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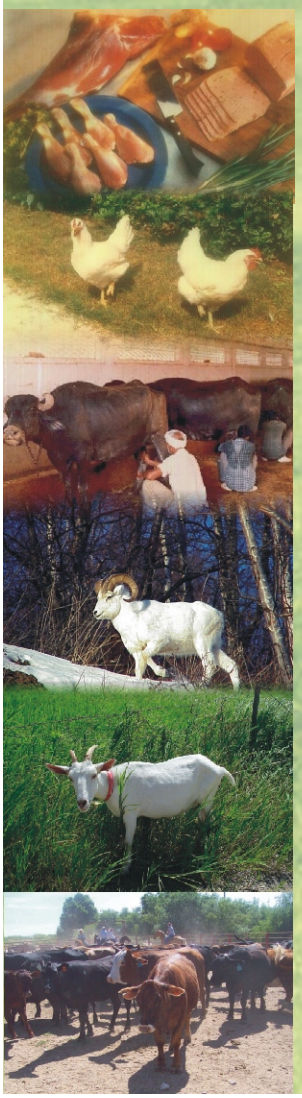
Demand and Supply Projections for Livestock Products in India



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राष्ट्रीय कृषि आर्थिकी एवं नीति अनुसंधान केन्द्र
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Demand and Supply Projections for Livestock Products in India

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FOREWORD

It is amazing that despite a continuous increase in the supply, per capita consumption of livestock products in India remains low. The per capita consumption of milk is only about half of its consumption in the US and Australia, and in the case of poultry meat, it is still lower, only about 12 per cent of the consumption in China.

In the developing countries, the demand for livestock products is more elastic than the demand for cereals. This implies that with the rise in per capita income, the demand for livestock products would rise faster. The supply for these products is also highly price-elastic.

In this study, the supply and demand functions for major livestock products have been evaluated, and projections have been made for the years 2010 and 2020. For demand analysis the study uses consumer expenditure data from 50th round of National Sample Survey Organization pertaining to the year 1993-94 while supply analysis is based on time series data on quantity, prices and technologies of livestock products for the period 1970 to 1998.

The findings of the study provide an insight into the projections for 2020, and foresee holistically the demand and supply gap for livestock products. I hope the policy paper would be useful to both researchers and policy planners.

I congratulate the author for conducting such a detailed study.

January 2004
New Delhi

Mruthyunjaya
Director

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The study on demand and supply projections for livestock products in India, illustrates the kind of constructive dialogue NCAP hopes to encourage in policy research in livestock sector.

Dr Dayanatha Jha, the former Director, NCAP has motivated me to undertake this project. Dr Mruthyunjaya, Director, NCAP has offered his valuable comments, suggestions and remained instrumental in completing this project. I thank both of them for the encouragement, advice and support in conducting this study.

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Author

EXECUTIVE SUMMARY

The livestock sector plays a significant role in the welfare of rural population of India. Of the total households in the rural area, about 73 per cent own livestock. More importantly, small and marginal farmers account for three-quarters of these households. Income from livestock production accounts for 15-40 per cent of the total farm household's income in different states. Thus, an increase in demand for livestock products, can be a major factor in raising the income and living standards of the rural households.

In the low-income countries, the demand for livestock products is more elastic than the demand for cereals. This implies that with the rise in per capita income, the demand for livestock products would rise faster in the third world countries. The demand for livestock products in India is highly income-and price-elastic while supply for these products is also highly price-elastic. This study estimates complete system of demand-supply equations, and analyzes the effects of income and price changes on demand, and the impact of prices, technology, and various inputs on the supply for livestock products and makes projections for demand-supply for selected livestock products for the year 2020. The production of livestock products is demand-driven rather than supply-driven, as is in the case of cereals. The supply elasticities for livestock products are less elastic as compared to demand elasticities.

Demand study has been made using the latest available consumer expenditure data from National Sample Survey Organization (NSSO) 50th Round, which covers urban and rural households in various states. The data pertain to the year 1993-94. The Log Linear Model has been employed to estimate the complete systems of demand equations. The sample size is 76,784 households for rural and 40,009 households for urban India. The commodity groups for which demand equations have been estimated include milk, mutton and goat meat, beef and buffalo meat, chicken, egg, other-foods and non-foods. The supply study uses time series data on quantity of production, own prices, prices of inputs (feed), the existing stage of

production technologies of livestock products for the period 1970 to 1998. Linear and Polynomial Price Lag Models have been employed to estimate supply equations. The supply equations that have been estimated include milk, mutton and goat meat, beef and buffalo meat, chicken, and egg.

The livestock products being high-value commodities, exhibit high elasticities. The consumption pattern has revealed that rural population on an average consumes less quantities of livestock products than the urban population. The cross-price elasticities suggest that most livestock products substitute each other in consumption.

The income elasticity of demand for milk has been estimated as 1.36 for rural households and 1.07 for urban households. The demand for beef and buffalo meat, chicken and egg has been found to be more elastic in rural households (ranges from 0.74 to 2.35) than in urban households (ranges from 0.57 to 1.24). Interestingly, the income elasticity for mutton and goat meat has been found to be more elastic (3.19) in urban households, as compared to rural households (0.52). This implies that mutton and goat meat have higher demand in the urban areas.

The expenditure elasticities for livestock products are high, particularly in the rural areas than in the urban areas. It implies that increase in per capita income of rural population would accelerate the demand for livestock products. Further, the expenditure elasticities of livestock products are higher than other food expenditure elasticities. This implies that there is a shift in the consumption pattern towards livestock products and this would lead to diversification of agriculture.

High-income elasticities suggest the existence of a favourable environment for the growth of livestock sector and diversification of Indian agriculture. Further, growth in per capita income, urbanization and shift in consumption pattern towards livestock products would lead to acceleration in demand for livestock products and this would in turn give a boost to this sector.

The demand projections for livestock products corresponding to 5 per cent GDP growth rate, generally regarded as closer to the realistic situation. The estimated consumption in the year 1993 was of 45.02 million tonnes

milk, 0.78 million tonnes mutton and goat meat, 0.49 million tonnes beef and buffalo meat and 0.25 million tonnes chicken and 0.54 million tonnes eggs. In the year 2020, the demand would reach 147.26 million tonnes for milk, 12.72 million tonnes for mutton and goat meat, 1.15 million tonnes for beef and buffalo meat, 0.81 million tones for chicken and 2.58 million tonnes eggs.

From 1993 to 2000, the consumption has increased at an average growth rate (weighted) of 4.48 per cent for milk, 9.46 per cent for mutton and goat meat, 3.32 per cent for beef and buffalo meat, 4.6 per cent for chicken, 6.02 per cent for eggs. During 1993-2020, the average growth rate (weighted) for the total domestic demand of milk has been found to be 4.9%. It is 13.7% for mutton and goat meat, 3.5% for beef & buffalo meat, 4.8% for chicken and 6.2% for eggs. These growth rates indicate that the meat industry has bright prospects in the country.

