



Stability analysis of Indian Sugar Export – A Markov Chain Approach

Aditya Bhooshan Srivastava¹, K.K. Singh², Supriya^{3*}, Sachin Srivastava⁴, Ashish Srivastava⁵, MahimaPriyanka Neerugatti⁶ and Sachin Kumar Verma⁷

^{1,2,3,6,7}Department of Agricultural Economics, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya-224229, India.

⁴Department of Agribusiness Management, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh India.

⁵Department of Agricultural Economics, Rama University, Kanpur, Uttar Pradesh, India

*Corresponding author: drsupriya.anduat2019@gmail.com

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Abstract:

The paper aim to quantify the changing structure of sugar exports from 2011-12 to 2022-23, based on entirely secondary data collected information from Ministry of Commerce and Industry. The Markov chain analysis was made to use linear programming method to evaluate the transition probabilities for the sugar markets. The results revealed that UAE, Somalia, Iraq, Bangladesh, and Saudi Arabia were the stable markets for Indian sugar exports, while Sudan, Sri Lanka, and Djibouti were identified as unstable markets. So, policies may be designed by planners for export to these countries. India has successfully maintained one of its original markets. However, it is not advisable to rely heavily on a single market in order to mitigate trade risks in the long term. It is important to explore new markets, such as Sudan, and prioritize established buyers like UAE and Somalia in order to preserve our current export position and market share in the future.

Keywords: Export, markov chain, transition probability matrix, sugar, stability.

Introduction

Sugarcane (*Saccharum officinarum* L.) is a perennial plant belonging to the Gramineae (Poaceae) family, thriving best in the tropical and subtropical regions of the southern hemisphere. It originated in New Guinea, around 6000 BC. By 1000 BC, it spread to southern Asia, including India, due to human migrations. Sugarcane had already been recognized as "ikshu" during Vedic times in India, and the Atharva Veda refers to it in connection with the symbolic use of sweetness in the form. The term "sharara," that is, sugar, has been found in Sanskrit since the sixth century BCE, indicating that cultivation and production also took place in very early years (Sharma and Singh, 2013). In this way, the work of ICAR-SBI to create new varieties, such as Co 0238 and Co 86032, has led the sugarcane yield to rise from 65 tonnes per hectare to 105 tonnes per hectare. This has helped to increase the production of sugar and exploit the increased revenue. In this manner, the sugar industry and farmers both are benefitted. It is also important to note that approximately 87 percent of the contribution to producing sugar is by sugarcane, and the remaining is by sugar beet all over the world. These crops are grown in more than 100 countries.

According to estimates by the Food and Agriculture Organization of the United Nations (FAO), world sugarcane production in 2020 was 1,869.70 million tons, lowering by 4.4% from the previous year. As the most significant historical producer of sugarcane, Brazil increased its market share from 26.5 percent in 2000 to 40.6 percent in 2010 and slightly contracted to 39.2 percent in 2020. India, the second-largest producer, lost market share from 23.4 percent in 2000 to 20.1 percent in 2020. Other relatively recent large producers are Thailand, China, Pakistan, and Mexico, the first of those displacing the latter between 2010 and 2020. World production remained stuck at 181.2 million tonnes of sugar. Brazil and India hold the leading positions in sugar production now, with 20.4% and 18.8% stakes, respectively, which collectively tops 40% of global sugar output. These top five—Brazil, India, the European Union, China, and Thailand—gathered 59.3% of global consumption; global consumption is forecast at 176.3 million tonnes in 2022-23, a new record high (Directorate of Sugar and Vegetable Oils, 2023)

About one-third of world production is exported, usually under preferential or bilateral arrangements. The five biggest exporters—Brazil, India, Thailand, Australia, and Guatemala—represent over three-quarters of the global exports on an aggregate basis. Some noteworthy importing countries accounting for one-third of imports are Indonesia, China, USA, Bangladesh, and Algeria. In this respect, the global sugar market is widely distorted and unpredictable; it gives a headache to the policymakers with fluctuating prices according to the industry's supply and demand, protectionist policies, or even geopolitical factors such as the one facing Russia and Ukraine (USDA, 2023).

