



# **Markov Chain Analysis- A Discrete Assessment on Livestock Sector Trade in India and Allied Countries**

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. Author KPS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MMK and MRS managed the analyses of the study. Author VGP managed the literature searches, academic guidance and contributed in framing analytical approach to the research study. All authors read and approved the final manuscript.*

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## **ABSTRACT**

**Objective/Methods:** The research was to analyze the export and import of livestock products (India) to Oman, Afghanistan, Liberia, Maldives, Algeria, Bangladesh, Kuwait, Vietnam, Philippines, Jordan and Saudi Arabia and U.A.E countries through Markov-chain analysis, and to identify the important factors responsible for livestock production. The Markov chain Analysis was employed to analyse the dynamic nature of trade pattern specially the structural changes in any system whose progress through time can be measured in the term of single outcome variable. To accomplish the objective under study the period taken for all livestock products export was 2006-2007 to 2017-2018.

**Findings/Applications:** The study on import and export of agricultural commodities revealed a significant benchmark based on Markov chain analysis. The Markov Chain analysis revealed that, India has an edge to export milk products to Algeria, Bangladesh and U.A.E, as indicated by the highest retention probability. In case of egg, export to Oman, Afghanistan, Liberia, Maldives indicated by the highest retention capacity. In case of buffalo meat, export to Vietnam, Philippines, Jordan and Saudi Arabia as indicated by the highest retention probability. In case of sheep meat,

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export to Saudi Arabia, Oman and Kuwait had the highest retention probability. The multiple linear regression analysis indicated that the factors for milk production (number of buffaloes, Area under permanent Pasture and Grazing land and institutional credit), for meat production (number of animals slaughtered, population of poultry, buffalo, sheep and goat, number of veterinary institutes) and for egg production (Number of layers and number of veterinary institutes) were highly significant to increase the livestock product production.

*Keywords: Trade; Markov-chain analysis; export-import; livestock; meat; milk.*

## 1. INTRODUCTION

The share of livestock in agricultural sector GDP growth has been increasing faster than the crop sector in the past decade because of the rising demand for livestock products propelled by income and population growth and urbanization. The livestock sector plays an important role in the socio-economic development of rural households. It contributes about 6 percent to the Gross Domestic Product and 25 per cent to the Agricultural Gross Domestic Product. Based on the 20th Livestock Census, the total livestock population shows an increase of 4.6 per cent over the Livestock census 2012. Total Bovine population (Cattle, Buffalo, Mithun, and Yak) is 302.79 million in 2019 which shows an increase of 1.0 per cent over the previous census [1]. According to 70th round of NSSO (National Sample Survey of Organisation), livestock rearing was the principal source of income to about 3.7 per cent of the agricultural households. Sheep and goat are collectively known as small ruminants. India supports 16.1 per cent of the world's goat population and 6.4 per cent of its sheep (Food and Agriculture Organisation). Nationally, total livestock population is 512.1 million, of which goat and sheep population stands at 200 million (39 per cent of the country's total livestock population). Livestock, poultry, dairy and fisheries is a sub-sector of agriculture that provides livelihood to agricultural households during phases of seasonal unemployment. According to the 19th Livestock Census, India has vast resource of livestock comprising about 300 million bovines, 65.1 million sheep, 135.2 million goats and 10.3 million pigs [2]. Sustained growth in the livestock sector has a significant beneficial impact in generating employment and reducing rural poverty. More than 630 million people (74 per cent of the population) live in rural areas. Of the total households in the rural areas, about 73 percent own livestock. Income from livestock production accounts for 15-40 percent of total farm household incomes. More importantly, small and marginal farmers account for three-quarters of these households, raising 56 percent of the bovine (cattle and buffalo) and 62

percent of the sheep populations. Thus, increasing livestock product demand will be a major factor raising incomes in the rural areas in general, and of the rural poor in particular, provided that India's productivity is internationally competitive [3]. The Eleventh Five Year Financial Plan envisages an overall growth of 6-7 per cent per annum for the sector. In the year 2016-2017, this sector produced 165.4 million tons of milk, 88.13 billion eggs, 43.4 million tons wool and 7.4 million tons of meat [4].

The role of livestock sector is required to fulfill the growing food demand which is expected to increase by 40 per cent by 2030 and shall almost be double by 2050 [5].

India ranks first in world milk production, accounting for 20 per cent of world production. The per capita availability of milk is determined by the production of milk in the State. While the India per capita availability of milk is 375 grams per day, it varies between 71 grams per day in Assam to 1120 grams per day in Punjab [2]. The per capita availability of milk has also increased from 130 grams per day in the year 1951-1952 to 337 gram per day in 2016-2017. India ranks fifth in world meat production, increasing its production from 1.5 million tons in the year 1950-1951 to about 7.4 million tons in the year 2016-2017. India ranks third in world egg production, increasing its production from 1.83 billion eggs in the year 1950-1951 to about 88.13 billion eggs in the year 2016-2017. The per capita availability of egg has also increased from 5 eggs per annum in the year 1950-51 to 69 eggs per annum in the year 2016-2017. The output of wool that was 23.7 million kilogram in the year 1950-1951 increased to 43.5 million kilogram in the year 2016-2017 [4]. Fish and fish product exports emerged as the largest group in agricultural exports and in value terms accounted for 47,620 crore in 2018-2019 [2].

