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Artificial Neural Network Model for Synergy Analysis of Input Markets in Ornamental Fish Trade in Mumbai

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Abstract

Ornamental fish trade is highly complex. The radial basis function in a single-layer neural network has been used to study the relationships related with a response variable, viz. quantity and quality in ornamental fish trade in Mumbai ornamental fish market on the basis of five predictor variables which have been identified on the basis of a preliminary survey. Among the five defined predictor variables, post production services and institutional services have emerged as most important in the determination of the volume and quality of trade in the ornamental fish in the Mumbai market. This is in sync with the current trade environments, volume and quality of ornamental fish traded in the Mumbai market.

Key words: Ornamental fisheries; fisheries, artificial neural networks, input markets

JEL Classification: C45, M21, M31

Introduction

Eighty-five nations are involved in international trade in fish and fish products worth USD 102 billion, of which developing countries share USD 25 billion, making it their most significant traded food product. Note that the turnover in ecotourism related to reefs alone is worth USD 9 billion (World Bank, 2012). The global ornamental fish industry and accessories is worth USD 15 billion and more than 2 billion live ornamental fishes are traded every year (Nair, 2012).

During 2010-11, India exported ornamental fishes worth USD 1.26 million which is about 0.3 per cent of the global trade (Nair, 2012). The export potential of India is estimated to be of USD 30 million or ₹ 100 crore per year. Though oriented towards exports, ornamental fishes command a seller's market at home and abroad. India's overall domestic trade in ornamental fish is estimated to be nearly ₹ 15 crores (Swain, 2012).

Domestic Ornamental Fish Market

There are about 1800 commercial outlets in ornamental fishes in the country, comprising 350 full-time and more than 2000 part-time fish breeders (Swain, 2012). About 1.5 million people keep ornamental fishes in their houses in the country. Some 100 species are traded in the domestic markets, of which 35-40 species are freshwater species. Less than 15 species of ornamental aquatic plants are traded for aquarium keeping purposes.

The Government of India provides financial assistance to the ornamental fish hatcheries with a 10 per cent subsidy component of ₹ 15 lakh per unit with a capacity of 5-10 million fry every year. Marine Products Export Development Authority (MPEDA)

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Table 1. Ornamental fisheries units in India and districts with high concentration of breeding units

S. No.	State	Units	Places of concentration of ornamental fisheries activity	District with maximum breeding farms	Major ornamental fishes
1.	West Bengal (19 districts)	>700	Kolkata, Birbhum, Cooch Behar, Howrah, South and North 24 Paraganas, Nadia, Hoogly, Uttar Dinajpur, Dakshin Dinajpur, Murshidabad,	1. Uttar Dinajpur 2. Howrah 3. South Paraganas 4. Nadia	Native ornamental species: *Colisa chune* (honey gourami), *Puntius chochonius* (Rosy barb), *Brachydanio rerio* (Zebra fish), Chandanama, *Botia lohachata* (reticulate loach) Exotic species: Goldfish, Angel fish, Molly, Guppy, Koi carp, Platy, Oscar, Tiger barb, Swordtail, Catfishes
2.	Tamil Nadu (32 districts)	>500	Chennai, Thiruvallur, Coimbatore, Cuddalore, Dharmapuri, Dindugal, Erode, Kanchipuram, Kanyakumari,	1. Chennai 2. Madurai 3. Dindigul 4. Virudhunagar	Goldfish, Angel fish, Molly, Platy, Guppy and Siamese fighters
3.	Maharashtra (33 districts)	>250	Akola, Amarawati, Buldhana, Wasim, Yewatmal, Aurangabad, Beed, Hingoli, Jalana, Latur, Nanded.	1. Mumbai 2. Pune 3. Thane	Angel fish, Discus, Oscar, Goldfish, Swordtail, Molly, Guppy, Arowana
4.	Odisha	>50	Deogarh, Keonjhar and Rourkela, Sambalpur, Mayurbhanjand, Bhubaneshwar, Jagatsingpur, Khurdha	1. Bhubhaneshawar 2. Cuttack	Molly, Platy, Swordtail, Goldfish (Oranda), Golden gourami, Pearl spot gourami
5.	Andhra Pradesh	20	Hyderabad, Visakhapatnam	-	Gold fish, Angel fish, Live bearers such as Guppy, Molly and Platy
6.	Kerala (14 districts)	100	Thiruvanathapuram, Kollam, Pathanamthitta, Alappuzha, Kottayam, Idukki, Ernakulam, Thrissur.	1. Thrissur 2. Ernakulam 3. Kottayam 4. Wayanad	Native ornamental fish: *Puntiusdenisonii, P. arulius, P. ticto, P. vittatus, P. fasciatus, Parambasis thomassi, Horabagrus brachysoma* Exotic species: Goldfish, Oscar fish, Guppy, Molly, Platy, Swordtail
7.	Karnataka (30 districts)	-	Bagalkot, Belgaum, Bijapur, Dharwad, Gagad, Haveri, Bellary, Bidar, Gulbarg, Koppal, Raichur, Banglore city,	1. Bangalore 2. Tumkur 3. Hassan 4. Mangalore	Gold fish, Orando, Angel fish, Discus, Black molly, Swordtail, fighter fish