The International Sugar Organization has projected world sugar to reach a record 181.9 million tonnes in 2022-23 surplus of 5.6 million tonnes. Is the growth projected to happen in Brazil, China, and Russia while there is a declines in India and Ukraine. India is the world's second-largest producer and consumer of sugar; its share in world sugarcane output is 18.8%, and in global sugar consumption, it is 16.2%.

Sugar production in India has increased by 6.1% per annum over 20 years, while consumption in the country has risen by 2.6%. India expects to produce 36 million tonnes in the 2021-2022 sugar season, showing a 16% increase compared to last year. The country, on average, ships 6.8 million tons of sugar each year. Its major export destinations are Indonesia, Bangladesh, Saudi Arabia, Iraq, and Malaysia. During 2021-22, India exported 110.58 lakh tonnes of sugar, and now it has become the second largest sugar exporter in the world, after Brazil (Ministry of commerce and Industry, 2023).

Under such scenario, it is essential to evaluate the direction and stability of exports from the country's major sugar market using an appropriate econometric model, which may assist us in quantifying variations in share allocation to different countries as well as between markets over time. As a result, the current work considers a probability model based on the Markov chain technique. There is an increasing recognition of the utility of this approach for study in a variety of fields, including exports, particularly when the process is steady yet gradually changes (Eswarprasad *et al.*, 1997). Sananseet *et al.*,(2004) investigated basmati rice export from an export potential perspective and discovered that rice is more competitive. Mahadevaiah *et al.*,(2005) used a first-order Markov chain model to study the dynamics of changes in cotton exports from India, predicting the likelihood of retention and switching patterns. Purohit *et al.*,(2008) employed a two-state Markov chain model to calculate the odds of dry and wet weeks, as well as conduct weekly rainfall study in Bangalore. Joshi *et al.*, (2015) investigated the stability of Indian spice exports, while Swarnalatha *et al.* (2024) analyzed Indian sugar exports using a Markov chain model.

Materials and Methods

In this paper, the structural change in sugar exports from India in terms of market retention and market switching was examined by using the Markov chain approach. Country

wise export data (in quantity and value terms) for the period 2011 to 2022 was collected from Ministry of commerce and industry.

The trade directions of Indian sugar (export) were analysed using the first order Markov Chain Analysis. The estimate of the transitional probability matrix 'P' is a basic component of Markov Chain Analysis. The chance that exports will eventually shift from nation "i" to country "j" is indicated by the components P_{ij} of the matrix P. The likelihood that a nation's export share would be maintained is shown by the diagonal members of the matrix. Stated differently, the importing country's level of allegiance to a certain country's exports may be determined by analyzing the diagonal components of the transitional probability matrix. The row parts show the likelihood of trade loss due to rival nations, while the column elements show the likelihood of trade gain from other rival nations.

Markov chain analysis

$$E_{jt} = \sum_{i=1}^n E_{it-1} P_{ij} + e_{jt} \quad \dots\dots\dots(1)$$

Where,

E_{jt} = export from India to the j^{th} country in the year t,

E_{jt-1} = exports of i^{th} country during the year t-1,

P_{ij} = probability that exports were shifted from i^{th} country to j^{th} country

e_{jt} = error term which is statistically independent of E_{it-1} ,

n = the number of importing countries and

t = number of years considered for the analysis

The transitional probabilities P_{ij} which can be arranged in a (c*r) matrix have the following properties.