The production of livestock products is largely demand-driven. Time variable, which represents the technological and other structural changes in the livestock subsector, is highly significant indicating that the technological progress would be crucial. Feed price elasticities of mutton, beef, egg, milk in the Linear Model and feed price elasticities of mutton, beef, chicken, egg in the Polynomial Model are negative and significant indicating that the rise in feed prices would influence the production of these commodities adversely. Similarly, price elasticities of mutton, and egg in the Polynomial Model and price elasticities of mutton, beef and milk in the Linear Model are significant at 1 per cent level, implying that higher prices stimulate the production of these commodities.

In the case of Polynomial Price Lag Model, the price impact in the first period is positive and significant, indicating that the immediate lag prices are affecting production of these products. It is interesting to note that the dynamic price impacts (as depicted by the lagged price elasticities) increase first with lag, then decrease and increase again.

The base-line scenario at 5% GDP growth rates has revealed that the actual production trends for all the commodities closely follow those for the actual consumption. These results generally indicate that in 2020, India would be

self-sufficient in these products as all the projected production figures are more than consumption figures. However these results have to be updated with newer data relating to consumer expenditure as well as better estimates of production of livestock products as they become available. This policy paper is a modest beginning in this direction.

1 INTRODUCTION

The importance of livestock in India's economy can be gauged from the fact that 90 million farming families, cultivating 140 million hectare area, rear 90 million milch animals. Livestock production is an important source of income and employment in the rural sector. The sector employs eight per cent of the country's labour force, including small and marginal farmers, women, and landless agricultural workers. Milk production alone involves more than 30 million small producers, each raising one or two cows or buffaloes annually. Livestock provides a large share of draught power, with about half the cattle population and 25 per cent of the buffalo population being used to cultivate 60 million ha of crop land (World Bank, 1998). It acts as a supplementary and complementary enterprise. Livestock is also important as a part of agriculture diversification and income enhancement, and crucial for nutrition enhancement. Livestock plays a vital role in the economic development. In India, 25 % of the agricultural GDP is contributed by this sector in 1998-99 (Economic Survey, 1999-2000).

In order to formulate an effective policy for the growth and development of livestock sector, it is crucial to know the demand and supply situation of various livestock products. What would be the growth rates of demand and supply, and difference between the two during the next two decades? What factors are relevant to demand and supply and what are their impact on future growth of production and consumption?. In this study, Seemingly Unrelated Regression Equations (SURE) and Polynomial Lag Models have been used to estimate the effect of various factors on the demand and supply of livestock products like milk, mutton and goat meat, beef and buffalo meat, chicken, and egg. Besides, demand equations for other food and non-food commodities have also been studied. Based on the available data, the likely gap between the demand and supply of livestock products has been estimated.

1.1. Objectives

(i) to study the effect of prices, income and other variables on the demand and supply,

(ii) to make projections for demand and supply of selected livestock products towards 2020 under different scenarios, and

(iii) to examine the prospects of attaining different growth rates in output of selected livestock products to meet the growing domestic demand and suggest policy measures to attain a different set of output growths.

1.2. Organisation of the Report

This report has been organized in four Chapters. Introduction has been presented in Chapter 1. The second chapter provides analysis of demand of livestock products, which includes, a brief overview of sources and nature of data, estimation procedures, and model specifications. The results of the estimated log linear model such as system of equations, expenditure and price elasticities, projection scenarios of livestock products for 2020 are also presented in this chapter. The supply analysis of livestock products has been discussed in Chapter 3. It includes sources of data, estimation procedure, model specification, elasticities, projection scenarios of livestock products. In the fourth chapter, conclusions and policy implications of the study have been presented.

2 DEMAND

India's livestock sector employs eight per cent of the country's labour force, including many small and marginal farmers, women, and landless agricultural workers. More than 630 million people (74% of the population) live in the rural areas, and about 73 per cent households own livestock. More importantly, small and marginal farmers constitute 75 per cent of these households, and income from livestock production accounts for 15-40 per cent of the total farm income. Thus, the rise in demand for livestock products can significantly increase the income of rural households.

Several empirical studies have revealed (Huang and Bouis 1996; Kumar 1996) that a structural shift is taking place in food consumption towards livestock products. Indications are there that the shift would continue and intensify further with increase in per capita income and rapid urbanization. Trade liberalization may further accelerate the growth in demand for livestock products. These emerging scenarios would have considerable bearing on future demand and supply patterns of livestock products.

Methodology

2.1. The Data

The demand study was based on the data compiled from the publication of NSSO (National Sample Survey Organization) on 'Consumption of Some Important Commodities in India' of NSSO, 50th round, 1993-94, which was published in 1997. The 1993/94 Survey of NSSO, has separate rural and urban samples. This survey is particularly important since for the first time it has provided quantity as well as value data for different livestock products, thereby permitting detailed analysis of the demand behaviour.

The data consisted of the cross-sectional series on aggregate quantity consumed and values of different food and livestock products per person per 30 days in different states under rural and urban categories pertaining

to the year 1993-94. The commodity groups for which demand was studied included milk, mutton and goat meat, beef and buffalo meat, chicken, egg, other-foods and non-foods. The last two categories are the mixed bundles, incorporated to specify a complete demand system[1] . The sample size was 76,784 households for rural and 40,009 households for urban India.

2.2. Models

Several demand models are available for estimating the income and price elasticities of demand for a commodity. The recent demand studies have been centred around complete demand systems which take into account mutual interdependence of a large number of commodities in the budgetary decisions of the consumer.

The models which have received considerable attention are: the Linear Expenditure System (Stone, 1954), and Almost Ideal Demand System (AIDS) (Deaton and Muellbauer, 1980). These models are generally used for estimating the demand equations for a group of commodities, and not for commodities at a disaggregate level. Also, these models do not allow increasing or decreasing income elasticities.

Bouis (1991) had suggested a non-econometric model based on demand characteristics known as food characteristics demand system (FCDS). This model requires far less data than needed in the usual econometric approaches and therefore may be implemented relatively quickly and cost-effectively. The Normalized Quadratic Demand System (NQDS), Generalised Leontief Demand System (GLDS) and Transcendental Logarithmic Demand Systems (TLDS), suggested by Swamy and Binswanger (1983), are the models which satisfy all the general restrictions of demand theory and also allow the estimation of cross-price elasticities within a group of close substitutes or complements and do not assume additivity. These models also include linear and squared income terms which allow more flexibility in the response of

[1] These have no prices or quantities. The quantities were notionally derived by dividing expenditures by the price index. The consumer price index of food was used as price of other food and consumer price index of non-food were used for non-food prices. Non-food price index for industrial workers was used for urban , and price index of agricultural workers was used for rural area. These indexes were obtained from *Statistical Abstract of India, 1997*.

consumer items to changes in income. Several studies have shown that demand elasticities can vary widely across income groups (see Alderman (1986) for a review) and by regions as the production environments and the tastes change.