Contd...

Table 1. Ornamental fisheries units in India and districts with high concentration of breeding units — *Contd*

S. No.	State	Units	Places of concentration of ornamental fisheries activity	District with maximum breeding farms	Major ornamental fishes
8	Bihar	>10	Patna, Darbhanga, Madhubani, Muzaffarpur, Sitamarhi, Begusarai		Native ornamental fish: *Colisa fasciatus, Botia dario, Lepidocephalus thermalis, Glossogobius giuris, Chandanama, Puntius ticto* Exotic species: Goldfish, Angel fish, Guppy, Molly
8.	Others	130	Goa, Guwahati, Ahmedabad, Delhi		Goldfish, Angel fish, Live bearers, Oscar fish and Discus, Arowana
	Total	1750			

Source: Swain (2012); Sekharan (2008); Nightingale Devi (2013)

and National Fisheries Development Board (NFDB) have provisions for supporting enterprises in ornamental fish culture and trade. There is a great scope for developing small-scale units with an investment of ₹ 2 lakh for cement cisterns, fish seed, feed and other material. There is no comprehensive database of ornamental fish breeders in India (Shekharan and De, 2010).

Objectives and Background of Study

The export of ornamental fish from Mumbai has increased in value from ₹ 0.37 crore (US$ 0.08 million) in 2006-07 to ₹ 0.66 crore (US$ 0.15 million) in 2010-11. Moreover, the breeders, traders and other ancillary business personnel engaged in ornamental fish are not shy of investing in this sector which clearly shows its potential and viability for widening the scope of its business opportunities. The markets in the city are mainly dominated by the exotic freshwater species and few indigenous ornamental fishes as the demand for exotic ornamental fishes is more in the domestic market as reported by some of the major traders (Table 2)[1]. This study has addressed the relative importance of the services and inputs to the quantity and quality of fish traded in the Mumbai market.

Data and Methodology

Ornamental fish trade is driven by volumes, quality, timeliness of supply and price[1] (Nightingale Devi, 2013). Five predictor variables (independent variables) have been identified which influence the trade of ornamental fish in the Mumbai market. The relationships related with a response variable, viz. quantity and quality in ornamental fish trade in Mumbai have been studied. Three major markets selected based on the preliminary studies and interactions with key informants were Crawford, Kurla and Boriveli markets. The input markets for ornamental fish trade are highly specialized and comprise, one, which are directly used in the process of production and second, which are involved in packaging, transportation and marketing.

The data were obtained by conducting a primary survey in 2011-2012 in the Mumbai ornamental fish market. A total of 50 traders selected from Boriveli, Kurla and Crowford markets were contacted and data were collected through personal interview with the traders using interview schedules.

The data were prepared for the modelling using artificial neural network (ANN). The responses to the dependent variables were recorded in binary mode, 1 for 'Yes' and 0 for 'No'. The responses of traders were scaled 1 to 5 for each of the independent variable (production input supply chain, labour supply chain, post-production /sale systems and services, information delivery system and institutional services[2]). The responses were 1 for essential, 2 for very important, 3 for important, for 4 for desirable and 5 for superfluous.