In order to study the implications of trade in livestock sector in India, following objectives were studied, firstly to analyze the export and import of livestock products to different countries,

and to identify the important factors responsible for livestock production.

## 2. RESEARCH METHODOLOGY

The Markov chain analysis was employed to analyse the dynamic nature of trade pattern specially the structural changes in any system whose progress through time can be measured in terms of single outcome variable. The gain and losses in market share of livestock products by major importing countries was examined by first order Markov process. The Markov Chain analysis is the estimation of the transitional probability matrix P [6].

It is expressed as:

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

Where,

$E_{jt}$  = Export from India during the year t to  $j^{th}$  country  
 $E_{it-1}$  = Export to  $i^{th}$  country during the year t-1  
 $P_{ij}$  = Probability that exports will shift from  $i^{th}$  country to  $j^{th}$  country  
 $e_{jt}$  = Error term which is statistically independent of  $E_{it-1}$   
 $r$  = Number of importing countries  
 $t$  = Number of years considered for analysis

The factors responsible for livestock production in India were assessed by fitting a multiple linear regression equation.

### 2.1 Milk Production

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + U_t \quad (2)$$

Where,

Y = Milk production (million tonnes) a = Intercept  
 $X_1$  = Number of cows („000“ Nos.)  $X_2$  = Number of female buffalos („000“ Nos.)  $X_3$  = Rainfall (mm)  
 $X_4$  = Area under permanent pastures and grazing lands („000“ ha.)  $X_5$  = Area under fodder („000“ ha.)  
 $X_6$  = Total institutional credit to agriculture and allied sectors (billion ₹)  $U_t$  = Error term

### 2.2 Meat Production

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + U_t$$

Where,

Y = Meat production (million tons)  $X_1$  = Total animals slaughtered (000)  
 $X_2$  = Number of veterinary institutions (No.)  
 $X_3$  = Area under fodder (000 ha.)  
 $X_4$  = Area under permanent pastures and grazing lands (000 ha.)  $X_5$  = Population of sheep, goat, buffalo, poultry (million)  
 $X_6$  = Total institutional credit to agriculture and allied sector (billion Rs.)  $U_t$  = Error term

### 2.3 Egg Production

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + U_t \dots \quad (3)$$

Where,

Y = Egg production (million Nos.)  $X_1$  = Number of layers (000 Nos.)  
 $X_2$  = Number of veterinary institutes (Nos.)  
 $X_3$  = Area under cereals (000 ha.)  
 $X_4$  = Total institutional credit to agriculture and allied sector (billion Rs.)  $U_t$  = Error term

## 3. RESULTS AND DISCUSSION

### 3.1 Transitional Probability Matrix for India's Export of Livestock Products Markov Chain Analysis

The gains and loss in market share of livestock products by major importing countries was examined by first order Markov process. The basic assumption of first order Markov process is that the average export of a commodity from a country to its importing countries in any period depends only on export in the previous period and its dependence is the same among all periods. To accomplish the objective under study the period taken for all livestock products export was 2006-07 to 2017-18 [7-8].

The Markov chain analysis was used and the results of the transitional probability matrix are presented in Table 1. It depicts a broad indication of the changes in the direction of trade of dairy products. The time period considered is for twelve years (2006-07 to 2017-18). The seven major importing countries taken for this analysis were Algeria, Bangladesh, Egypt, Nepal, Saudi Arabia, Singapore and United Arab Emirates. As could be seen from the Table, the transition probability matrix indicated that India could not retain its previous export to Algeria, Egypt, Nepal, Saudi, Arabia and Singapore during the study period. Nearly entire share of Saudi Arabia dairy products imports from India was lost to

Bangladesh while, 54% share of Egypt dairy products import was lost to Bangladesh and the remaining 28 per cent share lost to Algeria. However, Egypt has higher probability to gain Nepal import market (33 per cent). A major share of India's previous dairy product export to United Arab Emirate's market was retained to the tune of 35 per cent during the current period. Of the remaining 65 per cent, 5 per cent was diverted to Bangladesh. Also, Bangladesh has probability to gain 51 per cent of the market share of Singapore alone. India's previous dairy product export to the Bangladesh market was retained to the level of only 5 per cent during the current period. The remaining 93 per cent was diverted to the countries viz., Egypt (35 per cent), Nepal (29 per cent), United Arab Emirates (19 per cent and Singapore (10 per cent). Nepal gained about 29 per cent of the Indian export to Bangladesh.