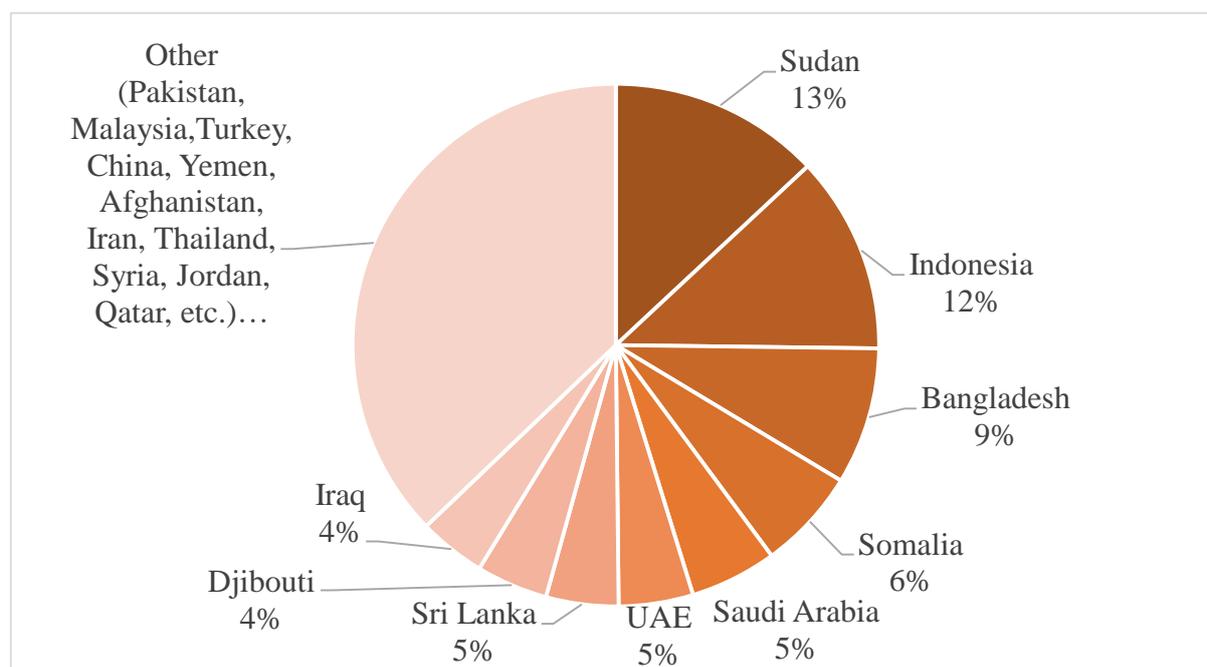
$$0 \leq P_{ij} \leq 1,$$

$$\sum_{i=1}^n P_{ij} = 1 \text{ for all } i$$

Thus, the expected export share of each country during period 't' is obtained by multiplying the export to these countries in the previous period (t-1) with the transitional probability matrix (Srivastava *et al.*, 2023; Swarnalatha *et al.*, 2024)

Results and Discussion

India is the world's second largest exporter of sugar, after Brazil. According to Directorate General of Commercial Intelligence and Statistics, Ministry of Commerce & Industry (2022), India majorly exports sugar to countries viz., Sudan (13.00 %), Indonesia (12.20 %), Bangladesh (8.48 %), Somalia (6.26 %), Saudi Arabia (5.34 %), UAE (4.57 %), Sri Lanka (4.45 %), Djibouti (4.40 %), Iraq (4.13 %) and rest of countries. Though Indonesia being the largest importer since last two years it has not been selected in the study due to the unavailability of data from last 10 years because it has started importing since 2020.

Figure 1 Sugar Export data from India 2022-23

Source: Directorate General of Commercial Intelligence and Statistic, Ministry of Commerce & Industry (2022)

The direction of trade of sugar to different importing countries was studied by estimating the transitional probability matrix using the Markov chain framework. The analysed was carried out in LINGO software. Transitional probability matrix of sugar export is presented in **Table 1** depicts a broader idea of change of the direction of trade over a period of twelve years. The major importing countries in term of quantity were the Sudan, Bangladesh, Somalia, Saudi Arabia, UAE, Sri Lanka, Djibouti, Iraq and rest of countries are categories in “Other” group. The diagonal value in a transitional probability matrix provide the information on the probability of retention of the trade. Furthermore the row elements indicate the probability of loss in trade on account of competing countries. The column elements indicate the probability of gain of import from other competing countries.