Table 2. Species, trade names and price range of ornamental fishes in Mumbai market

Name of species	Trade name	Price (₹/piece)
	Live bearer	
Poecilia reticulata	Guppy	10 (male); 4-5 (female)
Poecilia latipinna	Molly	8-10 (2 inch)
Xiphophorus sp.	Platy	5-7
Xiphophorus helleri	Swordtail	7-12
	Egg layers	
Colisa lalia	Dwarf gourami	5- 10
Betta splendens	Siamese fighting fish	10-12 – 15-18 (45-85)
Helostoma temminckii	Kissing gourami	7-8 (2 inch)
Trichogaster leeri	Pearl gourami	12
Ancistrus sp.	Brittlenose	250 (one and a half inch)
Plecostomus punctatus	Sucker mouth catfish	5-8 (2 inch)
Colossoma macropomum	Pacu	10-12
Metynnis hypsauchen	Silver dollar	12 (1 coin size)
Paracheirodon axelrodi	Cardinal tetra	55-60
Paracheirodon innesi	Neon tetra	12-18
Pygocentrus nattereri	Piranha (local)	20-50
Botia striata	Stripe loach (local)	7-10
Epalzeorhynchos bicolor	Red tail black shark	10-25
Puntius conchonius	Rosy barb	7-8
Puntius tetrazona	Tiger barb	7-8
Epalzeorhynchos frenatum	Rainbow shark	3-15
Balatiocheilos melanopterus	Silver shark	25-45
Catla catla	Carp	5-10
Astronotus ocellatus	Oscar	45-60 (local)
Flower horn	Flower horn	120 (2 inch)
Symphysodonaequifasciatus	Discus	300-1500
Pterophyllums calare	Angel fish	8-15
Gold fish	Orando	12-200
Carassius auratus	Bubble eye Red cap Black moore	
Apteronotus albifrons	Black ghost knife fish	75 (2 inch); 100 (3 inch)
Atractosteus sp.	Alligator	250-2500
Osteoglossum bicirrhosum	Silver Arowana	700-1.5 lakh
Pseudambassis ranga	Indian glass fish	6-15
Esomus dandricus	Indian flying barb	2-10

In this paper, the radial basis function (RBF) network has been applied to the responses of trade to the relative importance of various inputs and their roles in ornamental fish trade in Mumbai on the basis of five predictor variables. The radial basis function (RBF) type artificial neural networks (ANNs) approach for modelling differs from the more widely used multilayer perceptron (MLP) approach in that the non-linearity of the model is embedded only in the hidden layer of the network. Search for optimal model parameters is carried out in two steps, each of which can be made more efficient and much faster than in MLP. An added advantage of RBF network-based model is that it can be developed with relative ease and in less time

Table 3. Network information

Input layer	Factors	1. Production input supply chain
		2. Labour supply chain
		3. Post production services
		4. Information delivery system
		5. Institutional services
	Number of units	21
Hidden layer	Number of units	3[a]
	Activation function	Softmax
Output layer	Dependent variables	1. Quantity and Quality
	Number of units	2
	Activation function	Identity
	Error function	Sum of Squares

[a]Determined by the testing data criterion: The "best" number of hidden units is the one that yields the smallest error in the testing data.

compared with their MLP counterparts (Jayawardene and Fernando, 1998).

The RBF procedure trains the network in two stages. At the first stage, it determines the radial basis functions using clustering methods. The centre and width of each radial basis function are determined. At stage 2, it estimates the synaptic weights given the radial basis functions. The sum-of-squares error function with identity activation function for the output layer is used for both prediction and classification. Ordinary least squares regression is used to minimize the sum-of-squares error. Because of this two-stage training approach, the RBF network is in general trained much faster than MLP.SAS-JMP and SPSS v 17 was used to train ANN.

In the case of RBF networks, training in the output layer was terminated after 300 training iterations. In all the cases the weights that correspond to the minimum error during the training stage were taken as the final model parameters. In this case, the Mean Absolute Error (MAE), Mean Square Error (MSE), Mean Absolute Percentage Error (MAPE) and Root Mean Square Error (RMSE) were calculated for the output.

Results and Discussion

The network information in this model is given in Table 3 and the most suitable model on the basis of the least error produced during both training (calibration) and testing (validation) stages is given in Table 4. But at the model development stage, it has to be chosen on the basis of the least error during the training stage alone.

Table 5 indicates that among the predictors, the post production services is the key factor that governs the performance of the Mumbai ornamental fish market in terms of quantity and quality of fish traded, followed by institutional services, information delivery system and production input supply chain. Labour supply which actually includes both technically experienced workers and casual workers was found to be of least importance. Post production services that include efficient handling and bagging, oxygenisation of the bagged fish, proper equipment, transport linkages, smooth transit and distribution at the market is of primary importance in the neural network.