Most of the earlier works on demand is based on a single equation model relating consumption (expenditure) and income (total expenditure) and prices. We have estimated a demand system comprising consumption of selected commodities and two broad groups (other food and non-food). The system equations of log linear model was specified as:

$$\log Y_i = a_i + b_{i1} \log m + \sum_{j=1}^{N} c_{ij} \log P_j$$

$$i, j = 1, 2, ..., N$$

where Y_i is the quantity of consumption of the i^{th} commodity, P_j is commodities prices, m is real income (or total expenditure), and C_{ij} are price coefficients,

The actual model is specified as:

$$Y_i = b_0 .P_{x_1}^{b1}.P_{x_2}^{b2}.P_{x_3}^{b3}.P_{x_4}^{b4}.P_{x_5}^{b5}.P_{x_6}^{b6}.P_{x_7}^{b7}.P_{x_8}^{b8}.m^{b9}.d_i D$$

where, Y_i= Quantity of different livestock products consumed per capita over 30 days. This includes milk, mutton and goat meat, beef and buffalo meat, chicken, eggs, fish, other food and non-food (log).

P_{x_1} = Prices of milk (log)
P_{x_2} = Mutton & goat meat prices (log)
P_{x_3} = Beef & buffalo meat prices (log)
P_{x_4} = Chicken prices (log)
P_{x_5} = Egg prices (log)
P_{x_6} = Fish prices (log)
P_{x_7} = Other food prices (log)
P_{x_8} = Non-food prices (log)
P_{x_9} = Real income/ Expenditure (log), and
b_i and d_i are the coefficients for the structural and dummy variables, respectively.
D = Dummy variable (to capture regional variation)

2.3. Estimation Procedure

The data for each commodity consisted of 64 observation sets, representing rural and urban population across all the states and union territories of India. The complete demand system of simultaneous equations was estimated using Generalized Least Square (GLS) procedure.

The estimated coefficients gave elasticities in the double log specifications. We tried imposing homogeneity and symmetry restrictions but were unable to estimate the restricted form. Hence, restricted form was not used in the study. The variables included in the model explained the variability in the range 46% to 92% in the rural, 29% to 96% in the urban, and 28% to 93% in the pooled data in various equations.

The projections for 1993-2020 were made using simple growth rate model[2] based on estimated expenditure elasticities, growth in population, and per capita income growth rates[3].

Double log model was employed to estimate the complete systems of demand equations. The expenditure and price elasticities of Double Log Model are given in Section 2.5 & 2.6 and the demand projection scenarios of livestock products for 2020 are described in Section 3.7.3.

2.4. Demand Estimation

The annual per capita consumption of livestock products in India is shown in Table 1. It is apparent from this table that the rural population consumed less livestock products than the urban population in the year 1993. A similar trend was noticed earlier in 1987. The per capita consumption of commodities was higher quantitatively in 1993 than that in 1987, for pooled population except for mutton and goat meat.

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[2] Simple growth rate model: $D_t = d_o * N_t (1+ y * e)^t$; Where, D_t is the household demand for a commodity in year t ; d_o is the per capita demand of the commodity in the base year; y is the growth in per capita income; e is the expenditure elasticity of demand for the commodity; and N_t is the projected population in year t.

[3] Assumptions; population growth and per capita income growth as given in 7& 8 Tables.

Table 1. The per capita consumption (per annum) of livestock products for rural, urban and pooled population in India (1987 and 1993)

Commodity	Rural		Urban		Pooled	
	1987	1993	1987	1993	1987	1993
Milk (litres)	38.40	47.28	51.12	58.68	41.52	50.28
Mutton & goat meat (kg)	0.72	0.72	1.56	1.32	0.96	0.84
Beef & buffalo meat (kg)	0.36	0.48	0.84	0.72	0.48	0.60
Chicken (kg)	0.24	0.24	0.24	0.36	0.24	0.24
Egg (number)	6.24	7.68	17.16	17.76	8.88	10.32

Source: GOI (1997) 'Consumption of some important commodities' NSS, 50th round, 1993-94.

The systems of the estimated log linear model equations, means of quantities and prices of dependent and independent variables used in the estimation and intercept, and goodness of fit are given in Appendices, I - V.

2.5. Expenditure Elasticities

The values of expenditure elasticities are recorded in Table 2. High and significant expenditure elasticities were obtained for milk, mutton and goat meat, chicken, and eggs in the total sample. These results clearly showed that demand for livestock products was elastic. On the other hand, the demand for other food was inelastic. For milk, meat and poultry, the increase in income led to more than proportionate increase in their consumption. For beef & buffalo meat, non-significant elasticity was observed.

The rural and urban samples showed the differences in elasticities as per expectations. For milk, chicken and eggs, the rural demand was found to be more elastic. Urban demand for mutton & goat meat and egg was more elastic. Hazell and Bhalla (1996) reported that the demand for livestock products in India is highly income elastic. They had estimated the expenditure elasticity for milk and milk products range from 1.14 to 1.47 for rural households and 0.61 to 1.09 for urban households. The demand for meat, fish and eggs is more elastic in rural households (0.92-1.18) than urban house holds (0.54-0.88).

Table 2. Expenditure (income) elasticities at predicted means

Commodity	Rural	Urban	Pooled
Milk	1.3655 ***	1.0701	1.5028 *
	(1.6381)	(1.1967)	(3.089)
Mutton & goat meat	0.52255	3.1978 **	2.2645 *
	(0.3741)	(1.9083)	(2.6342)
Beef & buffalo meat	0.7484	0.5702	0.3270
	(0.4124)	(0.2256)	(0.2555)
Chicken	1.571 8 ***	0.9439	1.1653 **
	(1.8277)	(0.7655)	(1.9364)
Eggs	2.3541 *	1.2417 **	1.5687 *
	(3.0771)	(2.2184)	(4.2311)
Other food	0.0722	0.1212	0.2583 **
	(0.3457)	(0.5425)	(1.8398)
Non-food	1.2770 *	1.6886 *	1.5136 *
	(10.5878)	(12.8189)	(19.2885)

The figures within parentheses indicate t- values
Note : * 1 per cent level of significance
** 5 per cent level of significance
*** 10 per cent level of significance

2.6. Cross Price Elasticities

2.6.1. Rural and Urban categories

The estimates of own and cross-price elasticities of rural and urban categories are presented in Tables 3 and 4 respectively. All own price elasticities except for beef/buffalo meat in case of rural sample, was negative. Milk, eggs, beef and buffalo meat in rural areas and, milk, egg in urban category showed the demand to be highly price elastic. Thus both income and price changes affected the demand for chicken and eggs in rural areas, and eggs in urban areas. High price elasticities also imply high instability in consumption. The cross price elasticities supported the view that most livestock products are substitutes in consumption, while high cross-elasticities suggest that consumers were highly price responsive.