From these results it could be inferred that the stability in dairy product export of India was higher with United Arab Emirates and Bangladesh. The dairy product exports to Algeria, Egypt, Nepal, Saudi Arabia and Singapore were completely unstable. Thus, India could not retain its previous year export to all the importer countries except United Arab Emirates and Bangladesh [7].

The Markov-chain analysis was used and the results of the transitional probability matrix are

presented in Table 2. It depicts a broad indication of the changes in the direction of trade of dairy products. The time period considered is for twelve years (2006-2007 to 2017-2018). The seven major importing countries taken for this analysis were Algeria, Bangladesh, Egypt, Nepal, Saudi Arabia, Singapore and United Arab Emirates. The transition probability matrix indicated that India could not retain its previous export to Nepal, Saudi Arabia and Singapore during the study period. Nearly entire share of Singapore dairy products imports from India was lost to Bangladesh while, 69% share of Egypt dairy products import was lost to Bangladesh and the remaining 14.4% and 8.6% share lost to Algeria and Saudi Arabia respectively. However, Egypt has higher probability to gain Nepal import market (95.9%).

A major share of India's previous dairy product export to United Arab Emirate's market was retained to the tune of 36.4% during the current period. Of the remaining 63.6 per cent, 13.6 per cent was diverted to Bangladesh. Also, Bangladesh has probability to gain 37 per cent of the market share of Saudi Arabia. India's previous dairy product export to the Bangladesh market was retained to the level of only 12.1 per cent during the current period. The remaining 78 per cent was diverted to Egypt (35%), Nepal (6.6 per cent), United Arab Emirates (68.5 per cent) and Singapore (12.8 per cent).

**Table 1. Transitional probability matrix for India's export of dairy products in quantity (2006-07 to 2017-18)**

Sr. No.	country	Algeria	Bangladesh	Egypt	Nepal	Saudi Arabia	Singapore	U.A.E.
1	Algeria	0.000	0.000	0.223	0.000	0.266	0.000	0.511
2	Bangladesh	0.000	0.053	0.353	0.296	0.000	0.103	0.195
3	Egypt	0.286	0.545	0.000	0.000	0.139	0.030	0.000
4	Nepal	0.000	0.329	0.335	0.000	0.143	0.167	0.026
5	Saudi Arabia	0.000	1.000	0.000	0.000	0.000	0.000	0.000
6	Singapore	0.000	0.510	0.000	0.000	0.071	0.000	0.419
7	U.A.E.	0.000	0.000	0.000	0.294	0.000	0.354	0.353

**Table 2. Transitional probability matrix for India's export of dairy products in value (2006-07 to 2017-18)**

Sr. No.	Country	Algeria	Bangladesh	Egypt	Nepal	Saudi Arabia	Singapore	U.A.E.
1	Algeria	0.073	0.000	0.707	0.000	0.219	0.000	0.000
2	Bangladesh	0.000	0.121	0.000	0.066	0.000	0.128	0.685
3	Egypt	0.144	0.695	0.075	0.000	0.086	0.000	0.000
4	Nepal	0.000	0.000	0.959	0.000	0.035	0.007	0.000
5	Saudi Arabia	0.000	0.371	0.000	0.629	0.000	0.000	0.000
6	Singapore	0.000	1.000	0.000	0.000	0.000	0.000	0.000
7	U.A.E	0.000	0.136	0.030	0.197	0.122	0.151	0.364

Nepal gained about 62.9 per cent of the Indian export to Saudi Arabia. With regard to Algeria, only 7.3 per cent of the previous period dairy product imports from India were retained during the current period. From these results it could be inferred that the stability in dairy product export of India was higher with United Arab Emirates, Bangladesh, Egypt and Algeria. The dairy product exports to Nepal, Saudi Arabia and Singapore were completely unstable. Thus, India could not retain its previous year export to all the importer countries except United Arab Emirates and Bangladesh, Egypt and Algeria.

The Markov-chain analysis was used and the results of the transitional probability matrix are presented in Table 3. It depicts a broad indication of the changes in the direction of trade of buffalo meat. The time period considered is for twelve years (2006-2007 to 2017-2018). The seven major importing countries taken for this analysis were Egypt, Jordan, Malaysia, Philippines, Saudi Arabia, United Arab Emirates and Vietnam. The transition probability matrix indicated that India could not retain its previous export to Egypt. However India retains its previous export to Vietnam, Philippines, Jordan, Saudi Arabia, Malaysia, and United Arab Emirates with 81, 69, 63, 56, 48 and 43 per cent, respectively. Nearly entire (96 per cent) share of Egypt buffalo meat imports from India was lost to Vietnam. While 42 per cent of cent share of Saudi Arabia buffalo meat import was lost to Egypt and the remaining 3 per cent share lost to United Arab Emirates. However, Jordan lost 25 and 11 per cent of buffalo meat market share to Saudi Arabia and Malaysia, respectively. In case of Malaysia, it lost 34 and 13 per cent of buffalo meat market share to Vietnam and United Arab Emirates, respectively. Philippines lost 10, 9 and 8 per cent of buffalo meat market share to Malaysia, Saudi Arabia, and Egypt, respectively. United Arab Emirates lost 34, 13 and 10 per cent of buffalo meat market share to Egypt, Malaysia and Philippines, respectively. Vietnam lost 11 and 8

per cent of buffalo meat market share to Egypt and Malaysia, respectively [9].

