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Research Article

Growth and instability of fish production and marine export of India: An empirical study

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Abstract

India being the 3rd largest fish and aquaculture producing country, its fisheries sector plays a pivotal role in India's economic and nutritional landscape, providing livelihoods to millions of people and contributing significantly to the country's food security. The present study estimates Compound Annual Growth Rates (CAGR), Cuddy-Della Valle index (CDV) and Coefficient of Variation (CV) to analyze the growth and instability in fish production and export of marine products from India for a period of 40 years from 1980 to 2020. The study revealed that CAGR of inland fish production was much higher than that of marine, indicating resource depletion taking place in the marine segment of the Indian fishery. The computation of CAGR based on total quantity of fish exported indicated positive results across all the countries considered in the present study. The countries of Southeast Asia including China followed by USA have achieved highest CAGR in terms of export value of total quantity of fish. The estimates of CDV index based on quantity of total fish exported were highest for the USA and lowest for Japan. Addressing these challenges through sustainable practices and strategic interventions is crucial for ensuring the long-term viability and prosperity of the Indian fisheries sector and diversification of the market to enhance the stability and growth of marine product exports in a rapidly changing global environment.

Keywords: Coefficient of variation (CV), Compound growth rate (CGR), Cuddy-Della Valle (CDV) index of instability, Marine products export, Risk assessment

INTRODUCTION

Fisheries sector plays a catalyst role in the Indian economy by making significant contributions to the national income, exports, food, nutritional security and employment generation. India is recognized as the 3rd largest fish and aquaculture-producing country and accounts for about 16% of total inland and 5% of total global marine fish production. In 2021-22, India's total fish production was estimated at 162.48 lakh tonnes, which includes 121.21 lakh tonnes and 41.27 lakh tonnes from inland and marine sectors, respectively (Handbook of Fisheries Statistics, GOI, 2022). Being the 3rd position among global fish exporting countries, Indian marine product export has been an important contributor to India's foreign exchange earnings for several decades, starting from the late 1930s (Dash and Patra, 2014). The demand for fresh and processed fish, both within India and in international markets has led to significant economic growth in the marine product export sector (Das *et al.*, 2016). The liberalization of the Indian economy in the 1990s and the subsequent inclusion of fisheries in Non-Agricultural Market Access in 2001 were indeed pivotal moments that played a significant role in the growth of the fisheries sector in India. During 2021-22, the export earnings from marine products crossed 7.76 billion USD, aggregated to 13,69,264 tons in volume and 57,586.48 crores in value, which is the highest export value ever. Compared to the previous year, seafood exports recorded a growth of 19.12% in quantity, 31.71% in Rupee and 30.26% in US$ earnings, respectively (MPEDA, 2022). This indicates the potential for increasing the export of marine products from India. The goal of this study was to examine the growth and instability of Indian marine product exports to the key importing nations viz., Japan, USA, Southeast Asia, the European Union and the Middle East, to identify the most desirable destination for marine products export from India. This will enable the policymakers and exporters to plan for an adequate quantity of exportable surplus every year. Thus, this study aimed to examine the export trend of marine fish production in terms of quantity and value in India in the last two decades, to estimate the growth and instability of Indian fish production, risk assessment of Indian marine products export in the last four decades.

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MATERIALS AND METHODS

Time series data on fish production and marine products export of India for a period of 40 years from 1980 to 2020 (Fig. 1 and 2) was collected from MPEDA, Handbook on Fisheries Statistics, 2021. Using the exponential growth function (Salim and Biradar, 2009), the growth in terms of the quantity exported and the export value realized from exports was examined. It had the following form: $Y = ab^t e_t$ _____(1)

where, Y = Dependent variable for which growth rate was estimated; a = Intercept; b = Regression coefficient; t = Time variable and e = Error term

The compound growth rate was obtained for the logarithmic form of the equation as: $\widehat{l\_y} = \hat{\beta} + \hat{\beta}_2 t$ —(2)

The compound growth rate was obtained for the logarithmic form of the equation as:

CAGR=(Antilog of $\hat{\beta}_2 - 1$) 100 ——————(3)