Table 3. Own and cross price elasticities of rural areas in India

Commodity	Milk	Mutton & goat meat	Beef & buffalo meat	Chicken	Egg	Fish	Other food	Non food
Milk	-2.989*	-0.9361***	-0.0679	0.607	0.749	0.537	-1.093	-0.938
	(-2.51)	(-1.32)	(-0.100)	(0.633)	(0.59)	(0.74)	(-0.45)	(0.81)
Mutton & goat meat	-1.069	-0.030	-0.028	1.256	-0.90	-0.570	-3.447	-0.045
	(-0.54)	(-0.03)	(-0.02)	(0.78)	(-0.43)	(-0.472)	(-0.84)	(-0.02)
Beef & buffalo	-3.598***	1.965	3.179***	-0.416	0.241	2.20***	-0.085	1.036
Meat	(-1.39)	(1.27)	(2.16)	(-0.20)	(0.09)	(1.40)	(-0.01)	(0.41)
Chicken	3.797*	-1.726	-0.157	-0.432	-2.619**	0.031	-0.922	-3.897*
	(3.09)	(-2.35)	(-0.22)	(-0.44)	(-2.02)	(0.04)	(-0.36)	(-3.26)
Eggs	1.698	-0.348	0.273	-0.283	-2.852*	-0.129	0.392	-0.661
	(1.55)	(-0.53)	(0.44)	(-0.32)	(-2.48)	(-0.19)	(0.17)	(-0.62)
Other food	-0.181	0.347**	-0.003	0.646*	0.136	-0.017	-0.536	-0.310
	(-0.61)	(1.95)	(-0.02)	(2.69)	(0.434)	(-0.09)	(-0.87)	(-1.07)
Non-food	-0.103	-0.180**	-0.046	-0.032	-0.208	-0.052	0.002	-0.847*
	(-0.60)	(-1.75)	(-0.47)	(-0.23)	(-1.15)	(-0.49)	(0.006)	(-5.05)

The figures within parentheses indicate t- values

Note : * 1 per cent level of significance

** 5 per cent level of significance

*** 10 per cent level of significance

Table 4. Own and cross-price elasticities of urban areas in India

Commodity	Milk	Mutton & goat meat	Beef & buffalo meat	Chicken	Egg	Fish	Other food	Non food
Milk	-2.766***	-0.655	-0.347	0.346	-0.288	0.319	1.215	-1.163
	(-1.45)	(-0.45)	(-0.55)	(0.88)	(-0.19)	(0.35)	(0.39)	(-0.69)
Mutton & goat meat	2.364	-3.308	-2.522**	-0.059	-0.955	0.877	-5.246	1.390
	(0.66)	(-1.21)	(-2.135)	(-0.080)	(-0.33)	(0.51)	(-0.89)	(0.440)
Beef & buffalo	-0.290	6.486***	-0.476	-0.450	-3.277	-1.318	5.335	0.879
Meat	(-0.05)	(1.584)	(-0.27)	(-0.40)	(-0.76)	(-0.51)	(0.60)	(0.187)
Chicken	0.994	1.413	-0.108	-0.328	-2.541	0.805	5.155	-4.696**
	(0.379)	(0.71)	(-0.12)	(-0.61)	(-1.21)	(0.64)	(1.19)	(-2.02)
Eggs	1.478	1.433***	0.011	-0.122	-1.842**	0.212	-1.644	0.415
	(1.24)	(1.58)	(0.03)	(-0.497)	(-1.94)	(0.37)	(-0.83)	(0.39)
Other food	-0.134	-0.298	-0.059	0.033	-0.262	0.009	-0.234	0.359
	(-0.28)	(-0.82)	(-0.38)	(0.34)	(-0.69)	(0.04)	(-0.30)	(0.85)
Non-food	-0.271	0.112	-0.102	0.043	-0.055	0.110	-0.057	-1.028*
	(-0.97)	(0.524)	(-1.09)	(0.75)	(-0.25)	(0.82)	(-0.12)	(-4.14)

The figures within parentheses indicate t- values

Note : * 1 per cent level of significance

** 5 per cent level of significance

*** 10 per cent level of significance

2.6.2. A comparison of differences in elasticities of livestock products

A comparison of differences in elasticities of different livestock products is shown in Table 5. The milk, chicken, and eggs in the rural areas, and milk, mutton & goat meat and eggs in the urban areas were found to be highly income elastic. This implies that increase in consumer income can create more demand for these products. In all the three categories milk and eggs were found to be price elastic. This clearly shows that increase in prices of these commodities would reduce the demand.

Table 5. A comparison of differences in elasticities of livestock products in rural and urban India

Category	Income elasticity		Price elasticity	
	High elastic (>1)	Inelastic (0-1)	High elastic (>1)	Inelastic (<1)
Rural	Milk Chicken Egg	M&G B&B	Milk B&B Egg	Chicken M&G
Urban	Milk M&G Egg	B&B Chicken	Milk Egg	B&B Chicken
Pooled	Milk M&G chicken Egg	B&B	Milk Egg	B&B Chicken

M & G = mutton and goat meat B &B = beef and buffalo meat

2.7. Demand Projections

A sustained economic growth and steady increase in per capita income are expected to substantially boost the demand for livestock products. The demand for direct consumption of each of the livestock products - milk, mutton and goat meat, beef and buffalo meat, chicken and eggs were projected based on the following factors;

(i) The means of quantity consumption (Appendix III),
(ii) The projections for populations made by the Government of India,
(iii) The per capita income growth at 1.46%, 3.62% and 3.49% for rural, urban and pooled areas respectively,
(iv) The continuance of the recent trends in urbanization,

(v) The ratio of rural to urban per capita expenditure based on NSS data, and
(vi) The existing (1993-94) inequality in expenditure.

The demand projections for livestock products were made for the years 2010 and 2020. These demand projections are limited to the household consumptions only.

Before presenting the results of these projections, it is necessary to get some idea about the growth rates of population and per capita income used in this study.

2.7.1. Population Growth and Urbanization

India's population of 895 million in 1991 was nearly twice as large as 20 years ago, and three-times of its size at independence. During the past two decades, the growth rate has been slowing down, from 2.1 per cent per annum during the 1980s to 1.9 per cent in the 1990s. Most experts expect the growth rate to slow down even further during this century, but the population in number has already reached 1 billion in the year 2000. For our analysis, we have taken the population projections as per the report of "Technical Group on Population Projections" (GOI, 1996).

India, like other developing countries, is also moving fast towards urbanization. In 1993, 26.4 per cent of the total population lived in the urban areas, which is projected to increase to 32% by 2010 and 35% by 2020 (Table 6). As a result, while the rural population is expected to increase only by 24 per cent between 1993 and 2020, the urban population would increase by 50 per cent during this period.

Table 6. Projections of population

(in million)

Year	Rural	Urban	Total
1993	658.5	236.7	895.2
2000	715.9	286.2	1002.1
2010	796.9	371.1	1168.0
2020	871.8	470.4	1342.2

Source: Government of India (1996) ' Technical Group on Population Projections'.

