Production, Sustainability and Fish Trade Prospect of India by Using Markov Chain Analysis

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Abstract. The paper attempts to analyze fish production and the direction of trade. Data for the analysis was taken from a period of 10 years (2011-2021) from the Ministry of Commerce & Industry and FAO. To examine the type and extent of increase in the fish area, production, and productivity throughout the course of the year for several countries, including China, Vietnam, the United States, Norway, and India, descriptive statistics and the sustainability index were utilized. Markov chain analysis employing linear programming was then applied to determine transition probabilities in fish trade. The fish export markets were the USA, China, Japan, Thailand, Taiwan, Kuwait, Hong Kong, and others. The fish export markets were categorized as stable markets (China, USA, Taiwan, Thailand, and Hong Kong) and unstable markets (Japan and Kuwait) based on the magnitude of transition probabilities. Though the country has a good potential for export of fish. India must therefore give rising output more consideration, supported by measures that encourage exports. In addition, initiatives must be made to develop a new market and broaden the trade area to include other significant, global markets.

1. Introduction

In India, the fisheries sector employs about 14.5 million people at the primary level and many more across the value chain because to its vast resources and potential. The surge in global demand for fish products in recent years can be mostly attributed to a shift in dietary preferences towards fisheries, driven by their health-a enhancing properties, including the ability to lower blood pressure and lessen the risk of heart attack or stroke. Fish is also rich in omega-3 fatty acids. During pregnancy, the development of the baby's vision and nerves depends on these nutrients for healthy heart and brain function [1]. The most significant sector of the global economy is fishing [2]. The social and economic landscape is changing quickly, and there has been an increase in globalization, which has increased fish production worldwide.

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When it comes to fish production, India comes in third place globally. India accounts for around 7.56 percent of the world's fish production, contributing approximately 1.24 percent to the nation's Gross Value Added (GVA) and over 7.28 percent to the agricultural GVA. Since 2014–15, the fisheries sector has demonstrated remarkable double-digit annual growth of 10.87%, achieving a record fish production of 145 lakh tonnes in FY 2020–21. In terms of employment, the sector sustains the livelihoods of over 28 million individuals in India, particularly benefiting marginalized and vulnerable communities. Export earnings from the fisheries sector was ₹ 46,662.85 crore during 2019-20 [3].

The coastal states, particularly West Bengal, contribute significantly to the country's fish production, with West Bengal leading at 508.89 metric tonnes, followed by Andhra Pradesh and Gujarat at 358.68 and 294.92 metric tonnes, respectively. The Union Minister reported that Karnataka has received 734.77 crore rupees under the Pradhan Mantri Matsya Sampada Yojana (PMMSY) flagship program from 2020–21 to the present, aiming to develop infrastructure amenities. The PMMSY program aims to achieve a fish production of 22 million tonnes by 2024–2025, providing employment opportunities for 55 lakh people [4].

India is a significant fish exporter to the world. Currently, fish and fish products make up the majority of India's agricultural exports. India exported fish products worth a total of 57,586.48 crore rupees in 2021, or around 13,69,264 metric tonnes. The primary purchasers of marine products from India are American nations. The amount exported to these nations in 2021 was valued at USD 3371.66 million, with China coming in second with 2,66,989 metric tonnes valued at USD 1,175.05 million. Japan, South East Asia, and the European Union are further significant importers. The most valuable export product is frozen shrimp, which is followed by frozen fish, frozen cuttlefish, frozen squid, dry goods, and live goods [5]. In light of the fishery sector's improved export performance, production growth, and sustainability index, the present study was undertaken with the following specific objectives: (1) to estimate the growth and sustainability index of fish production in India and other countries; and (2) to examine the growth pattern and trade direction of fish exports from India.

2. Materials and Methods

Period of study:

The Fish production and Direction of trade was analysed from period 2011-2021.

Source of the study:

The collected data was purely secondary. It was collected from the Ministry of Commerce and Industry.