The index of instability can be measured using a variety of methods (Massell, 1970; Weber and Sievers, 1983; Parthasarathy, 1984; Singh and Byerlee, 1990; Wasim, 1999). In this study, Instability analyses instability in production and export of total fish examined by using two different measures of instability such as Coefficient of Variation and Cuddy-Della Valle Index. Although Coefficient of Variation (C.V) is the simplest measure of instability, it overestimates the level of instability in time series data, which are characterized by long-term trends. The long-term trend's coefficient of variation is adjusted by the Cuddy-Della Valle Index. The precise direction of the instability is indicated by the de-trends of the Cuddy- Della Valle Index. Low production and export instability is indicated by a low index value, and vice versa. Cuddy-Della Valle index (Cuddy and Della Valle, 1978) was used to assess the instability, as follows:

Coefficient of Variation (CV)

$$= \frac{Standard\ Deviation}{Mean} x100$$

Cuddy-Della Valle (CDV) = $CV x\sqrt{1 - \bar{r}^2}$ where, $\bar{r}^2$ is the adjusted R squared.

In order to determine the risk of exporting Indian marine products, the relationship between growth and instability was visually examined, and the importing nations were categorized into four groups: high

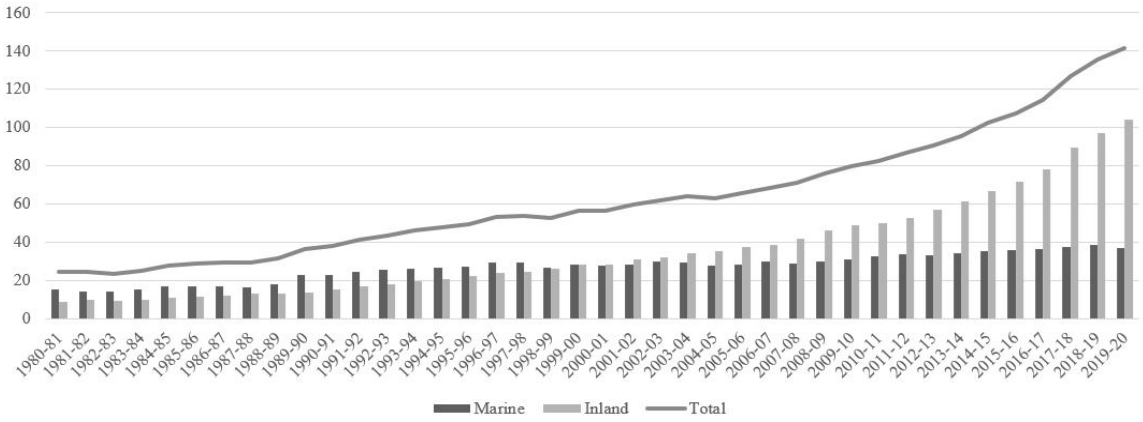

Fig. 1. Volume of fish production in India (in lakh tonnes) from 1980 to 2020

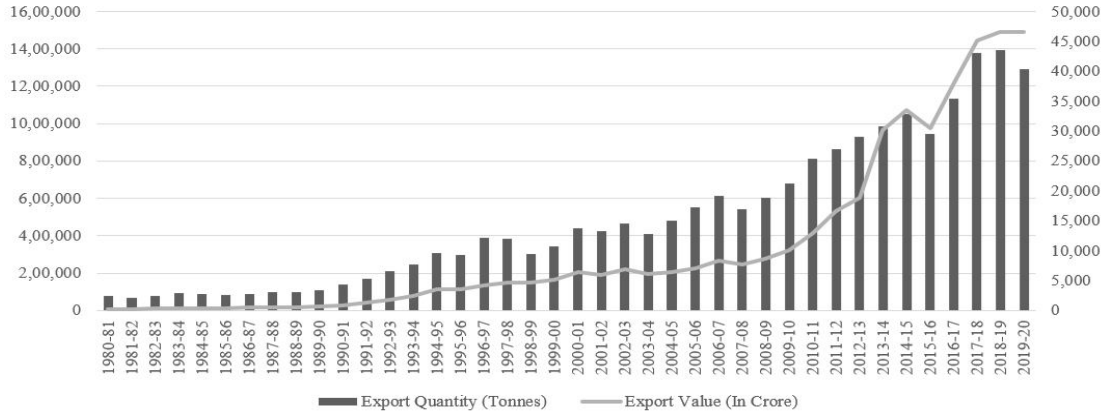

Fig. 2. Export quantity and value of marine products from India (1980 to 2020)