From these results it could be inferred that the stability in buffalo meat export of India was higher with Vietnam, Philippines, Jordan, Saudi Arabia, Malaysia, and U.A.E. The buffalo meat exports to Egypt were completely unstable. Thus, India retains its previous year export to all the importer countries except Egypt.

The Markov-chain analysis was used and the results of the transitional probability matrix are presented in Table 4. It depicts a broad indication of the changes in the direction of trade of buffalo meat. The time period considered is for twelve years (2006-2007 to 2017-2018). The seven major importing countries taken for this analysis were Egypt, Jordan, Malaysia, Philippines, Saudi Arabia, United Arab Emirates and Vietnam. The transition probability matrix indicated that India could not retain its previous export to Saudi Arabia. However India retained its previous export to Vietnam, Philippines, Jordan, Malaysia, United Arab Emirates and Egypt with 81, 69, 63, 48 and 43 and 7.3 per cent, respectively. Nearly entire (89 per cent) share of Egypt buffalo meat imports from India was lost to Vietnam. While 69 per cent of cent share of Saudi Arabia's buffalo meat import was lost to Egypt and the remaining 24.6 per cent and 6.1 per cent share lost to Malaysia and Vietnam respectively. However, Jordan lost 25 and 8.9 per cent of buffalo meat's market share to Saudi Arabia and United Arab Emirates, respectively. Malaysia lost 30.5 and 18 per cent of buffalo meat's market share to Saudi Arabia and United Arab Emirates, respectively. Philippines lost 12.1, 9.7 and 7.4% of buffalo meat's market share to United Arab Emirates, Saudi Arabia and Egypt, respectively. United Arab Emirates lost 24, 15.1 and 10 per cent of buffalo meat's market share to Philippines and United Arab Emirates. Vietnam lost 6.9, 6.1 and 2.4 per cent of buffalo meat's market share to Egypt, Malaysia and Saudi Arabia, respectively.

**Table 3. Transitional probability matrix for India's export of buffalo meat in quantity (2006-07 to 2017-18)**

Sr. No.	Country	Egypt	Jordan	Malaysia	Philippines	Saudi Arabia	U.A.E.	Vietnam
1	Egypt	0.000	0.032	0.000	0.000	0.000	0.000	0.968
2	Jordan	0.000	0.633	0.111	0.000	0.254	0.003	0.000
3	Malaysia	0.000	0.000	0.489	0.042	0.000	0.129	0.340
4	Philippines	0.083	0.003	0.104	0.699	0.099	0.013	0.000
5	Saudi Arabia	0.418	0.000	0.000	0.000	0.558	0.024	0.000
6	U.A.E	0.335	0.000	0.127	0.101	0.000	0.436	0.000
7	Vietnam	0.108	0.000	0.077	0.000	0.000	0.000	0.814

**Table 4. Transitional probability matrix for India’s export of buffalo meat in value (2006-07 to 2017-18)**

Sr. No.	Country	Egypt	Jordan	Malaysia	Philippines	Saudi Arabia	U.A.E.	Vietnam
1	Egypt	0.073	0.031	0.006	0.000	0.000	0.000	0.890
2	Jordan	0.000	0.665	0.000	0.000	0.254	0.082	0.000
3	Malaysia	0.000	0.000	0.515	0.000	0.305	0.180	0.000
4	Philippines	0.074	0.000	0.022	0.686	0.097	0.121	0.000
5	Saudi Arabia	0.693	0.000	0.246	0.000	0.000	0.000	0.061
6	U.A.E.	0.000	0.000	0.000	0.240	0.021	0.151	0.588
7	Vietnam	0.069	0.000	0.061	0.000	0.024	0.000	0.846

From these results it could be inferred that the stability in buffalo meat export of India was higher with Vietnam, Philippines, Jordan, Malaysia, United Arab Emirates and Egypt. The buffalo meat export to Saudi Arabia was completely unstable. Thus, India retains its previous year export to all the importer countries except Saudi Arabia.

The Markov-chain analysis was used and the results of the transitional probability matrix are presented in Table 5. It depicts a broad indication of the changes in the direction of trade of poultry products. The time period considered is for twelve years (2006-2007 to 2017-2018). The seven major importing countries taken for this analysis were Afghanistan, Bahrain, Kuwait, Liberia, Maldives, Oman and United Arab Emirates. The transition probability matrix indicated that India has retained its previous export to all countries. However India retained its previous export to Oman, Afghanistan, Liberia, Maldives, Bahrain, Kuwait, and United Arab

Emirates with 67, 58, 44, 43, 16, 14 and 13 per cent, respectively. 86 per cent share of Kuwait’s poultry products imports from India was lost to Afghanistan [10].

