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Understanding the Potential of Livestock Market with Special Reference to the Export of Swine Meat from India: A Study of Time-series Analysis using ARIMA-based Forecasting Method

Priyanka Jaiswal, Mahua Bhattacharjee

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ABSTRACT

Background: The increasing demand of swine meat, both for local consumption and for export,can be taken as an opportunity for increased revenue and foreign exchange. Since north east India is considered as the hub of pork market in India, an attempt is made to study the current trend of export of swine meat from India and forecasting the same for the next decade.

Methods: Six different ARIMA models were fitted to the time- series data pertaining to the period 2003 to 2019 for the export of annual swine meat (fresh, chilled or frozen). The forecasting of future annual meat export value in leading 10 years is done using the best model with higher accuracy.

Result: The most fitted model (1,0,1) out of other models (1,1,0), (2,0,2), (1, 2, 1), (1,1,1) and (1,1,2) suggests the positive trend of annual swine meat export from India. It is anticipated to grow at 6.54 units from 2020 to 2029 as compared to 1.45 units from the last decade (2010-2019). The commercialisation of piggery sector can be a vital source for sustainable livelihood, for doubling the farmer's income and for an enterprise building.

Key words: ARIMA, Export, Forecasting, Pig/swine meat, SDGs.

INTRODUCTION

As per food and agriculture organisation, twelve per cent of the world's population derive their livelihood solely from the livestock sector (FAO, 2004). Livestock is considered as the most vital sector for achieving the sustainable development goals (SDGs) by providing food, income, draught-power, fertilizer, household energy and a way for disposing otherwise-unwanted crop residues (FAO, 2018). India with 535.78 million livestock population-a rise of 4.6 per cent from the previous 2012 Livestock Census-is one amongst the largest livestock population country in the world (20th Livestock Census, 2019). In 2011-12 the value of output from Livestock sector in India was merely 4.9 lakhs which has increased over the past 10 years to 11.6 lakhs in 2018-19 (Anonymous, 2018). This suggests that four of the five highest value agricultural products are livestock products (pig meat, milk, beef, chicken meat). Thanks to the rising demand for livestock products propelled by high income, population growth and urbanization, the share of livestock in agricultural GDP has been increasing faster than the crop sector within the past one decade (Birthal and Negi 2012). It's contribution to the total gross value product at current prices is 5.1 per cent in 2018-19 (Anonymous, 2019). This increase in the value of livestock products owes to the shift in consumers eating habits.

Livestock products (meat, milk, eggs) provide essential nutrients that contribute to food and nutritional security of the individuals. Even the small amounts of animal protein in the diets of young children will improve not only their physical development but also their cognitive and learning abilities (FAO, 1996). The growing demand for livestock products in developing countries, driven by the increase in population, high income level and urbanization, represents an enormous opportunity for many scores of small and poor livestock farmers to fulfil the market demand and rise out of poverty cycle (Thornton, 2010).

The shift within the utility pattern/preferencefor animal proteinis the underlying factor for the achievement of SDG No. 3 by ensuring nutritional security, good health and well-being of the individuals. This if further supplemented by improving the efficiency of livestock production, especially the productivity per animal, can double livestock income and generate huge employment opportunities for the agricultural Indian masses which can go long way in the removal of poverty and hence, for theachievement of SDG No.1. Livestock sector alone provides livelihood to two-third of the rural community and employment to about 8.8% of the population in India (Bharadwaj *et al.*, 2020). In keeping with the NSSO 66th round survey on employment and

Amity School of Economics, Amity University, Noida-201 301, Uttar Pradesh, India.

Corresponding Author: Priyanka Jaiswal, Amity School of Economics, Amity University, Noida-201 301, Uttar Pradesh, India. Email: jaiswalpriyanka005@gmail.com

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unemployment (July 2009-June 2010), 15.60 million workers as per usual status (Principal status plus subsidiaries status) were engaged in farming of animals, mixed farming and fishing.This number goes as highas to 16.44 million workers as per usual status (Principal status plus subsidiaries status) where people are engaged in the activities of farming of animals, mixed farming, fishing and aquacultureas per NSS 68th round survey on employment and unemployment (July 2011-June 2012). Precisely, 1.3 billion people (one in five of the world population) rely upon livestock for his/her livelihood (FAO, 2018; World Bank, 2021). It is therefore, rightly considered that SDG No. 3 is supplementary as well as complementary to SDG no. 3 especially within the case of Indian Economy. Hence, it is safely assumed that livestock contains a huge potential both for the development of human capital and reduction of poverty levels of the country and of the planet in the widest sense.