Model 1. Calculation of CAGR for total marine fish production in India during 1980-81 to 2019-20

	Coefficients	Standard Error	t Stat	P-value
Intercept	1.20823	0.014909	81.04217	3.53E-44
Time	0.010141	0.000634	16.00304	1.79E-18

R-squard =0.87, Adj. R-squard=0.867, n=40

$$In_{Marine} = \hat{\beta}1 + \hat{\beta}2\,year$$

$$In_{Marine} = 1.21 + 0.010 * Time$$

$$CAGR = (Antilog\ of\ \hat{\beta}2 - 1) * 100$$

$$= (1.010 - 1) * 100 = 1.005\%$$

Model 2. CAGR calculation of inland fish production volume from 1980-81 to 2019-20.

	Coefficients	Standard Error	t Stat	P-value
Intercept	0.905597283	0.007032132	128.7799045	8.55931E-52
Time	0.026495879	0.000298902	88.644162	1.19004E-45

R-squard = 0.995, Adj. R-squard=0.995, n=40

$$In_{Inland} = \hat{\beta}1 + \hat{\beta}2\ year$$

$$In_{Inland} = 0.905 + 0.026 * Time$$

$$CAGR = (antilog\ of\ \hat{\beta}2 - 1) * 100$$

$$= (1.026 - 1) * 100 = 2.634\%$$

Model 3. CAGR calculation of volume of total fish production in India from 1980-81 to 2019-20

	Coefficients	Standard Error	t Stat	P-value
Intercept	1.356826	0.008894	152.5513	1.39E-54
Time	0.018909	0.000378	50.01751	2.74E-36

R-squard =0.985, Adj. R-squard=0.984, n=40

$$In_{Total} = \hat{\beta}1 + \hat{\beta}2\,year$$

$$In_{Total} = 0.356 + 0.018 * Time$$

$$CAGR = (Antilog\ of\ \hat{\beta}2 - 1) * 100$$

$$= (1.018 - 1) * 100 = 1.816\%$$

Table 1. Comparison of CAGR and Cuddy-Della Valle (CDV) of Indian fish production from 1980-81 to 2019-20

	CAGR (%)	Cuddy-Della Valle (CDV)%
Marine Production (Volume in lakh tonnes)	1.005	9.501
Inland Production (Volume in lakh tonnes)	2.634	4.959
Total Fish Production (Volume in lakh tonnes)	1.816	6.296

growth-low risk, high growth-high risk, low growth-low risk, and low growth-high risk. (Jeyanthi and Nikita, 2012; Manjunath *et al.*, 2017; Singh *et al.*, 2017; Nisar *et al.*, 2020; Siby and Arunachalam, 2020).

RESULTS

Growth rate of Indian fish production and marine products export: The compound annual growth rates (CAGR) were estimated using the equation (3) to examine the changes in total marine fish production, total inland fish production and total fish production during the period 1980-81 to 2019-20 (Fig. 1) and presented in Table 1. The compound annual growth rate has been estimated using Model 1, Model 2 and Model 3 for total marine fish production, total inland fish production, and total fish production, respectively. The production of total inland fish has achieved highest CAGR (2.63%), followed by the CAGR estimated for production of total marine fish (1.005%) during the period of study. The CAGR calculated for total fish production becomes 1.82%. The estimated results are statistically significant at 1% level of significance. Table 1 reports comparison of computed CAGR and Cuddy-Della Valle (CDV) index for marine, inland and total fish production during the period 1980-81 to 2019-20. The estimated result shows that the instability of inland fish production is low compared to that of marine fish Production. Table 2 highlights estimated Compound growth rate (CGR) and Cuddy-Della Valle (CDV) index for Indian marine products exports in terms of value and quantity. On the basis of estimated CDV index for marine products export in terms of both value and quantity it has been observed that USA ranks first position. The estimated instability index for USA becomes 45.1% and 51.8% with

Table 2. Compound annual growth rate (CGR) and Cuddy Della Valle (CVD) index of Indian Marine products exports (2000-2020)