While 87 per cent share of United Arab Emirates poultry products import was lost to Kuwait and it retained 13 per cent. However, Afghanistan lost 20, 10, 7 and 6 per cent of poultry products market share to Liberia, Oman, Maldives and Bahrain, respectively and retained 58 per cent. Bahrain lost 68 and 16 per cent of poultry products market share to Oman and Afghanistan. Kuwait lost 86 per cent of poultry products market share only to Afghanistan and retained only 14 per cent. Liberia lost 40 and 15 per cent of poultry products market share to Oman, Bahrain and retained 45%. Maldives lost 56 per cent of poultry products market share to Oman. Oman lost 26 and 6 per cent of poultry products market share to Maldives and Bahrain. United Arab Emirates lost 87% of poultry products market share only to Kuwait.

**Table 5. Transitional probability matrix for India’s export of poultry products in quantity (2006-07 to 2017-18)**

Sr. No.	Country	Afghanistan	Bahrain	Kuwait	Liberia	Maldives	Oman	U.A.E.
1	Afghanistan	0.575	0.061	0.000	0.196	0.070	0.098	0.000
2	Bahrain	0.156	0.160	0.000	0.000	0.000	0.684	0.000
3	Kuwait	0.862	0.000	0.138	0.000	0.000	0.000	0.000
4	Liberia	0.000	0.152	0.000	0.443	0.000	0.401	0.003
5	Maldives	0.000	0.000	0.000	0.000	0.437	0.563	0.000
6	Oman	0.000	0.058	0.000	0.000	0.263	0.674	0.004
7	U.A.E.	0.000	0.000	0.873	0.000	0.000	0.000	0.127

**Table 6. Transitional probability matrix for India’s export of poultry products in value (2006-07 to 2017-18)**

Sr. No.	Country	Afghanistan	Bahrain	Kuwait	Liberia	Maldives	Oman	U.A.E.
1	Afghanistan	0.410	0.056	0.000	0.055	0.110	0.370	0.000
2	Bahrain	0.000	0.584	0.000	0.000	0.390	0.025	0.000
3	Kuwait	0.768	0.000	0.232	0.000	0.000	0.000	0.000
4	Liberia	0.067	0.106	0.000	0.647	0.000	0.000	0.179
5	Maldives	0.000	0.000	0.000	0.000	0.218	0.779	0.003
6	Oman	0.000	0.029	0.000	0.000	0.127	0.802	0.042
7	U.A.E.	0.119	0.205	0.512	0.000	0.000	0.028	0.136

From these results it could be inferred that the stability in poultry products export of India was higher with Oman, Afghanistan, Liberia, Maldives, Bahrain, Kuwait, and United Arab Emirates. The stability was meager with United Arab Emirates and Kuwait Thus; India retained its previous year export to all the importer countries.

### 3.2 Transitional Probability Matrix for India's Export of Poultry Products in Value

The Markov-chain analysis was used and the results of the transitional probability matrix are presented in Table 4. 19. It depicts a broad indication of the changes in the direction of trade of egg products. The time period considered is for twelve years (2006-2007 to 2017-2018). The seven major importing countries taken for this analysis were Afghanistan, Bahrain, Kuwait, Liberia, Maldives, Oman and United Arab Emirates. The transition probability matrix indicated that India has retained its previous export to all countries. However India retained its previous export to Oman, Liberia, Bahrain, Afghanistan, Kuwait, Maldives and United Arab Emirates. With 80.2, 64.7, 58.4, 41, 23.2, 21.8 and 13.6 per cent, respectively. 76 per cent share of Kuwait poultry products imports from India was lost to Afghanistan and retained only 14 per cent. While 51.2 per cent of cent share of United Arab Emirates poultry products import was lost to Kuwait and it retained 13 per cent. However, Afghanistan lost 37, 11, 5.6 and 5.5 per cent of poultry products market share to Oman, Maldives, Bahrain and Liberia, respectively and retained 41 per cent. Bahrain lost 39 and 25 per cent of market share to Maldives and Oman. Liberia lost 17.9 and 10.6 per cent of poultry products market share to U.A.E and Bahrain and retained 64.7 per cent. Maldives lost 77.9 per cent of poultry products market share to Oman. Oman lost 12 and 4.2 per cent of poultry products market share to Maldives and United Arab Emirates. United Arab Emirates lost 51.2, 20.5 and 11.5% of poultry products market share to Kuwait, Bahrain, and Afghanistan, respectively [11].

From these results it could be inferred that the stability in poultry products export of India was higher with Oman, Liberia, Maldives, Bahrain, Afghanistan, Kuwait, and United Arab Emirates. The stability was meager with United Arab Emirates and Kuwait Thus; India retained its previous year export to all the importer countries.