2.7.2. Per Capita GDP Growth

In the simulation, three scenarios of income growth rates in the gross domestic product (GDP) were considered; these were 4, 5 and 7 per cent, of which, the first has been the most pessimistic rate historically. The results of demand predictions for livestock products, corresponding to the scenario of 5 per cent GDP growth, have been considered the most realistic in future. Recent policies of liberalization in trade and structural reforms in different sectors of the economy are likely to accelerate the growth process even up to 7 per cent. In the first scenario (low growth), the annual GDP growth rate has been assumed as 4 per cent, with 2.25 per cent in rural and 4.8 percent in urban areas (Table 7). The second scenario (moderate growth) assumed 5 per cent growth in GDP, 2.5 per cent in rural and 6.2 in urban areas, and the third scenario assumed 7 per cent GDP growth rate with 3.5 per cent in rural and 8.0 per cent in urban areas (high growth) (Kumar,1998).

Table 7. Alternative income growth rate assumptions used in demand projections

(per cent)

Scenario	Income			Per capita income		
	Rural	Urban	Total	Rural	Urban	Total
Low Growth	2.25	4.76	4.00	1.21	2.18	2.49
Moderate growth	2.50	6.20	5.00	1.46	3.62	3.49
High growth	3.50	8.00	7.00	2.46	5.42	5.49

Population growth rates are 1.04%, 2.58% and 1.51% for rural, urban and total respectively under all income growth scenarios.

The growth rates in per capita income under alternative scenarios were calculated by subtracting the population growth from income growth and used in predicting the per capita consumption of different food items. The demand projections in this study covering the rural, urban and all India levels, were made using the simple growth rate model formula under the assumptions already stated.

2.7.3. Demand Projections for Livestock Products

The demand projections for livestock products corresponding to the scenario of 4 per cent GDP growth (low income growth) at constant prices are

Table 8. Demand projections for livestock products in India in different years

(Low income growth)

Livestock product	Rural/ Urban	Year				Growth rates (%)		
		1993	2000	2010	2020	1993-2020	1993-2000	2000-2020
Milk	Rural	31.13	37.96	49.78	64.16	2.71	2.87	2.66
	Urban	13.89	19.74	32.23	51.45	4.97	5.15	4.91
	Total	45.02	57.70	82.01	115.61	3.71	3.65	3.66
Mutton & Goat meat	Rural	0.47	0.54	0.64	0.74	1.68	1.84	1.63
	Urban	0.31	0.61	1.54	3.83	9.73	9.91	9.66
	Total	0.78	1.15	2.18	4.57	8.42	6.12	8.36
Beef & Buffalo meat	Rural	0.32	0.37	0.45	0.53	1.96	2.12	1.90
	Urban	0.17	0.22	0.33	0.47	3.85	4.03	3.79
	Total	0.49	0.59	0.78	1.00	2.88	2.83	2.79
Chicken	Rural	0.16	0.20	0.26	0.35	2.97	3.13	2.91
	Urban	0.09	0.12	0.19	0.29	4.69	4.86	4.62
	Total	0.25	0.32	0.45	0.64	3.75	3.78	3.68
Egg	Rural	5.10	6.69	9.87	14.29	3.92	4.08	3.87
	Urban	4.20	6.13	10.38	17.18	5.35	5.53	5.29
	Total	9.30	12.82	20.25	31.47	4.70	4.77	4.64

- Growth rates of total is weighted average growth rates
- The units in million tones in case of Milk, Mutton & goat meat, Beef & buffalo meat, & chicken and billion numbers in case of egg.
- 1993 is considered as base.

given in Table 8. In the year 1993, the actual total demand for milk was 45.02 million tonnes, 0.78 million tonnes for mutton and goat meat, 0.49 million tonnes beef and buffalo meat, 0.25 million tonnes chicken and, 9.30 billion eggs.

The total demand is likely to increase in the year 2010 for fresh milk, (82.01 million tonnes), 2.18 million tonnes for mutton and goat meat, 0.78 million tonnes for beef and buffalo meat, 0.45 million tonnes for chicken, and 20.25 billion for eggs.

In the year 2020, the total demand for fresh milk is likely to be 115.61 million tonnes, 4.57 million tonnes for mutton and goat meat, 1.00 million tonnes for beef and buffalo meat, 0.64 million tonnes for chicken, and 31.47 billion for eggs.

During 1993-2020, the demand will grow at the annual compound growth rate of 3.71 per cent for milk, 8.42 per cent for mutton and goat meat, 2.85 per cent beef and buffalo meat, 3.75 per cent for chicken, and 4.70 per cent for eggs. The demand for mutton and goat meat will grow much faster among livestock products followed by eggs.

The demand projections of livestock products under the scenario of 5 per cent (moderate income growth) GDP growth for India are presented in Table 9. The actual consumption in 1993 was 45.02 million tonnes milk, 0.78 million tonnes for mutton and goat meat, 0.49 million tonnes beef and buffalo meat and 0.25 million tonnes chicken and 9.30 billion eggs.

Table 9. Demand projections for livestock products in India in different years

(Moderate income growth)

Livestock product	Rural/ Urban	Year				Growth rates (%)		
		1993	2000	2010	2020	1993-2020	1993-2000	2000-2020
Milk	Rural	31.13	38.86	52.70	70.24	3.06	3.22	3.00
	Urban	13.89	21.91	41.55	77.02	6.55	6.73	6.49
	Total	45.02	60.77	94.25	147.26	4.88	4.48	4.82
Mutton &	Rural	0.47	0.54	0.65	0.77	1.82	1.97	1.76
Goat meat	Urban	0.31	0.81	3.15	11.95	14.45	14.46	14.38
	Total	0.78	1.35	3.80	12.72	13.68	9.46	13.62
Beef &	Rural	0.32	0.37	0.46	0.56	2.15	2.31	2.09
Buffalo meat	Urban	0.17	0.24	0.38	0.59	4.69	4.87	4.63
	Total	0.49	0.61	0.84	1.15	3.45	3.32	3.39
Chicken	Rural	0.16	0.20	0.28	0.39	3.36	3.52	3.31
	Urban	0.09	0.13	0.24	0.42	6.08	6.26	6.02
	Total	0.25	0.33	0.52	0.81	4.77	4.60	4.72
Egg	Rural	5.10	6.97	10.87	16.67	4.52	4.68	4.46
	Urban	4.20	6.91	13.92	27.38	7.19	7.37	7.12
	Total	9.30	13.88	24.79	44.05	6.18	6.02	6.11

- Growth rates of total is weighted average growth rates
- The units in million tones in case of Milk, Mutton & goat meat, Beef & buffalo meat, & chicken and billion numbers in case of egg.
- 1993 is considered as base.

In the year 2010, the total demand for fresh milk is likely to be 94.25 million tonnes, 3.80 million tonnes for mutton and goat meat, 0.84 million tonnes for beef and buffalo meat, 0.52 million tonnes for chicken, 24.79 billion for eggs.