Country	Export quantity (Q)		Export value (V)	
	CAGR%	CDV%	CAGR%	CDV%
Japan	0.84	10.30	1.85	26.34
USA	0.67	45.11	6.92	51.76
European Union	1.88	13.17	4.69	13.74
Southeast Asia including China	3.16	17.03	7.37	21.97
Middle East	3.61	15.19	6.90	16.15

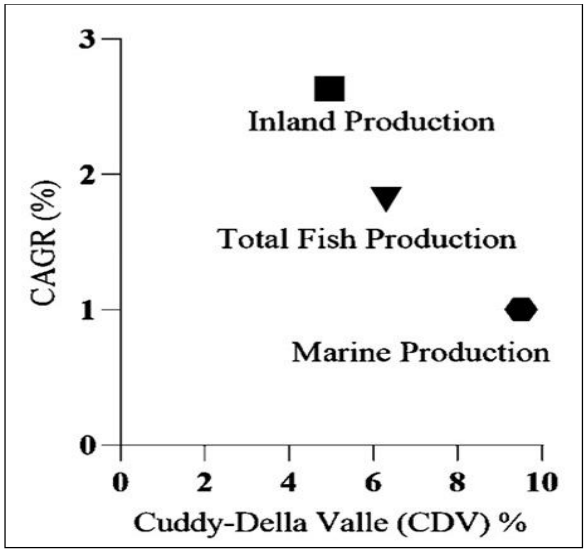

Fig. 3. Growth and instability of Indian fish production from 1980-81 to 2019-20

respect to export quantity and export value, respectively.

Instability of Indian fish production: The level of instability in production and product export is very important for both sustainable production and export. Regarding instability analysis, the Cuddy- Della Valle (CDV) index of instability was used in this study. Table 1 and Fig. 3 depict that as per CDV, the instability in the volume of marine fish production was 9.501%, and the volume of inland fish production was found to be 4.959%, respectively.

Growth rate of Indian marine products export: The compound annual growth rate (CAGR) and Cuddy- Della Valle (CDV) index of instability of Indian marine products export in terms of quantity and value during the period 2000-2020 for five major important importer countries were estimated and reported in Table 2 and Fig. 4. CAGR of quantity (CAGR_Q) was found to be positive for all the countries. The highest CAGR was found for the Middle East (3.61%), followed by Southeast Asia, including China (3.16%), the European Union (1.88%), Japan (0.84%) and the USA with the lowest (0.67%). On the other side, CAGR of value (CAGR_V) was highest for Southeast Asia, including China (7.37%), followed by the USA

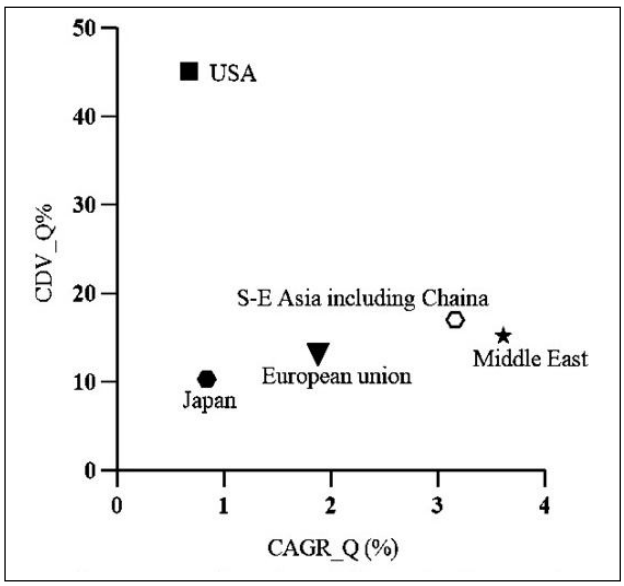

Fig. 4. Growth vs instability of Indian marine product export in terms of quantity