The Markov-chain analysis was used and the results of the transitional probability matrix are presented in Table 6. It depicts a broad indication of the changes in the direction of trade of sheep meat. The time period considered is for twelve years (2006-2007 to 2017-2018). The seven major importing countries taken for this analysis were Bahrain, Kuwait, Maldives, Oman, Qatar, Saudi Arabia and United Arab Emirates. The transition probability matrix indicated that India could retain its previous export to all countries with variation. However India retains its previous export to Saudi Arabia, Oman, Kuwait, Bahrain, Maldives and United Arab Emirates with 80, 65, 59, 42, 24, 21 and 14 per cent, respectively. 78 per cent share of Qatar sheep meat imports from India was lost to Saudi Arabia. While 75 per cent share of Maldives sheep meat import was lost to Bahrain. However, Bahrain lost 37, 11, 6 and 5.5 per cent of sheep meat market share to Saudi Arabia, Qatar, Kuwait and Oman, respectively. Kuwait lost 38 and 2.5 per cent of sheep meat market share to Qatar and Saudi Arabia. Maldives lost 76 per cent of sheep meat market share only to Bahrain .Oman lost 17, 10 and 6% of sheep meat market share to United Arab Emirates, Kuwait and Bahrain. Qatar lost 78%, of sheep meat market share only to Saudi Arabia. Saudi Arabia lost 13, 4 and 3 per cent of sheep meat market share to Qatar, United Arab Emirates and Kuwait, respectively. United Arab Emirates lost 51, 20.5, 11 and 3 per cent of sheep meat market share to Maldives, Kuwait, Bahrain, and Saudi Arabia, respectively [12].

From these results it could be inferred that the stability in sheep meat export of India was higher with Saudi Arabia, Oman and Kuwait. The stability was meagre Maldives and United Arab Emirates with Thus, India retain its previous year export to all the importer countries.

The Markov-chain analysis was used and the results of the transitional probability matrix are presented in Table 7. It depicts a broad indication of the changes in the direction of trade of sheep meat. The time period considered is for twelve years (2006-2007 to 2017-2018). The seven major importing countries taken for this analysis were Bahrain, Kuwait, Maldives, Oman, Qatar, Saudi Arabia and United Arab Emirates. The transition probability matrix indicated that India could retain its previous export to all countries with variation except Maldives and Qatar. However India retained its previous export to Saudi Arabia, United Arab Emirates, Bahrain, Kuwait and Oman with 89.3, 76.8, 24.3, 12.0, and 3.7 per cent, respectively. Qatar lost of

sheep meat imports from India completely to United Arab Emirates. While 65.1 per cent of share of Maldives sheep meat import was lost to United Arab Emirates. However, Bahrain lost 73.1 per cent of sheep meat market share solely to Saudi Arabia. Kuwait lost 37, 26.6 and 21.9 per cent of sheep meat market share to Saudi Arabia, United Arab Emirates and Oman, respectively.

Maldives lost 65.1 and 34.9 per cent of sheep meat market share to United Arab Emirates and Qatar .Oman lost 45, 37.2 and 14.1 per cent of sheep meat market share to Qatar, Saudi Arabia and Kuwait, respectively. Saudi Arabia lost 9.1 per cent, of sheep meat market share to Kuwait. United Arab Emirates lost 13.8 and 7.6 per cent of sheep meat market share to Qatar and Kuwait.

From these results it could be inferred that the stability in sheep meat export of India was higher with Saudi Arabia, United Arab Emirates and Bahrain. The stability was meager Oman. Maldives and Qatar lost completely. Thus, India retained its previous year export to all the importer countries except Maldives and Qatar [13].

### 3.3 Determinant Factors for Livestock Production

The growth and development of livestock sector is highly contributed by availability of factors that

affects the livestock sector and mainly the various species are important one. Livestock sector is important for the overall development of agriculture sector. As livestock products like milk, meat, and egg also influence the growth of livestock sector. As these are the important for growth of livestock sector, it is also necessary to know the factors contributing in livestock growth. Livestock sector development is important. To find out the determinants for livestock production, the multiple linear regressions were fitted by using the secondary data of 20 years starting from 1997-98 to 2016-2017.

The results of estimated multiple linear regression analysis for the factors affecting on meat production of India are depicted in the Table 8. The regression coefficients of the variables viz., number of Animals Slaughtered, number of veterinary institutes ( $X_2$ ), population of sheep, goat, buffalo, poultry ( $X_5$ ), were positive and significant at 1% level of significance. Area under fodder crops ( $X_4$ ) was turned to be positive and non-significant. While the variables viz., permanent pasture & grazing land 000 ha ( $X_3$ ), institution credit to agriculture and allied sector ( $X_6$ ), was turned to be negative and non-significant. The value of  $R^2$  was 0.90 indicates that 90% total variations in output was jointly explained by six explanatory variables [14].