The formulated RBF ANN is shown in Figure 1. The X_is represent the input layer, i.e. the responses of the traders (1 to 5) to the importance of independent

Table 4. Training and testing error of ANN (Dependent variable: Quantity and Quality)

Particulars	Training	Testing
Sum of squares error	8.119	3.890
Incorrect predictions (%)	38.2	37.5
Training time	0:00:00.012	-

Table 5. Normalised importance among predictors for Y1 (quantity and quality)

Predictor	Importance	Normalized importance, %
Production input supply chain (X_1)	0.209	89.7
Labour supply chain (X_2)	0.111	47.6
Post production services (X_3)	0.233	100.0
Information delivery system (X_4)	0.220	94.7
Institutional services (X_5)	0.227	97.3

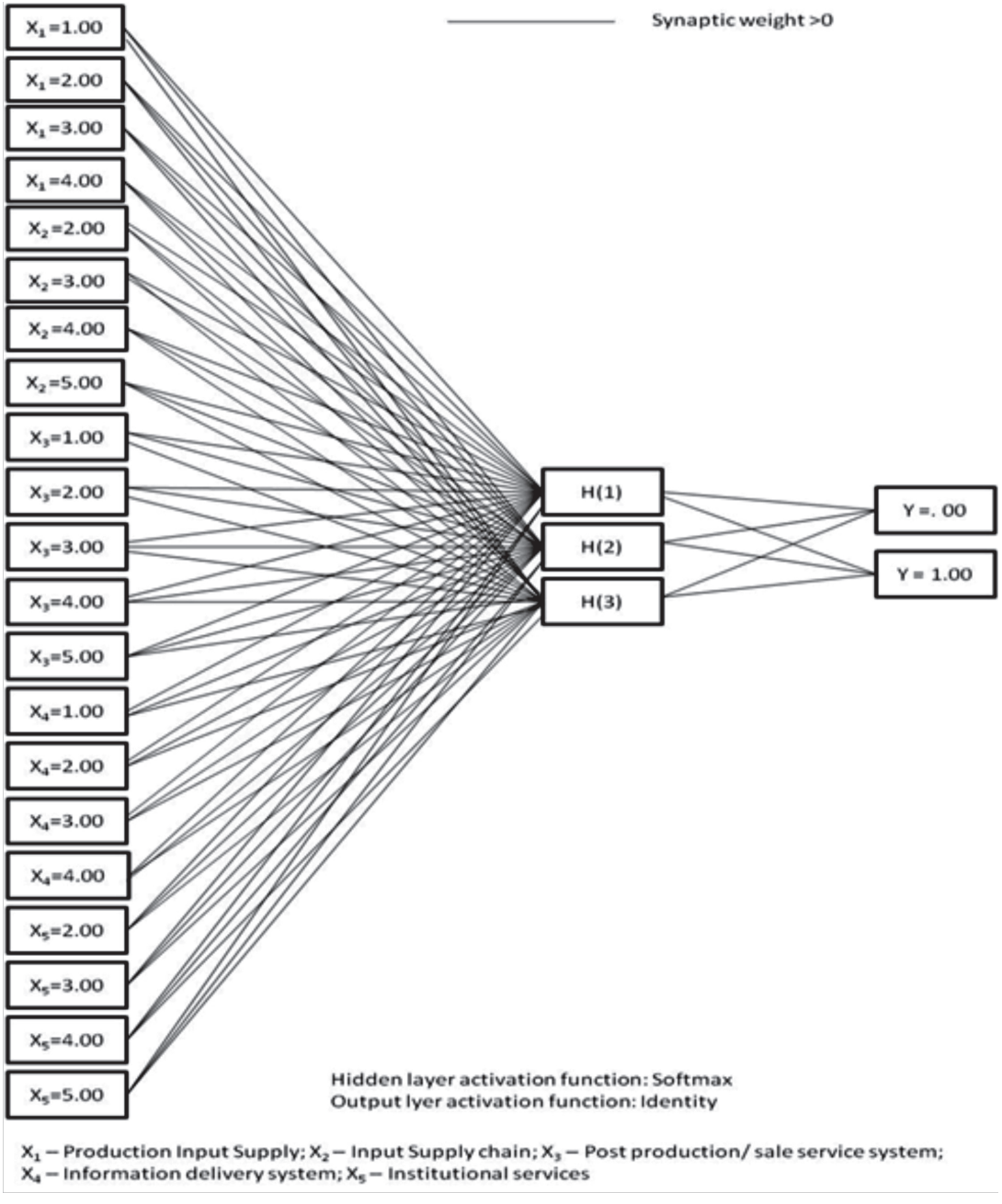

Figure 1. ANN network diagram for ornamental fish trade in Mumbai

variables, namely production input supply chain, labour supply chain, post-production /sale systems and services, information delivery system and institutional services in influencing the input market synergy of the quantity and quality of ornamental fish supply in the Mumbai market. It maybe noted that X_1=5 is missing in the network diagram, which implies that institutional services were not found superfluous (5) according to the responses of all the 50 traders. The absence of X_2=1 indicates that labour supply chain was not found essential in input market synergy in ornamental fish markets in Mumbai. This interpretation gains credence since the informal labour supply chain in Mumbai is well entrenched. Similarly, X_4=5 is also not available, indicating that information delivery system in Mumbai was not superfluous. X_5=1 is absent in the network diagram, indicating that the relative responses to institutional service ranged from very important to superfluous but did not merit to be ranked essential (1) by the traders. The H_is represent the hidden layer the Y_is represent the output layer. The RBF-ANN being a supervised neural network devoted to approximation and classification tasks, non-linear dimension reduction is a typical task performed by the supervised ANNs.

Input Market Linkages and Ornamental Fish Trade

The ANN analysis has revealed that the role of predictor, post-production services in the stability and growth of the ornamental fish trade in Mumbai is paramount. The quantity and quality of the ornamental fish traded in the Mumbai market are governed by intricate and complex networking of minute services involved in the post-production services in ornamental fish marketing. Post-production /Sale systems and services such as maintenance of the fish, equipment, segregation, feeding, cleaning, regular prophylaxis measures, etc. should be timely and appropriate as such services may reflect premium prices. Post-production services, including after sales services, play a key role in the performance of the ornamental fish trade in the Mumbai market. This is essentially because the customer base is not only the household demand but also corporate demand. Mumbai being a city with high density of population and being the commercial capital of India, also has a high demand for ornamental fishes not only for their aesthetic value but also for their *vaastu* value (Nightingale Devi, 2013).