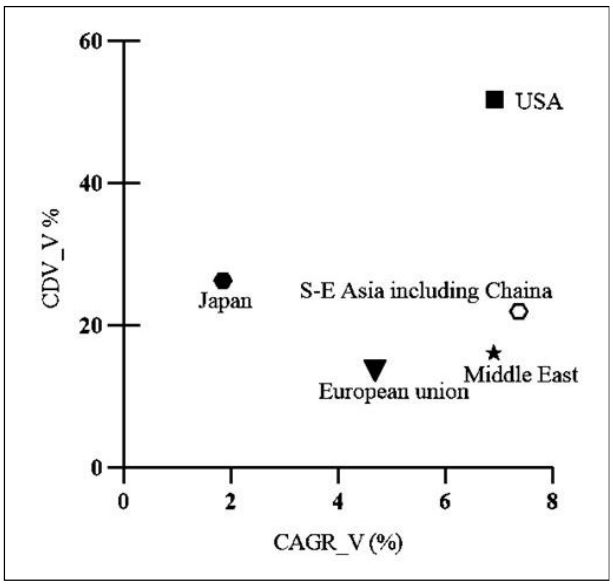

Fig. 5. Growth vs instability of Indian marine product export in terms of value

(6.92%), the Middle East (6.90%), European Union (4.69%) and the lowest for Japan (1.85%).

Instability in Indian marine products export: The level of instability in marine products export is very important for sustainable export. The estimated Cuddy Della Valle (CVD) index in marine products export for the period 2000-2020 is presented in Table 2. The instability index of the quantity of export (CDV_Q) was low for Japan (10.30%), and highest was observed for the USA (45.11%), followed by Southeast Asia, including China (17.03%), Middle East (15.19%) and the European Union (13.17%). The result shows higher instability in the quantity exported to the USA, which deters its growth rates (CAGR: 0.67%). The export value instability (CDV_V) was found to be high for the USA market (51.76%); besides this, all are found to be low (Fig. 5).

Risk assessment of Indian marine products export: According to a risk assessment of the export of Indian marine products, in terms of quantity, USA fell in the most undesirable low growth-high risk category, as presented by the top left corner of Fig. 4. Japan and the European Union fell in low growth-low risk category, which indicates export must be restrained from an economic point of view. Markets like Southeast Asia including China and the Middle East were falling in the high growth-low risk category. In terms of value (Fig. 5), the USA was less desirable, falling in the high growth-high risk category, and Japan fell in the low growth-low risk category. East Asia including China, the Middle East and European Union were found to be the most desirable high growth-low risk category.

DISCUSSION

Resource depletion in the marine sector of the Indian fisheries was demonstrated by the increasing rate of fish production and the exports of marine products. The Indian government must take corrective action to revitalize the marine fishing sector, which contributed over 70% of the country's total fish production in the early decades of independence, as its output is nearly at a standstill (Table 1, Fig. 3).

According to Jeyanthi and Nikita (2012), the quantity, value, and unit value of Indian scampi exports showed low and negative over the study period. Evidence of a highly concentrated market for Indian scampi exports to other nations was found. Coppock's instability index (CII) and the absolute difference approach were used to identify the high level of volatility in Indian scampi exports. According to the report, the majority of India's scampi exports went to nations that fall into the least desirable (low growth and low risk) or less desirable (low growth and high risk) categories, which has an impact on the nation's economic development. The present study also identifies the countries on the basis of a comparison between the achieved growth rate and the risk captured by CDV index of instability. The study by Siby and Arunachalam (2020) evaluates the growth and instability patterns in the production and export of fish from India using the Compound Annual Growth Rates (CAGR), Coefficient of Variation (CV), and Cuddy-Della Valle (CDV) estimates. The study also makes use of double log multiple regression analysis to estimate the demand elasticity of US market for Indian shrimp, which is a major constituent in Indian fishery export basket. As far as instability analysis is concerned, the two measures of instability used in this study are the Coefficient of Variation (CV) and the Cuddy-Della Valle (CDV) index. The coefficient of Variation in the volume of marine fish production in the current decade is 4.57%, whereas it is 20.2% in the volume of inland fish production. As per the Cuddy-Della Valle index, the instability in the volume of marine fish production is 1.26%, and in the volume of inland fish production, it is 2.11%. In

Table 3. Comparison of decadal CAGR and Cuddy-Della Valle (CDV) of Indian fish production from 1980-81 to 2019-20

