278.73	63561	23317.37	27183
2014-15	284918.1	269047	389517.4	389366	25070.07	23362	13636.55	12923
2015-16	109830.9	104679	374587	376722	49200.38	46314	9203.46	9060
2016-17	156295.1	233520	408822.3	446388	65549.28	70056	23779.6	23352
2017-18	138234.5	162319	407556.3	545659	65414.3	74664	18877.65	23262
2018-19	240990.8	209531	262409.3	220253	12868.66	5509	5100.17	6016
2019-20	178428.3	192900	457232.2	514700	42683.94	44600	5095.07	5400
2020-21	480326.2	626800	568426.1	813500	69353.88	89900	8783.22	12200

Table 2: Country-wise export data on cotton exports from India

Year/Country	Turkey		Korea		Others		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
2011-12	4583.71	4809	1405.9	1442	180990.7	189681	2202795	2348859
2012-13	5120.74	5576	1867.45	1846	373408.7	393822	1723163	1746287
2013-14	55329.39	63015	624.41	11310	384427.1	438348	1988246	2315324
2014-15	7269.37	7149	5243.14	5080	255546	243060	981200.7	949987
2015-16	19919.92	19084	2424.54	2333	609012.8	585288	1174179	1143480
2016-17	14120.71	11514	1907.57	1391	319021.5	381379	989496.1	1167600
2017-18	5233.28	6704	4103.97	5529	513664.9	579534	1153085	1397671
2018-19	151.47	225	1865.58	2220	259517.1	168504	782903.1	612258
2019-20	16528.59	16400	1580.49	1000	95784.97	98100	797333.5	873100
2020-21	2865.69	3900	345.95	400	188929.2	246600	1319030	1793300

The matrix's row elements shows the probability that trade will be lost due to competing countries. The column elements show the likelihood of gaining trade from competing countries. The Table 3 presents the transitional probability matrix for Indian cotton exports, which provides a general overview of the change in the direction of cotton trade during the study period. China, Bangladesh, Indonesia, Thailand, Turkey, and Korea were the top six importing nations taken into account for the study. The exports to nations other than these were grouped together under the heading "Others."

Table 3: Transitional probability matrix of Indian cotton exports (2011-12 to 2020-21)

Countries	China	Bangladesh	Indonesia	Thailand	Turkey	Korea	Others
China	0.6896	0.1038	0	0.0050	0.0039	0.0008	0.1967
Bangladesh	0.2931	0.6022	0.0750	0	0	0.0009	0.0286
Indonesia	0	0	0	0	0	0	1
Thailand	0	0	0	0	0	0	1
Turkey	0	0.9640	0	0.0359	0	0	0
Korea	0	0	0	0	0	0.1075	0.8925
Others	0	0.3525	0.0797	0.0401	0.0268	0.0035	0.4971

The probability matrix presented in Table 3 indicates that during the current period (2020-21), China is the most stable market amongst the studied markets as it has retained to the extent of about 69 per cent of its share. On the other hand, 20 per cent of its share was lost to other countries and 10 per cent to Bangladesh. Bangladesh, which is the next stable importer, could retain 60 per cent in the current time diverting 29 per cent of its share to China, 7 percent to Indonesia and 3 percent to other countries. However, Bangladesh gained 96 per cent share from Turkey, 35 percent from other countries and 10 per cent from China during the study period. On the other hand Indonesia, Thailand and Turkey turned out to be unstable importers of Indian cotton during the period losing 100 per cent of its share. But Indonesia gained 7 per cent share from Bangladesh and 8 per cent from others. Thailand gained 3 per cent share from Turkey and 4 per cent from others. The other countries retained almost 50 per cent, losing its share to the extent of 35 per cent to Bangladesh, 8 percent to Indonesia, 4 percent to Thailand and gaining 100 per cent from Indonesia and Thailand each, 89 percent from Korea. The high retention by other countries indicates that India has the opportunities to increase its cotton export to countries other than considered for the study. Therefore, efforts need to be taken to widen the geographical spread of cotton export to other potential countries. The major gainers among importers of Indian cotton during the reference period were other countries and Bangladesh. Other countries had gained 100 per cent from Indonesia and Thailand each and 89 percent from Korea. Bangladesh had gained 96 per cent from Turkey and 35 percent from other countries.

Other countries were having 49 per cent probability of retention which indicated that other countries were relatively moderate importer of Indian cotton. Korea with retention probability of 10 per cent was relatively less stable country for Indian's cotton import. Indonesia, Thailand and Turkey had zero probability of retention, hence are most unstable. The similar results was observed by Yamini, *et al.* (2020) [9] and Mahadevaiah, *et al.* (2005) [3].

Conclusion

China was found to be the most stable country among major importers of Indian cotton (69%) followed by Bangladesh (60 %). Whereas, other countries were having 49 per cent probability of retention. Indonesia, Thailand and Turkey had zero probability of retention. The major gainers among the importers of Indian cotton during the period were other countries and Bangladesh. Other countries had gained 100 per cent from Indonesia and Thailand each and 89 percent from Korea. Bangladesh had gained 96 per cent from Turkey and 35 percent from other countries.

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