Conclusions

The appropriateness of the use of ANN in analyzing the synergy in input markets for ornamental fishes has been exemplified by the informal arrangements in the supply chain. The ornamental fish supply chain begins with seed production/ natural collection and does not end with the sale of fish. The role of inputs that go into the process of seed production and culture, the intricate skills of the labour honed through years of practice in production and post-production and marketing services, the word of mouth information delivery and networking and informal institutional arrangements unique to ornamental fisheries can only be captured by a methodology that can network non-parametric information in a flexible format (Nightingale Devi, 2013)

The most important part of the market chain lies in after sale services which ensure product and outlet loyalty. The product is a live item and is highly susceptible to minor variations in environment and/or feeds and feeding regimes.Thus, the post-production and after sales services have important bearing on the trade and largely determine the quantity and quality of sale of ornamental fishes in the Mumbai market.

The prediction performance of ANN has been effective in predicting the extent of interfacing of inputs markets that include physical inputs and services prior to, during, and after sales related to ornamental fisheries. The methodology has enabled the capturing of most important predictors that influence the volume and quality of ornamental fish trade in the Mumbai market.

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End-notes

1. The inputs markets and services are interlinked to a greater degree in the ornamental fisheries sector than in any other pet trade. The degree and strength of inter-linkages are magnified in the context of the high propensity of the ornamental fishes to

mass kill in the event of collapse of any of the smallest parameter that may impede their survival. The intricate inter-linkages are also compounded by the role of physical and environmental parameters…… taking up the inter-linkages from the point of view of sale to its delivery and upkeep, several minor, major and interwoven networking of services are involved in the post production and after sales (Appendix 3 in Nightingale Devi, 2013).

2. Though, despite its potential prospect and rapid expansion, there exist certain problems that act as barriers towards the expansion of the venture and hence require suitable management strategies. Some of the major problems are insufficient space, water-related problems, non-availability of live feed (*Daphnia*), and lack of scientific interventions and training in the sector which really need to be dealt with in the near future.

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