UAE was the largest importer of Indian sugar. It held a share of about 38.45 percent of sugar export during the entire study period. It is gained 10.21 percent share from Sudan, 9.25 percent share from Saudi Arabia, 8.21 percent share from Djibouti and 7.71 percent share from Somalia. Also it lost its 15.55, 12.51, 12.14, 9.19, 7.08 and 4.64 percent share to Saudi Arabia, Sri Lanka, Bangladesh, Djibouti, Iraq and Other respectively.

Somalia retained its 28.66 percent share. It is gained 24.82, 19.68, 11.69, 10.14, 8.47 and 1.96 percent share from Saudi Arabia, Sudan, Djibouti, Sri Lanka Iraq and Bangladesh respectively. It lost 15.77, 11.53, 10.87, 10.61, 10.16, 7.71 and 4.29 percent share to Bangladesh, Sudan, Saudi Arabia, Sri Lanka, Djibouti, UAE and Iraq respectively.

Iraq retained its 20.20 percent share. It is gained from 88.97, 35.01, 18.26, 11.57, 7.08, 4.29 and 1.22 percent share to other, Djibouti, Sri Lanka, Saudi Arabia, UAE, Somalia and Sudan respectively. Whereas, it lost 20.54, 19.77, 18.53, 12.53 and 8.47 percent share to Iraq, Bangladesh, Djibouti, Other and Somalia respectively.

Bangladesh retained its 14.33 percent share. These country gained from 19.77, 15.77, 15.28, 14.33, 12.14, 10.63 and 7.55 percent share from Iraq, Somalia, Sudan, UAE, Other and Saudi Arabia. These country lost from 29.70, 29.16, 14.63, 14.33, 9.99 and 1.96 percent share to Djibouti, Other, Sri Lanka, Sudan and Somali respectively.

Saudi Arabia retained its 10.28 percent share. It is gained from 32.93, 15.55, 11.84, 10.87 and 10.28 percent share to Sudan, UAE, Djibouti, and Somalia respectively. Whereas it lost 17.76, 11.57, 11.36, 9.25, 7.55 and 7.23 per cent share to Sri Lanka, Iraq, Djibouti, UAE, Bangladesh and Other respectively.

Furthermore, the result depict that in quantity term Sudan, Sri Lanka, Djibouti and Other retained none of its share. UAE, Somalia, Iraq, Bangladesh and Saudi Arabia were the stable market and Sudan, Sri Lanka and Djibouti were the unstable market. The probable reason may be that these countries are importing sugar from other region.

In value term UAE was the largest importer of Indian sugar. It retained about 46.69 percent share of Indian sugar during the entire study period. The probable reason behind this may be because of its increased domestic demand for sugar. Sugar is used for a wide range of purposes, including as a preservative, a viscosity-enhancing agent, a sweetening agent, and for various other reasons in foods and beverages. Additionally, sugar is utilized in the production of biofuels like ethanol, in the manufacturing of various products such as detergents, and in the fermentation process for alcoholic beverages like beer, wine, and distilled spirits. Moreover, sugar is employed in the textile industry for sizing and finishing fabrics, as well as in leather tanning. Furthermore, UAE lost to 10.43, 10.17, 9.18, 8.41, 7.68 and 7.66 percent share to Bangladesh, Somalia, Sri Lanka, Other, Iraq and Djibouti respectively whereas it future gained 22.76 percent share from Sudan, 23.48 percent share from Bangladesh, 12.95 percent share from Djibouti, 8.89 percent share from Saudi Arabia and 8.03 percent share from Somalia respectively (**Table 2**).