Scope of pig rearing/ farming as an integral part of north east India

The North Eastern region of India holds high proportion of tribal people whose integral way of life, since time immemorial, is highly dependent upon Pig rearing. As a result, it is the largest market for pork meat in India (Taluqdar *et al*., 2019). According to the 20th Livestock Census (2019), Assam has the highest number of pigs in the country. The region consumes more than 75% of meat produced country, which is about 4.26 metric tonnes. Because of the food habit of the inhabitants being mostly non- vegetarian, the scope of pig production has high potential in North East India (INSIDENE, 2019). Also, swine is considered as an important commodity that has contributed to the food security of the country (Macasait *et al.* 2021). Realising the potential of this sector, increasing number of youths across India are taking up this piggery venture as a means of their livelihood/ occupation or as subsidiary source of income generation.

The sector *via* international trade can play a vital role in economic development of the country (Bardhan 2007). There is a positive and significant relationship between exports and domestic investment with the GDP of the country. The classical and neo-classical economists have placed much credence of international trade as an engine of economic growth (Yemi, 2014). The explicit goals of the economic reform strategy in India after 1991 with respect to the external sector were to create a major shift in the momentum of export growth and to attract very large inflows of foreign capital (Abubakar *et al*., 2015).

MATERIALS AND METHODS

The study is based on the time-series data pertaining to the period 2003 to 2019. The data for export of annual swine meat (fresh, chilled or frozen) were obtained from HS-02 code of COMTRADE database. All statistical analyses were done in stata-14 software.

The Autoregressive Integrated Moving Average (ARIMA) model, introduced by Box-Jenkins in 1970, is used for time series modelling and forecasting of the swine meat export value for the ten leading years from the sample data. Stationarity of the series is the pre- requisite of any time-series to develop the forecasting model (Edward and Manoj 2016). Therefore, to stationarize the data, differencing of order 1, 2 or many (as per the requirement) is done. This stabilizes the mean of the time series data and eliminates the trend or, seasonality in the data (Paul *et al.* 2014). ARIMA models include autoregressive (AR) terms, differencing operations and moving average (MA) term.

An auto regressive (AR) process is a series which is dependent on its own lagged values. It may be represented as:

$$Yt = \alpha 0 + \alpha 1Yt\text{-}1 + \alpha 2Yt\text{-}2 + \ldots + \alpha pYt\text{-}p$$

Here,

$\alpha 0$ is constant.

$\alpha 1Yt\text{-}1 + \alpha 2Yt\text{-}2 + \ldots + \alpha pYt\text{-}p$ are lagged values of dependent variable.

An MA (q) process represented as:

$$\varepsilon t = \beta 1\varepsilon t + \beta 2\varepsilon t\text{-}2 + \beta 3\varepsilon t\text{-}3 + \ldots + \beta q\varepsilon t\text{-}q$$

Here, the series is a linear combinations of white noise errors. As the model works on its own lagged values, thus the predictors here, are basically its own lagged values for time t-1, t-2 and t-n time period.

With the help of correlograms, the Box Jenkins methodology identifies the value of p and q for AR and MA terms respectively.

RESULTS AND DISCUSSION

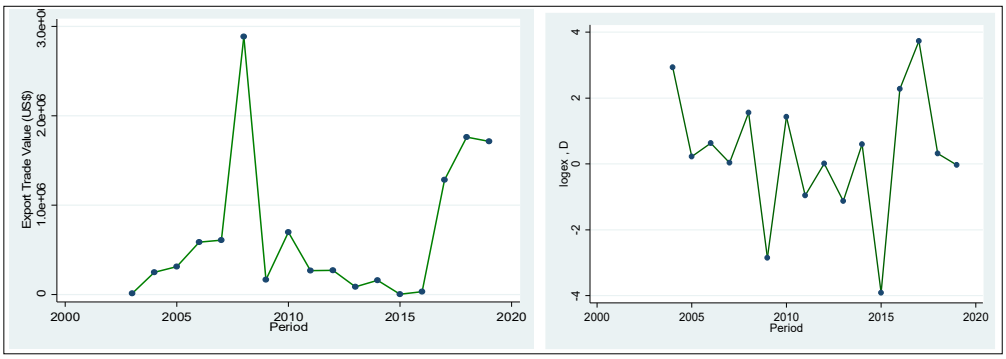
Model identification and estimation

Using autocorrelation function (ACF), partial autocorrelation function (PACF) and degree of differencing, the appropriate autoregressive and moving average terms are determined (Paul *et al.* 2014). The autocorrelation function graph indicates the value of q while the Partial autocorrelation function graph indicates the value of p. This is further confirmed by the least values of akaike's information criterion (AIC) and Bayesian information criterion (BIC), which is a measure of goodness of fit. The lesser the value of AIC and BIC, the more fit the model is.