**Table 7. Transitional probability matrix for India’s export of sheep meat in quantity (2006-07 to 2017-18)**

Sr. No.	Country	Bahrain	Kuwait	Maldives	Oman	Qatar	Saudi Arabia	U.A.E.
1	Bahrain	0.420	0.058	0.000	0.055	0.100	0.370	0.000
2	Kuwait	0.000	0.594	0.000	0.000	0.380	0.025	0.000
3	Maldives	0.759	0.000	0.242	0.000	0.000	0.000	0.000
4	Oman	0.068	0.106	0.000	0.657	0.000	0.000	0.168
5	Qatar	0.000	0.000	0.000	0.000	0.218	0.779	0.003
6	Saudi Arabia	0.000	0.029	0.000	0.000	0.127	0.802	0.042
7	U.A.E.	0.108	0.208	0.513	0.000	0.000	0.028	0.146

**Table 8. Transitional probability matrix for India’s export of sheep meat in value (2006-07 to 2017-18)**

Sr. No.	Country	Bahrain	Kuwait	Maldives	Oman	Qatar	Saudi Arabia	U.A.E.
1	Bahrain	0.243	0.000	0.026	0.000	0.000	0.731	0.000
2	Kuwait	0.004	0.120	0.000	0.219	0.053	0.336	0.266
3	Maldives	0.000	0.000	0.000	0.000	0.349	0.000	0.651
4	Oman	0.000	0.141	0.000	0.037	0.450	0.372	0.000
5	Qatar	0.000	0.000	0.000	0.000	0.000	0.000	1.000
6	Saudi Arabia	0.000	0.091	0.000	0.017	0.000	0.893	0.000
7	U.A.E.	0.014	0.076	0.004	0.000	0.138	0.000	0.768



Number of animals slaughter was significant and positive. It indicates that if one thousand animal slaughtered then meat production will increase by 0.000204 million tonnes. Population of sheep, goat, buffalo and poultry also significant for meat production. It indicates that if one million of these combine animals increased then meat production will increase by 0.003073 million tonnes.

The results of estimated multiple linear regression analysis for the factors affecting on milk production of India are depicted in the Table 9. The regression coefficients of the variables viz; number of female buffaloes ( $X_2$ ), institution credit to agriculture and allied sector ( $X_6$ ), and area under permanent pasture and grazing land ( $X_4$ ) are positive and significant at 1%, 1% and 5% level of significance respectively. The value of  $R^2$  was 0.89 indicates that 89% total variations in output was jointly explained by six explanatory variables.

Number of female Buffaloes was significant and positive. It indicates that, if we increase buffalo by one thousand then milk production will increase by 0.004290 million tonnes). Then area under permanent pasture and grazing land also positive significant this means that if we increase

thousand hectare of area under permanent pasture and grazing land then milk production will increase by 0.00809 million tonnes. i.e., Area under permanent pasture and grazing land indirectly contributes to milk production. Institution credit to agriculture and allied sector also significant for milk production this means that if we increase of one billion credit then milk production will increase by 0.00291 million tonnes [15].

The results of estimated multiple linear regression analysis for the factors affecting on egg production of India are depicted in the Tables 10-11. The regression coefficients of the variables viz., number of layers ( $X_1$ ) and number of veterinary institutions ( $X_3$ ) are to be positive and significant at 1% and 5% level of significance respectively. The value of  $R^2$  was 0.91 indicates that 91 % total variations in output was jointly explained by four explanatory variables [16].

Number of layers was significant and positive. It indicates that, if we increase thousands of layers then egg production will increase by 0.2367 million number.

**Table 9. Results of regression analysis for meat production**

Sr. No.	Particulars	Variables	Period (1997-98 to 2017-18)
1	Intercept		2.69623486
2	No. of Animals Slaughtered ( „000“)	$X_1$	0.00020467*** (0.000073)
3	No. of Veterinary Institutes (No.)	$X_2$	0.00011021*** (0.000036)
4	Permanent pasture and Grazing land ( „000 „ha)	$X_3$	-0.0005621 (0.00027)
5	Area under fodder crops („000“ha)	$X_4$	0.00001062 (0.000044)
6	Population of Sheep, Goat ,Buffalo, Poultry (million)	$X_5$	0.00307333*** (0.00052)
7	Institution credit to Agriculture and Allied sector (Billion \$)	$X_6$	-0.0000442 (0.00007)
8	$R^2$		0.90

*N=20, Figure in the parentheses indicates standard errors of respective regression coefficient) („\*\*\*\*, indicate significance at 1, % level)*

**Table 10. Results of regression analysis for milk production**

Sr. No.	Particulars	Variables	Period(1997-98 to 2017-2018)
1	Intercept		-139.614
2	No .of Cows („000“)	$X_1$	0.00032 (0.000613)
3	No. of female Buffaloes ('000“)	$X_2$	0.00429 *** (0.00094)
4	Rainfall (mm)	$X_3$	-0.00174 (0.0042)
5	Area under permanent Pasture and Grazing land („000“ ha.)	$X_4$	0.00809** (0.0034)
6	Area under Fodder („000“ ha.)	$X_5$	0.00058 (0.000813)
7	Institution credit to Agriculture and Allied sector (Billion \$)	$X_6$	0.00291*** (0.00096)
8	$R^2$		0.89