In the year 2020, the demand will reach 147.26 million tonnes milk, 12.72 million tonnes mutton & goatmeat, 1.15 million tonnes beef and buffalo meat, 0.81 million tonnes chicken and 44.05 billion eggs. According to Kumar (1998), the domestic demand in 2020 is likely to be 126-183 million tonnes milk and 6.3 to 12.1 million tonnes meat and eggs. Hazell and Bhalla (1996) has also projected that in the year 2020 (assuming that economy grows at 5.5 per cent per year) the demand for milk would increase to about 497 million metric tones, for eggs, the demand would increase to 7.21 million metric tonnes and the demand for poultry meat would increase to 1.35 million metric tonnes, and for mutton the demand would reach 2.5 million metric tonnes.

During 1993-2020, the weighted average growth rate for the total Indian domestic demand of livestock products will grow at the growth rates of 4.88% (milk), 13.68% (mutton &goat meat), 3.45% (beef & buffalo meat), 4.77% (chicken), 6.18% (egg). These growth rates indicate that meat, poultry meat and eggs have higher demand in the country.

The results of livestock products corresponding to the scenario of 7 per cent GDP growth (high income growth) at constant price are given in Table 10. In the year 1993, the total demand for milk is estimated at 45.02 million tonnes, 0.78 million tonnes mutton and goat meat, 0.49 million tonnes beef and buffalo meat, 0.25 million tonnes chicken and 9.30 billion eggs. The estimates shows that in the year 2010, the total demand for fresh milk is likely to be 122.85 million tones, 8.13 million tonnes for mutton and goat meat, 0.97 million tonnes for beef and buffalo meat, 0.67 million tonnes for chicken, and 35.88 billion for eggs. In the year 2020, the total demand is likely to be 227.17 million tonnes of milk, 47.37 million tonnes of mutton and goat meat, 1.45 million tonnes of beef and buffalo meat, 1.23 million tonnes of chicken and 79.10 billion of eggs. During 1993-2020, the demand will grow at the annual compound growth rate of 6.71 per cent for milk, 20.01 per cent for mutton and goat meat, 4.41 per cent beef and buffalo meat,

Table 10. Demand projections for livestock products in India in different years

(High income growth)

Livestock product	Rural/ Urban	Year				Growth rates (%)		
		1993	2000	2010	2020	1993-2020	1993-2000	2000-2020
Milk	Rural	31.13	42.64	66.07	100.58	4.44	4.60	4.38
	Urban	13.89	24.92	56.78	126.49	8.53	8.71	8.46
	Total	45.02	67.56	122.85	227.17	6.71	5.48	6.65
Mutton & Goat meat	Rural	0.47	0.56	0.71	0.89	2.34	2.50	2.29
	Urban	0.31	1.16	7.42	46.48	20.35	20.56	20.28
	Total	0.78	1.72	8.13	47.37	20.01	12.75	19.95
Beef & Buffalo meat	Rural	0.32	0.39	0.52	0.68	2.90	3.06	2.85
	Urban	0.17	0.25	0.45	0.77	5.75	5.93	5.68
	Total	0.49	0.65	0.97	1.45	4.41	3.85	4.35
Chicken	Rural	0.16	0.22	0.36	0.58	4.95	5.11	4.89
	Urban	0.09	0.15	0.31	0.65	7.82	8.01	7.76
	Total	0.25	0.37	0.67	1.23	6.47	5.62	6.41
Egg	Rural	5.10	8.15	15.94	30.61	6.90	7.06	6.84
	Urban	4.20	8.02	19.94	48.49	9.48	9.67	9.41
	Total	9.30	16.15	35.88	79.10	8.48	8.38	8.42

- Growth rates of total is weighted average growth rates
- The units in million tones in case of Milk, Mutton & goat meat, Beef & buffalo meat, & chicken and billion numbers in case of egg.
- 1993 is considered as base.

6.47 per cent for chicken, and 8.48 per cent for eggs. The demand for mutton and goat meat will grow much faster among livestock products followed by eggs.

2.7.4. Comparison of Studies for Demand Projections for Livestock Products in 2020

Several studies on demand projections in the past for livestock products for India are shown in the Table 11. Among the most recent ones, the domestic demand estimates given by Kumar (1998), indicates 143 million tonnes milk and 7.8 million tonnes meat and eggs. These projections are nearer to the estimates of this study in case of milk but lower on the lower side in

case of meat and egg. This could be due to low expenditure elasticities used for meat and egg by Dr Kumar. Contrastingly, projections by Hazell and Bhalla (1996) are nearer in case of milk in the base year but on the higher side in the year 2020. In case of chicken, their projections are nearer to the estimates of this study. The present study estimates that in the year 2020, the demand will reach 147 million tonnes milk, and 16.45 million tonnes for meat and egg. The demand projections made in this study seem to be closer to reality as these projections also account for regional variations in consumption pattern.

Table 11. Comparison of studies for demand projections for livestock products in India

(Million tones)

Livestock products	Demand projections for Livestock Products							
	Present study (5%)				Kumar (1998) (5%)		Hazell and Bhalla (1996) (5.5%)	
	1993	2000	2010	2020	2000	2020	1990	2020
Milk	45.02	60.8	94.2	147.2	75	143	42.5	497
Chicken	0.25	0.33	0.5	0.8	-	-	0.2	1.4
Meat & egg	2.13	3.11	7.62	17.26	3.7	7.8	-	-

3 SUPPLY

Methodology

The Supply Model for Livestock Products

The quantity produced of a livestock food, like many other foods, is hypothesized to be a function of own prices, prices of inputs used in the production process, the existing state of production technology, and the government policy variables such as supply of credit. It is, however, observed that there is a lagged response to changes in prices, which is assumed to be the result of biological and technical factors. A number of statistical techniques that are available in the literature have been used to model the lagged response while estimating the supply response functions for livestock foods. Halvorson (1958) used geometrically declining lag scheme. Chen et al. (1972) used the Hall and Sutch (1968) estimation procedure to produce the more flexible distributed lags suggested by Almon (1965). They also used the partial adjustment formulation suggested by Nerlove (1956,1958). Loftlus et al. (1984) applied Jorgenson's (1966) rational distributed lags and Chavas and Kraus (1990) used Lutkepohl's (1981) distributed lag function in combination with a second degree polynomial to produce dynamic adjustments.

In this study, we have considered a polynomial distributed lag model to determine the lagged response of the livestock food producers to changes in the livestock food prices. It is generally believed that in the agricultural sector, in response to a given change in the price level, the production, first increases over time and then declines. This polynomial distributed lag model allows a great degree of flexibility to capture this type of phenomenon. This model was originally suggested by Almon (1965) and later modified by Bischoff (1966), Modigliani and Sutch (1966), and Cooper (1972).

Lagged values of the variables are important explanatory variables in most economic relationships, because economic behaviour in any one period is

to a great extent determined by the past experience and the past pattern in behaviour. There are problems with the use of lagged variables, for instance, if number of lags are more, then the degrees of freedom would be less. Multicolinearity and serial correlations are also serious problems with this approach. Distributed lag models involve a high degree of empiricism. They are called distributed lag models because the influence of the explanatory variable is distributed over a number of past values of the explanatory variables.