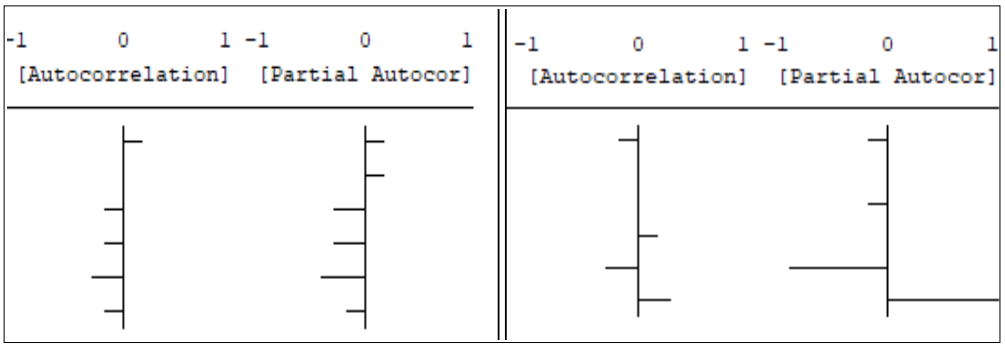
Graph 1A depicts the original data with seasonal fluctuations over the years. As one of the pre-requisites for running ARIMA is to normalise/stationarize the dataset, therefore, the functional form of the data was changed using logarithmic values. To further stationarize the data and remove trends and fluctutations, differencing of order 1 was done and hence, stationarity was attained at first difference (d=1) as shown in Graph 1B. The identification of p and q values for AR and MA terms respectively was done with the help of correlograms (Graph 2) and it is estimated that these orders can at most be 1 and 0 respectively (Graph 2 A and B).

Model verification

The six different autoregressive integrated moving average (ARIMA) models were fitted to annual swine meat export



Graph 1: A- Non-stationary Line plot of the Actual Swine Meat Export Value. B- Stationary line plot of the actual swine meat export value.



Graph 2: Autocorrelation function (ACF) for MA(q) and partial autocorrelation (PACF) for AR(p)- A- of the raw data of swine meat export. B- The differenced log values (d=1) export showing stationarity throughout the series.

Table 1: Model Selection- six ARIMA Models with different values of p,d,q.

Model	Significant	Highest ARMA	P-value of significant coefficients	Sigma significant	Log-likelihood	AIC	BIC
(1,1,0)	AR(1)	1	0.001	2.40	-34.64	75.28	77.28
(1,0,1)	AR(1)	1	0.000	1.71	-32.04	70.09	72.40
(2,0,2)	AR(1)	1	0.020	1.61	-31.62	73.24	77.10
(1,2,1)	AR(1)	1	0.016	2.47	-34.47	76.95	79.51
(1,1,2)	-	0	0	0.05	-32.51	75.02	78.56
(1,1,1)	-	0	0	1.90	-32.51	73.02	75.85

value from India using data records from 2003 to 2019. It includes statistics on the highest and significant AR or MA coefficients, p- values, sigma (measure of volatility), log-likelihood, AIC and BIC values, These are the parameters on which best model has been selected for forecasting.

The criteria for the best fit ARIMA model is-high significant coefficients, low coefficient of volatility, high log-likelihood statistics and low information criterions (AIC and BIC). For identifying best model, Akaike Information Criterion (AIC) and Bayesian information criterion (BIC) used are as follows:

$$AIC = 2k - 2 \ln (L)$$

Where,

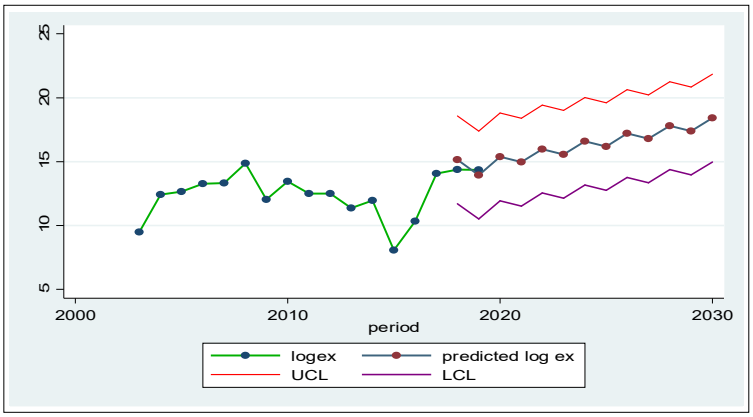
$$BIC = \ln (n)\, k - 2 \ln(L)$$

k is the number of free parameters to be estimated.
n is the number of data points.
ln(L) is natural logarithm of the maximized value of the likelihood function of the model.