Statistical Tools:

Many statistical tools were adopted to describe the above series are:

Descriptive statistics

These descriptive statistics offered simple summaries about the data and the measures. Quantitative data was presented logically and understandably using descriptive statistics. The research study employed a number of measures or just one to evaluate a sizable sample of participants. With the use of descriptive statistics, it allows for the comprehension of enormous amounts of data. Each descriptive statistic condenses a large amount of data into a concise statement.The descriptive statistics that were used for the study are maximum, minimum, mean, standard deviation, standard error, skewness, kurtosis, and simple growth rate (SGR%) to describe the production scenario of fish production in India.

$$SGR\ per\ cent = \frac{X_t - X_0}{X_0 \text{x}\ n} \text{x}100\,, \tag{1}$$

where, X_t = value of the series for the last period; X_0= value of the series for first period; and n = number of periods

Sustainability Index (SI):

Sustainability is multidimensional, multifariously defined (by various authors for various specific purposes) contested phenomenon. Despite being in dispute, it is generally acknowledged that it has several facets and must be evaluated in a variety of ways. In its most basic form, it can be evaluated in terms of its economic, social, and biophysical elements. As a result, in the current situation, sustainability indicates that a fish will continue to be produced over an extended period of time.In order to measure the sustainability index the study period was divided into three periods viz., period I (2011-2015); period II (2015-2020); and period III (entire period) denoted by;

$$SI = \frac{S_i}{\bar{Y}_i} . \frac{1}{S_{max}} \quad (2)$$

where,

S_i = Standard deviation of the production,

Y_i = mean production of ith treatment, and

Smax = Maximum Standard deviation.

As indicated by the index value, a lower value signifies a greater sustainability status [6].

Direction of Trade:

The trade directions of Fish (export) were analysed using the first order Markov Chain Analysis [7]. The estimation of the transitional probability matrix P is the core component of Markov Chain Analysis. The variables Pij of the matrix P show the probability that exports will gradually shift from country ‘i’ to country 'j'. The likelihood that a country's export share will be maintained is calculated using the matrix's diagonal elements or, to put it another way, a closer look at the diagonal parts of a transitional probability matrix reveals the commitment an importing nation has to its exports. The row parts display the likelihood of trade losses resulting from competing nations, while the column elements display the likelihood of trade gains from competing nations.

Markov chain analysis:

$$E_{jt} = \sum_{i=1} E_{it-1} P_{ij} + e_{jt} \quad (3)$$

Where,

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

E_{jt-1} represent the export of the i^{th} country in year t-1,

Pij represent likelihood that exports will transition from i^{th} country to j^{th} country ejtrepresent error term which is statistically independent of $E_{it-1,}$

n signifies the number of importing countries and t signifies number of years incorporated for the analysis

The transitional probabilities Pij which can be arrange dina (c*r) matrix have the following properties [8, 9].

$$\sum_{i=1}^{n} P_{ij} = 1 \; for \; all \; i \quad (4)$$

Therefore, in order to determine the anticipated export share of each nation in period 't', the export to that nation in period 't-1' is multiplied by the transitional probability matrix.

3. Result and Discussion

Descriptive Statistics of Fish Production

Descriptive statistics for fish production between 2011-2020 were presented in table for different countries i.e., China, Vietnam, USA, Norway and India. While the maximum value of fishproductioninIndiawas77.95thousandtonnes, where as the minimum value was 367.30 thousand tonnes between 2011-2020. Consequently, total fish production in India was expressed by SGR % i.e. 108.89 percent. Furthermore, production of growth rate was 3.53 percent, 5.30 percent, 105.20 percent and 2.03 percentin China, Vietnam, USA and Norway respectively.