	1980-1990		1990-2000		2000-2010		2010-2020	
	CAGR (%)	CDV (%)	CAGR (%)	CDV (%)	CAGR (%)	CDV (%)	CAGR (%)	CDV (%)
Marine production (Volume in lakh tonnes)	1.631746	8.459	0.962112	4.508	0.3236	3.086	0.778052	1.746
Inland production (Volume in lakh tonnes)	2.257941	3.487	2.81879	2.376	2.49897	2.672	3.737051	2.304
Total fish production (Volume in lakh tonnes)	1.883161	5.174	1.787605	2.972	1.535663	2.262	2.749544	1.822

Table 4. Decadal compound growth rate (CGR) and Cuddy Della Valle (CDV) index of Indian Marine products exports (2000-2020)

Country	2000-2010				2010-2020			
	Export quantity (Q)		Export value (V)		Export quantity (Q)		Export value (V)	
	CAGR%	CDV%	CAGR%	CDV%	CAGR%	CDV%	CAGR%	CDV%
Japan	0.057	10.763	-2.495	23.022	0.318	8.068	2.378	10.113
USA	-1.845	16.295	-2.004	21.679	9.038	7.065	10.896	16.679
European union	4.259	7.481	5.749	8.164	0.364	7.787	3.096	15.212
Southeast Asia including China	1.374	15.282	3.944	21.822	2.308	14.036	6.722	14.831
Middle East	3.169	15.985	5.906	9.765	1.907	12.594	5.011	16.994

both measures, instability is low in the production of marine fishery.

The present study emphasizes on Instability analysis in Indian marine products export where USA showed high instability in terms of both quantities exported to that country and for the value of the exported products. This ensures that the export value was mainly influenced by the quantity exported. An assessment based on growth rate (CAGR) and risk (measured by CDV index) reveals that Japan has low estimated value of CAGR compared to high CDV index value. On contrary, USA has high CDV index value based on export quantity and export value of marine products in India. Most of the countries considered in the present study possess low/moderate risk (reflected by CDV index) except USA. So, some policy measures are required for a country like USA towards correcting high instability.

Again, Table 3 establishes the fact that the highest decadal growth (CAGR) was found to be 3.74% and 2.75%, respectively for inland and total fish production during the decadal period 2010-2020 compared to the highest CAGR achieved by marine production during the decade 1980s. The computation of the CDV index over the decades brings out the picture that the value of the instability index gradually declines, indicating that the production of marine, inland, and total fish has become stable over the decades.

A comparison of the decadal growth rate, as mentioned in Table 4 based on export value and export quantity, reveals that the USA has achieved a negative growth rate in terms of both aspects during the decade 2000-2010. USA has achieved highest growth rate in terms of export value and quantity during the decade 2010-2020. It is interesting to note that the calculated value of the CDV index in terms of export quantity was lower during the decade 2000s compared to that of export quantity during the decade 2010s. Similar result has been obtained for all countries considered in the present study in terms of export value except Middle East and other countries resulting in higher value of CDV Index.

Export is the engine of economic growth for a country. Exports are of immense importance for a developing country like India. From the present study, it is evident that export growth in terms of quantity and value was low. However, no negative growth was experienced for any destination country in terms of quantity and value. The instability index indicated that marine products export from India was highly unstable. The marine segment of the Indian fishery is going through a rough stage.

The government needs to take remedial measures to check the fast depletion of resources in marine fishery, and at the same time, it has to find ways to better utilize the potential of deep-sea fishing. This calls for attention by policymakers to determine stable and competitive markets for the export of marine products. Efforts should be more concentrated towards the countries falling under the less desirable category which have high growth like Southeast Asia including China and the Middle East with trade and non-trade barriers at ceteris paribus. However, measures to stabilize exports may go a long way in reducing instability in marine products export from India. Successful identification of stable markets and stabilization measures will help to enhance foreign exchange earnings and would help to boost the economy of the country.

Conflict of interest: The authors declare no actual or potential conflict of interest associated with this study.

Author's contributions: SP: Acquisition and statistical analysis of data; SS, SJ, OB: Conception, design;

PV: Performed interpretation of the results.

Data availability statement: All the data supporting the research findings have been presented in this paper. The corresponding author is willing to provide the raw data upon reasonable request.

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