*N=16 Figure in the parentheses indicates standard errors of respective regression coefficient) („\*\*\* “ „ \*\* “ Indicate significance at 1, 5 % level)*

**Table 11. Results of regression analysis for eggs production**

Sr. No.	Particulars	Variables	Period (1997-98 to 2017-18)
1	Intercept		-4331.57
2	Number of layers (000 in numbers)	X <sub>1</sub>	0.2367*** (0.0166)
3	Area under cereals (000 ha)	X <sub>2</sub>	0.02291 (0.0995)
4	No. of veterinary institutions	X <sub>3</sub>	0.1398** (0.06333)
5	Total Institution credit to Agriculture and Allied sector (Billion \$)	X <sub>4</sub>	-0.8147(0.6122)
6	R <sup>2</sup> value		0.91

*N=20 Figure in the parentheses indicates standard errors of respective regression coefficient) („\*\*\*\*“, “\*\*“ Indicate significance at 1, 5 % level)*

#### 4. CONCLUSION

- Transitional probability matrix for export of milk products from India revealed that India has retained Bangladesh and Unite Arab Emirates. Algeria, Egypt, Nepal, Saudi Arabia, Singapore lost completely their retention probability. Bangladesh gain complete export of Saudi Arabia and half of Egypt's import. In terms of value India retains Unite Arab Emirates, Bangladesh, Algeria and Egypt. Highest retainer was Unite Arab Emirates with 37%.
- Transitional probability matrix for export buffalo meat from India, it revealed that India has retained its previous export Vietnam, Philippines, Jordon, Saudi Arabia, Malaysia, and Unite Arab Emirates. Egypt had lost retention capacity completely. Vietnam retained highest with 81%. In case of value terms India has retained Vietnam, Philippines, Jordon, Malaysia, U.A.E and Egypt but it had lost Saudi Arabia completely. Egypt and U.A.E shows unstable in importing.
- Transitional probability matrix for export egg products (in quantity terms) from India, it revealed that India has retained its previous export to Oman, Afghanistan, Liberia, Maldives, Bahrain, Kuwait, and Unite Arab Emirates. Oman retained highest with 67%. The stability was meagre with Unite Arab Emirates, Bahrain and Kuwait Thus; India retained its previous year export to all the importing countries. In case of value terms India has retained its previous export with same countries in case of quantity terms but Bahrain is stable here.
- Transitional probability matrix for export of sheep meat (in quantity terms) from India, it revealed that India has retained its previous export to Saudi Arabia, Oman, Kuwait, Bahrain, Maldives, and Unite Arab Emirates. Saudi Arabia has retained highest with 80.2%. The stability was meagre with Maldives and Unite Arab Emirates. Thus India retained its previous year export to all the importing countries. In case of value terms India has retained its previous export to same countries except Maldives and Qatar. Maldives and Qatar lost completely. The stability was meagre with Oman, Kuwait. Thus India retained its 2016-2017 export to all the importing countries.
- The analysis of multiple linear regressions for factors influencing the meat production revealed that, the six variables included in the model have jointly explained 90% of variation in total meat production. The regression coefficient of the variable viz., Number of Animals Slaughtered, Number of veterinary institutes, Population of Sheep, Goat, Buffalo, and Poultry were turned out to be positive and highly significant at 1% level of significance indicating that, the meat production was highly responsive to these important variables.
- The analysis of multiple linear regressions for factors influencing the milk production revealed that, the six variables included in the model have jointly explained 89% of variation in total milk production. The regression coefficient of the variable viz, Number of female Buffaloes, Area under permanent Pasture and Grazing land were turned out to be positive and highly significant at 5% level of significance and Institution credit to Agriculture and Allied sector at 1% level of significance indicating that, the milk production was

highly responsive to these important variables.

- The analysis of multiple linear regressions for factors influencing the eggs production revealed that, the four variables included in the model have jointly explained 91% of variation in total egg production. The regression coefficient of the variable viz: number of layers and number of veterinary institutes turned out to be positive and highly significant at 1 and 5% level of significance, respectively. Indicating that, the egg production was highly responsive to these important variables.
- The Markov Chain analysis revealed that India has an edge to export milk products to Algeria, Bangladesh and U.A.E as indicated by highest retention capacity. In case of egg, export to Oman, Afghanistan, Liberia, Maldives indicated by highest retention capacity. In case of buffalo meat, export to Vietnam, Philippines, Jordan and Saudi Arabia as indicated by highest retention capacity. In case of sheep meat, export to Saudi Arabia, Oman and Kuwait had the highest retention capacity.
- The multiple linear regression analysis indicated that the factors for milk production (number of buffaloes, Area under permanent Pasture and Grazing land and institutional credit), for meat production (number of animals slaughtered, population of poultry, buffalo, sheep and goat, number of veterinary institutes) and for egg production (Number of layers and number of veterinary institutes) were highly significant to increase the livestock product production.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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