3.1. The Data

The study was based on time series data on quantity produced, own prices, prices of inputs (feed) and the existing stage of production technologies of livestock products for the period 1970 to 1998. The commodity groups for which supply response was studied included milk, mutton, beef, chicken and egg. The prices of these commodities and the feed were deflated by agricultural prices excluding livestock products (APEL) index.

The important sources of data were: Basic Animal Husbandry Statistics; Livestock Census; Agricultural Prices in India; Wholesale Price Statistics, India; Index Numbers of Wholesale Prices of India (Ministry of Industry, Government of India), Bulletin of Food Statistics; and FAO Production Yearbooks.

3.2. Models Used

The models employed in the study were as follows:

3.2.1. Linear Regression Model

$$Y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + \mu$$

where,

Y = quantity of production of milk, mutton, beef, chicken and egg.
X_1 = price of own commodity
X_2 = feed prices of milk, mutton, beef, chicken and egg.
X_3 = time, which is a proxy for technological change
μ = random variable

3.2.2. Almon Polynomial Price Lag Model

This study used Almon Polynomial Price Lag Model given in **Theory of Econometrics,** Second edition, A. Koutsoyianis, PP.299-304 (1977).
The model specified as

$$Y_t = b_0 x_t + b_1 x_{t-1} + b_2 x_{t-2} + b_3 f + b_4 T + \mu_t$$

The transformed model is

$$Y_t = a_0 w_0 + a_1 w_{1+} a_2 w_2 + b_3 f + b_4 T + \mu_t$$

where,

Y_t = quantity of production of milk, mutton, beef, chicken, egg (1970-98).
x_t = price of current period
x_{t-1} = one lag price
x_{t-2} = two lag price
f = feed prices of milk, mutton, beef, chicken, egg,
T = time, which is a proxy for technological change.
μ = random variable

3.3. Estimation Procedure

The data for each commodity consisted of 29 observation sets. The estimates of price coefficient generally assumed expected positive signs and exhibited a high degree of precision. Linear and polynomial regression models were used for estimation of regression coefficients. The equations were estimated using the standard OLS method. The estimated response functions incorporated the price lags of 1 to 2 years. Elasticities were estimated using the relation: $e_p = b.\ p^-/y^-$.

The values of the adjusted R square were fairly satisfactory in the supply response functions of milk, mutton, beef, chicken and egg. This suggests that the own prices and feed prices as well as technological and biological developments (proxied by time trend), had played a significant role in enhancing the production of livestock products in India.

The projections for 2010 and 2020 were made by using simple growth rate model[4] based on price elasticities, livestock population growth rates, nominal price growth rates and productivity growth rates[5].

3.4. Results

The empirical results of the polynomial price lag model and linear model are summarized in Table 12 and 13. The system of supply response equations of these models are shown in Appendices VI and VII.

3.4.1. Estimates of Polynomial Price Lag Model

The polynomial price lag model estimates are presented in Table 12. Time variable, which represented technological and other structural changes in the livestock sub-sector, was highly significant in all five equations. These results confirmed that technological progress in the production, processing, and distribution would be crucial to the positive outcome of the livestock revolution. This finding was similar to the results of FAO study (FAO, 1995). Feed price elasticities in four equations (mutton, beef, chicken, egg) were negative, indicating that a rise in prices of feed would result in a decline in the production of these products.

The estimates of price coefficients generally assumed the expected positive signs and exhibited a high degree of precision. Interestingly, all the five price coefficients were positive. Price coefficients of mutton and eggs were significant at 1 per cent level, implying that the higher prices stimulated the production of foods from livestock sector. It requires relook at the price policy to create the environment in which farmers would increase investments in ways to improve productivity in the livestock sector.

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[4] $S_t = S_o * N_t (1+P_g * Ps)^t$; where, S_t is the production of commodity in the year t ; S_o is the per capita production of the commodity in the base year; P_g is the growth in nominal prices P_S is the price elasticity of supply for the commodity; and N_t is the projected livestock population in the year t.

[5] Assumptions: (i) Productivity: 307.4 litres, 4.02 kg, 9.55 kg, 1.54 kg, 84.28 number. (ii) Nominal price growth rates 7.37%, 9.06%, 2.25%, 3.12 %, 6.18% for milk, mutton & goat meat, beef & buffalo meat, chicken, eggs respectively. iii) Livestock population in 2000 and 2020 are furnished in Table 14.

Table 12. Estimates of the supply response model (Polynomial price lag model)

Equations/ Variables	Mutton	Beef	Chicken	Egg	Milk
Constant	-6489.92	-101232	-57093.5	-2310593	-4514.92
	(-4.522)	(-2.808)	(-4.652)	(-11.542)	(-17.64)
Price t_0	1.2119*	3.668	1.7509	2.3557*	0.4323
	(2.419)	(1.29)	(1.131)	(2.995)	(0.649)
Price t-1	-0.948	-1.209	-2.5018	-3.3059***	0.3474
	(-0.656)	(-0.131)	(-0.613)	(-1.397)	(0.196)
Price t-2	-0.2357	-0.694	1.7284	1.5409	-0.480
	(-0.21)	(-0.099)	(0.561)	(0.852)	(-0.361)
Feed price	-0.0728	-1.486	-0.5076	-0.5328*	0.0409
	(-0.609)	(0.18)	(-0.54)	(-2.299)	(1.284)
Time	3.347 *	50.929*	28.817*	1172.19*	2.287*
	(4.599)	(2.836)	(4.718)	(11.76)	(18.344)
R^2	0.971	0.863	0.896	0.984	0.998
R^{-2}	0.963	0.829	0.87	0.98	0.997

* 1 per cent level of significance

** 5 per cent level of significance

*** 10 per cent level of significance

The estimated supply response functions were satisfactory in terms of the degree of explanation of livestock food production. The price impact in the first period was, positive and significant, indicating that the immediate previous lag prices were affecting the production of these products. It was interesting to note that the dynamic price impacts (as depicted by the delayed price coefficients) increased first with lag, then decreased and again increased, indicating rise and fall of production every alternate years in response to price changes. This finding is consistent with the hypothesis that livestock production, in response to a given change in the price level, first increases through time and then starts declining.

3.4.2. Estimates of Linear Regression Model

The elasticities of linear regression model are presented in Table13. Time variable was highly significant in all the equations. The feed price elasticities in four (mutton, beef, eggs, milk) out of five equations were negative and

Table 13. Estimates of the supply response model (Linear regression)

Equations/ Variables	Mutton	Beef	Chicken	Egg	Milk
Constant	-3112.34	-66865.2	-34165.1	-2140856	-3900
	(-2.546)	(-2.505)	(-4.86)	(-11.813)	(-12.47)
Price	0.4836*	1.8633*	-0.13688	0.6341**	0.2264
	(3.613)	(3.488)	(-0.371)	(2.316)	(1.048)
Feed price	-0.252**	-1.2978	0.4780	-0.0948	-0.041
	(-2.083)	(-1.145)	(0.616)	(-0.342)	(-0.293)
Time	1.626*	33.828*	17.297*	1082.74*	1.983*
	(2.637)	(2.549)	(4.909)	(12.006)	(13.046)
R^2	0.959	0.837	0.873	0.969	0.98
R^{-2}	0.954	0.817	0.858	0.965	0.997

* 1 per cent level of significance
** 5 per cent level of significance
*** 10 per cent level of significance

in the case of mutton the coefficient was significant indicating that a rise in feed price would reduce its production. In the case of chicken the feed price coefficient was positive. This was due to the reason that poultry was one of the quickest and most efficient converter of plant products into food of high biological value.