The data for Vietnam and India were positively skewed and platykurtic, demonstrating that a small area was shifted in favor of fish farming during the early period. Leptokurtic and negatively skewed data for China and Norway point to a little shift in a region during the second half. The positive skewness (3.15) and kurtosis values suggested that output increased in the beginning of the study and remained nearly constant throughout the study period for USA. The measure of central tendency, namely, mean > median > mode, confirmed the positive skewness criterion, implying that the data were asymmetric in nature. As indicated by the assessment, fish production has been a progress in all countries.

Table 1. Descriptive Statistics of fish production

	China	Vietnam	USA	Norway	India
Mean	43912377.50	3627074.00	851182.50	1324517.50	5710700.00
Median	44782085.50	3516377.00	434340.50	1329327.00	5480000.00
Standard Deviation	4446951.40	546932.40	1309314.20	83079.28	1460180.00
Kurtosis	1.13	-1.18	9.98	2.02	-1.31
Skewness	-0.45	0.28	3.15	-0.94	0.25
Minimum	36613446.00	2845562.00	397292.00	1143893.00	3673082.00
Maximum	49546321.00	4442257.00	4576832.00	1452926.00	7795000.00
SGR%	3.53	5.30	105.20	2.03	108.89

Sustainability Index of production

Sustainability in the production of fish in different countries has been measured with the help of sustainability indices as described in the material and methods section in which the study period was divided into three periods: period I from 2011 to 2015, period II from 2016 to 2020, and period IIIfrom2011to 2020 (entire period).

From Table 2 it revealed that the sustainability index was increasing in period for five countries China, Vietnam, USA, Norway, and India as compared from 1.18 (period)to 1.61 (period 2) for China, 1.21 (Period I) to 4.89 (Period II) for Vietnam, 4.89 (Period I) to 7.79(PeriodII) for USA,1.10(PeriodI) to2.24(PeriodII) for Norway and 2.21 (Period I) to 7.28 (Period II) for India. Therefore, it was observed that the sustainability index for India was increased majorly which is undesirable as the higher value of the sustainability index means lower environmental balance and natural sustainability. Overall, the sustainability index was maximum for India i.e. 5.74 followed by Vietnam(3.39), China(2.27), Norway(1.41) and USA (1.17).

Table 2. SustainabilityIndexofproduction

SI	China	Vietnam	USA	Norway	India
Period I	1.18	1.21	4.89	1.10	2.21
Period II	1.61	4.89	7.79	2.24	7.28
Overall	2.27	3.39	1.17	1.41	5.74

Destination-wise growth rates in the export of fish from India

According to IBEF (2021), table 3 lists the top importers and exporters of Indian fish as the United States, China, Japan, Thailand, Taiwan, Kuwait, Hong Kong, and other countries. When it comes to the volume of exports, fish exports saw a positive growth rate of 1.00 % (P<0.01).

Fish exports to countries like the USA (-19.01% annually) and Thailand (-10.41% annually) have a negative growth rate, whereas positive compound growth rates were observed in China (57.99% annually), Japan (P0.01), Taiwan (P0.02), Kuwait (38.01% annually), Hong Kong (14.35% annually), and other (5.12% annually) countries. However, China, Japan, and Taiwan were statistically significant (P<0.01) countries.

Table 3. Destination-wise growth rates in the export of fish from India (2011-2012 to 2020-2021)

Destination	Growth rate per annum Quantity (%)	Share in total quantity export quantity (%)
USA	-19.01^{NS}	14.89
China	57.99*	8.31
Japan	8.39*	7.04
Thailand	-10.41 ^{NS}	6.58
Taiwan	34.02*	5.89
Kuwait	38.01 ^{NS}	2.13
Hong Kong	14.35 ^{NS}	7.68
other	5.12 ^{NS}	47.48
Total	6.67	100.00

Note: * denotes significance 1% (P<0.01) level of probability
** denotes significance at 5% (P<0.05) level of probability

Transition Probability Matrix for a quantity of fish export from India

The Markov chain model is used to analyze quantitative data from the past decade (2011-12 to 2020-21) in order to examine the trade direction and stability of the fish market. Table 4, which includes the Transitional Probability Matrix, provides a comprehensive measure of changes in the export direction of fish from India throughout this period. The USA, China, Japan, Thailand, Taiwan, Kuwait, and Hong Kong were the main importing countries in terms of quantity. All other importing nations were classified under the "other countries" category. The transitional probability matrix has row items that indicate the amount of trade loss caused by competition from other nations. The diagonal element represents the likelihood of a country maintaining its trade volume from the previous year.