The result indicate that in value term UAE, Somalia, Saudi Arabia, Iraq and Bangladesh are stable market and Sudan, Sri Lanka, Djibouti and Other are unstable market. Sudan lost majority share of 34.50, 28.07, 22.76 and 14.72 percent to Iraq, Bangladesh, UAE and Saudi Arabia respectively whereas future gained from 22.00, 20.03, 11.79 and 8.71 percent share from Bangladesh, Djibouti, Saudi Arabia and Somalia.

Sri Lanka lost its 50.81 and 48.81 percent share to Djibouti and other respectively whereas future gained from Somalia (9.98 %), UAE (9.18 %) and Saudi Arabia (7.35 %) respectively.

Djibouti Lost its 40.68 percent share from Iraq, 20.03 percent share from Sudan, 15.71 percent share from Saudi Arabia, 12.95 percent share from UAE and 10.59 percent share from Somalia respectively whereas future gained from 50.81, 21.03, 12.79, 12.59, 8.77 and 7.66 from Sri Lanka, Iraq, Bangladesh, Somalia, Saudi Arabia and Iraq.

Other country which include Pakistan, Malaysia, Turkey, China, Yeman, Afghanistan, Iran, Thailand, Syria, Jordan, Qatar, etc. These countries future gained from Sri Lanka (48.81 %), Iraq (22.65 %), Saudi Arabia (8.44 %), UAE (8.41 %) whereas it lost from Iraq (86.23 %) and Bangladesh (13.42 %).

Bangladesh has a low retention probability of its own share of import about 20.88 percent but it likely to gain from Sudan (28.07%), Iraq (21.09 %), Other (13.42%), Saudi Arabia (11.96 %), UAE (10.43 %), and Somalia (8.84 %).

The direction of trade concluded that India has an edge to export sugarcane because of the second largest producer in world. Therefore, from **figure 1, table 1 and 2** clearly depict that UAE and Somalia share is low but still is the strongest trading partner of Indian Sugar. But in recent Sudan was importing maximum amount of sugar from India but this was unstable markets. Sudan emerged as a new market opportunities for India.

Table 1 Transition Probability matrix of sugar export in quantity from India (2011 to 2022)

	Sudan	Bangladesh	Somalia	Saudi Arabia	UAE	Sri Lanka	Djibouti	Iraq	Other
Sudan	0.0000	0.1528	0.1968	0.3293	0.1021	0.1979	0.0132	0.0122	0.0000
Bangladesh	0.0999	0.1433	0.0196	0.0000	0.0000	0.1463	0.2970	0.0000	0.2916
Somalia	0.1153	0.1577	0.2866	0.1087	0.0771	0.1061	0.1016	0.0429	0.0000
Saudi Arabia	0.0000	0.0755	0.2482	0.1028	0.0925	0.1776	0.1136	0.1157	0.0723
UAE	0.0000	0.1214	0.0000	0.1555	0.3845	0.1251	0.0919	0.0708	0.0464
Sri Lanka	0.0000	0.0000	0.1014	0.0000	0.0000	0.0000	0.3906	0.1826	0.3243
Djibouti	0.2558	0.0000	0.1169	0.1184	0.0821	0.0766	0.0000	0.3501	0.0000
Iraq	0.2054	0.1977	0.0847	0.0000	0.0000	0.0000	0.1853	0.2020	0.1253
Other	0.0000	0.1063	0.0000	0.0000	0.0000	0.0000	0.0000	0.8897	0.0000

Table 2 Transition Probability matrix of sugar export in value from India (2011 to 2022)