As given in Table 1, with the lowest AIC (70.9) and BIC (72.40), significant coefficients [AR(1)] with significant p-value (0.000), less volatility (1.71), the model with order (1,0,1) was considered as most suitable model for forescasting the export value out of all the other models (1,1,0), (2,0,2), (1, 2, 1), (1,1,1) and (1,1,2).

Forecasting the growth of export of swine meat (fresh, chilled or frozen) from India for 2020 to 2030 with ARIMA (1,0,1) and with 95% level of significance

As mentioned in Table 2, the export of swine meat from India declined by 2.79% from 2018 to 2019, majorly because of decline of 12.03% pig population in India over the previous census.The export of swine meat from India is expected to be having an increasing trend, observed with a growth of



Graph 3: Actual and forecasted log values of export growth of swine meat from 2020 to 2030 with upper and lower confidence interval lines.

Table 2: Annual trend of export of swine meat from India over the year 2003 to 2019.

Period	Actual swine meat export value (US $)
2003	13197
2004	248713
2005	311404
2006	586804
2007	606973
2008	2886384
2009	167111
2010	697630
2011	266719
2012	269267
2013	86786
2014	157895
2015	3160
2016	30740
2017	1284603
2018	1762321
2019	1713059

Table 3: Forecasted growth of export of swine meat from India from 2020 to 2030 using ARIMA (1,0,1) with and upper and lower confidence interval lines.

Years	Forecasted swine meat export value (US $)	UCL	LCL
2020	4750878	146981899	153562
2021	3147283	97370125	101729
2022	8728377	270039823	282123
2023	5782288	178893283	186898
2024	16035892	496120798	518316
2025	10623403	328671720	343372
2026	29461061	911488923	952247
2027	19517655	603852186	630848
2028	54126259	1674616465	1749464
2029	35858457	1109416457	1159002
2030	99441491	3076627911	3214107

6.54 units from 2020 to 2029 (Table 3), whereas, in the last decade from 2010 to 2019, it was just 1.45 units. The forecasts for swine meat export quantity from 2020 to 2030 are presented in Table 3.

With ARIMA (1,0,1), it has been found that there is an increasing trend in the annual swine export from India. Graph 3 presents the logarithmic values of forecasted growth of swine meat export from India from 2020 to 2030 as against the actual growth from 2003 to 2019 with 95% upper and lower confidence interval lines. The model demonstrated a good performance in terms of explained variability and predicting power. The findings of the present study provided direct support for the potential use of accurate forecasts in decision making and pig rearing in India.

CONCLUSION

The empirical analysis shows the situation of Indian swine meat market which can be utilised by producers and other stakeholders of the value and the supply chain to understand the behavioural trends to make the most beneficial decisions to increase or decrease their production. This will make the stakeholders optimistic about the future of swine industry and attract more investors who would be willing to invest in it. Investments emphasizing on proper sanitary measures, packaging standardization and infrastructurual facilities will increase the swine export, fetch foreign exchange and help India capture higher share in world trade (Gaware, U.P., *et al.,* 2020; Kumar A., 2010). Since livestock is an integral component of agriculture, its social equity is more than agriculture because even landless people own livestock and their livelihood depends on its vocation and therefore, investment in livestock will have greater social impact as compared to agriculture. The entire piggery sector is poised for growth provided farmer-entrepreneurs are given the necessary support required to promote, secure and sustain their enterprises. Piggery sector could be leveraged for enterprise building and in doubling the farmer's income as well.Thus, at the national level, increased production of livestock products will help in India's economic growth by reducing the need for high-cost imports and will also help in

the attainment of sustainable development goals by providing nutritional security and eliminating poverty.

Conflict of interest: There is no conflict of interest of any kind between the authors or among anyone.

Data availability statement

Availability of Data	Template
Data openly available in a public repository.	COMTRADE-Export of swine meat (fresh, chilled or frozen) HS-2002 commodity code of 0203.

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