Table 4 clearly depicted that China was the most reliable and steadfast market among the main importers of Indian fish, with a retention probability of 68.34%. The USA had a retention probability of 34.15%, followed by Taiwan (22.65%), Thailand (20.92%), and Hong Kong (13.68%). Japan and Kuwait were the importing countries that showed a

retention rate of zero percent, suggesting a lack of consistency in India's exports to these nations.

Japan lost to the tune of 41.60 percent from other countries whereas, in the future gained from Hong Kong 58.31 percent. Kuwait lost about 63.41 percent of its previous share to China and about 27.98 percent of its share to the USA, which means in the future China can gain its share from Kuwait, Hong Kong, and other countries.

Hong Kong has a low retention probability of its share of imports about 0.1368but is likely to gain from Taiwan (59.37%), Japan (31.76%), and the USA (23.53 %).

Table 4. Transition Probability Matrix for the quantity of fish export from India (2011-2012 to 2020-2021)

Year	USA	China	Japan	Thailand	Taiwan	Kuwait	Hong Kong	other
USA	0.341517	0.123517	0.041036	0.006289	0.128430	0.187681	0.235300	0.019436
China	0.000000	0.683447	0.083984	0.000000	0.308154	0.000000	0.000000	0.000000
Japan	0.000000	0.000000	0.000000	0.000000	0.266340	0.000000	0.317602	0.416056
Thailand	0.110934	0.153938	0.102305	0.209209	0.136713	0.098181	0.000000	0.218761
Taiwan	0.000000	0.000000	0.17976	0.000000	0.226502	0.000000	0.593737	0.000000
Kuwait	0.279880	0.634178	0.000000	0.000000	0.000000	0.000000	0.000000	0.093478
Hong Kong	0.000000	0.26666	0.583102	0.000000	0.000000	0.000000	0.136846	0.074965
other	0.482245	0.256549	0.081553	0.000000	0.000000	0.186403	0.000000	0.075492

4. Conclusion

The above discussion emphasized the fact that fish production has progressed in which the maximum growth rate of fish production found in India (108.89) followed by the USA (105.20). Therefore, it was observed that the sustainability index for India was increased majorly which is undesirable as the higher value of the sustainability index means lower will be environmental balance and natural sustainability. Overall, the sustainability index was maximum for India i.e. 5.74 followed by Vietnam (3.39), China (2.27), Norway (1.41), and USA (1.17). Although China was the most reliable and devoted market among the major importers of Indian fish, as indicated by the probability of retention at 68.34 percent, the USA was the second-most stable and devoted market, followed by Taiwan, Thailand, and Hong Kong. However, the destination-wise growth rates in the export of fish from India show positive growth and significance at 1% and the maximum share of export maximum in the USA after other countries. However, several of the importing nations, such as Japan and Kuwait, have zero percent retention rates, indicating instability in India's exports to these nations.

Fisheries, despite being a sector with significant potential, have been ignored for a variety of reasons. The fisheries sector can contribute to the nation's food and nutritional security if it is well-organized and regulated. To ensure that fishermen receive higher rates, efforts must be made to replace the largely unorganized and unregulated auction system of fish marketing. By building the right infrastructure, it will be easier to move and store seafood. Due to the enormous potential for growth in the export of high-quality fish products from India, demand for these items on the global market is constantly rising. It is necessary to develop a common

market policy for fish to make operation and regulation easier, even if there are numerous organizations and policies in the country that support the promotion of fish marketing.

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