Countries	Sudan	Bangladesh	Somalia	Saudi Arabia	UAE	Sri Lanka	Djibouti	Iraq	Other
Sudan	0.0000	0.2807	0.0000	0.1472	0.2276	0.0000	0.0000	0.3450	0.0000
Bangladesh	0.2200	0.2088	0.1143	0.0891	0.2348	0.0000	0.1279	0.0000	0.0000
Somalia	0.0871	0.0884	0.4121	0.0941	0.0803	0.0998	0.1259	0.0110	0.0000
Saudi Arabia	0.1179	0.1196	0.0000	0.3647	0.0889	0.0735	0.0877	0.0668	0.0844
UAE	0.0000	0.1043	0.1017	0.0000	0.4669	0.0918	0.0766	0.0768	0.0841
Sri Lanka	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5081	0.0000	0.4881
Djibouti	0.2003	0.0000	0.1059	0.1571	0.1295	0.0000	0.0000	0.4068	0.0000
Iraq	0.0000	0.2109	0.1258	0.0000	0.0000	0.0000	0.2103	0.2299	0.2265
Other	0.0000	0.1342	0.0000	0.0000	0.0000	0.0000	0.0000	0.8623	0.0000

Figure 2 Directional Graph of sugar export in quantity from India

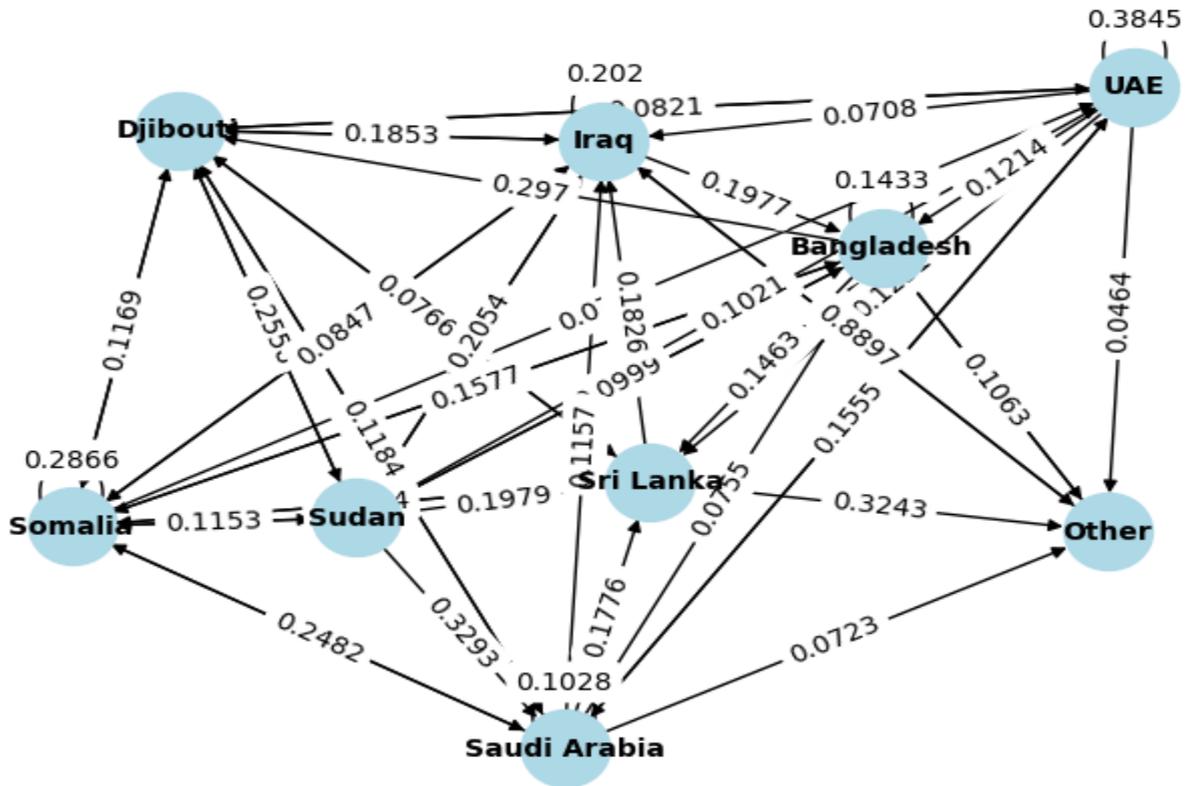
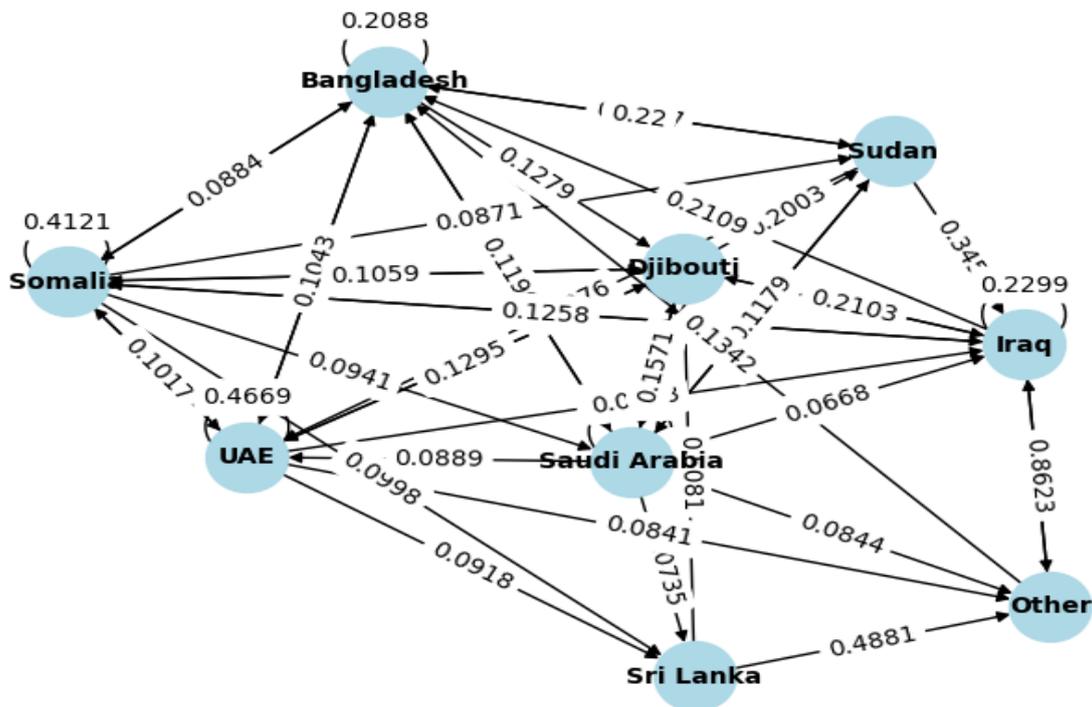


Figure 3 Directional Graph of sugar export in value from India



Conclusion

According to the discussion above, in terms of quantity, the analysis revealed that the UAE, Somalia, Iraq, Bangladesh, and Saudi Arabia were the most consistent markets,

accounting for a sizable portion of Indian sugar exports. Sudan, Sri Lanka, and Djibouti were labeled as unstable markets. In terms of value, the UAE, Somalia, Saudi Arabia, Iraq, and Bangladesh emerged as stable markets, whereas Sudan, Sri Lanka, Djibouti, and "Other" countries were unstable. According to the study, Sudan, which was previously the leading importer of Indian sugar, has lost market share to Iraq, Bangladesh, the United Arab Emirates, and Saudi Arabia. Sudan did, however, gain market share from Bangladesh, Djibouti, Saudi Arabia, and Somalia. In light of these findings, India has a significant advantage in sugar exports because it is the world's second-largest producer. While traditional markets like UAE and Somalia continue to be vital, new prospects have surfaced in nations like Sudan, which has become a key importer of Indian sugar.

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