Out of five price coefficients, three (mutton, beef, and egg) were significant at 1 per cent level, implying that higher prices stimulate the production of foods from livestock. Chicken price coefficient was negative. It clearly shows that production elasticities of livestock products are highly price elastic.

3.5. Supply Projections

The projections of production (supply) as well as domestic consumption (demand) into future requires a knowledge of the future values of the exogenous variables. The variables exogenous to the model were projected using trend growth over the last ten year period (1982-83 to 1992-93). The price elasticities, livestock population, nominal and real price growth rates that were used in the projections are presented in Table 14. It was found that beef and buffalo meat

with real price growth rates and rest of the commodities with nominal price growth rates abtained reliable projections. The nominal and real prices of livestock products during 1970-98 and their growth rates for 1970-98, 82-93, and 82-98 are given in appendix VIII and IX.

Table 14. Assumptions used in the supply projections

Livestock products	Price elasticities		Productivity 1998	Livestock population (millions)				Price growth rates (%)	
	Linear	Polynomial		1998	2000	2010	2020	Nominal	Real
Milk	0.2264	0.4323	307.4	243	250	319	407	7.37	-0.13
Mutton & goat meat	0.4836	1.2119	4.02	198	210	281	376	9.06	0.72
Beef & Buffalo meat	1.8633	3.688	9.55	306	312	344	379	10.71	2.25
Chicken	-0.1368	1.7509	1.54	388	420	620	917	3.12	-4.81
Egg	0.6341	2.3557	84.28	388	420	620	917	6.18	-1.91

The units of productivity, milk in liters, Mutton & goat meat, Beef & buffalo meat and, chicken in kgs and egg in number

The supply projections for the commodities were obtained by using the following formula:

$$S_t = S_o * N_t (1 + Pg * Ps)^t$$

where,

S_t = supply production for a commodity in year t ;
S_o = the per capita production of the commodity in the base year;
Pg = growth in nominal prices
Ps = price elasticity of supply for the commodity; and
N_t = projected livestock population in year t.

The futuristic supply projections for 2000, 2010 and 2020 with linear and polynomial price lag models are presented in Table 15. As per the Indian Economic Survey, in the year 2000-01 the actual production for milk is 81 million tones, eggs 32.4 billion and 4.7 million tones meat. This study for the

same year projects by Linear model for milk 80.7 million tones, 36.86 billion eggs and 4.7 million tones meat and Polynomial Price Lag Model projections shows that 81.9 million tones milk, 40.9 billon eggs and 4.83 million tones meat. These models projections are close to the prediction of production by Indian Economic Survey.

The Polynomial Price Lag Model projects that in the year 2020, the supply of different livestock products would be 218.8 million tonnes milk, 14.57 million tonnes mutton and goat meat, 15.95 million tonnes beef and buffalo meat and, 4.20 million tonnes chicken. The projections of egg were not quoted, as those figures seemed unrealistic. According to the Linear Model, the supply of eggs would reach 102.91 billions during 2020.

According to the Polynomial Price Lag Model, the growth rates of different livestock products during 2000-2020 would be 5.0% for milk, 14.7% for mutton & goat meat, 8.3 % for beef & buffalo meat and, 9.5% for chicken. These growth rates indicate that meat, and poultry meat have tremendous production potential in the country. A study conducted Kumar and Pandey (1999) reveals that livestock sector registered positive and significant growth rate. The estimated growth in milk projection was 3.39%, meat & meat products 1.99%, eggs & poultry 4.22% during 1950-51 to 1995-96. If growth in these products continues at these rates the country will meet the demand adequately.

3.6. Demand - Supply Gap

The projected production and consumption trends for livestock products for 2000, 2010 and 2020 are shown in Table 16. The base-line scenario in the year 1993 revealed that the actual production trends for all the commodities closely followed those actual for consumption. However, in 2020, a surplus production is likely to emerge in milk of 71.54 million tonnes, eggs 131.45 billion, beef & buffalo meat 6.64 million tonnes. The chicken production would be in surplus by 3.39 million tonnes. These results generally indicate that, in 2020, India would be not only self-sufficient in these products but would become surplus, as all the projected production figures are more than consumption figures. The expected production growth rates for milk, mutton and goat meat, beef and buffalo meat, egg, and chicken exceeded the corresponding consumption demand rates.

Table 15. Supply projections of livestock products towards 2020 for India

(million tones)

Commodity	Indian Economic Survey Production		Projections Linear Regression Model				Projections Polynomial Regression Model			
	1999-00	2000-01	2000	2010	2020	Growth rate, % (2000-2020)	2000	2010	2020	Growth rate % (2000-2020)
Milk	78.1	81.0	80.7	112.5	159.8	3.47	81.9	131.4	218.8	5.0
Eggs	31.5	32.4	36.86	78.8	175.5	8.1	40.9	221.8	-	-
Meat	4.49	4.7	4.62	7.53	12.93	5.3	4.83	12.05	34.74	10.4
i) Chicken			0.64	0.91	1.29	3.55	0.68	1.65	4.20	9.5
ii) Mutton & goat meat			0.88	1.80	3.85	7.64	0.94	3.50	14.57	14.7
iii) Beef & buffalo meat			3.10	4.82	7.79	4.7	3.21	6.90	15.95	8.3

· The units in million tones in case of Milk, Meat, Mutton & goat meat, Beef & buffalo meat, & chicken and billion numbers in case of egg.

The demand – supply projections as attempted in this study are to be taken as indicative trends at country level. The database for such an exercise was available for the first time for studying the individual livestock commodities. As and when refinements in the data on consumer expenditure and production of livestock products at more disaggregated levels take place, further fine tuning of future projections will become necessary. For instance, milk consumption projections used here consider only the liquid milk consumed by the human population. Data covering the milk diverted for milk products and other uses are not available. To that extent, the surplus in milk production projected in future would be an overestimation. Even methodological innovations along with data refinements are necessary since such demand-supply projections are sensitive to derived elasticity estimates as observed in the literature covering food grain projections.

Table 16. Projections of supply, demand and surplus/deficit

Livestock products		1993	2000	2010	2020	Growth rate % (2000-2020)
Milk	Supply	60.6	81.95	131.36	218.8	5.00
	Demand	45.02	60.77	94.25	147.26	4.82
	Surplus	15.58	21.18	37.11	71.54	
Mutton & goat meat	Supply	0.64	0.94	3.50	14.57	14.70
	Demand	0.78	1.36	3.80	12.72	13.62
	Deficit	-0.14	-0.42	-0.3	1.85	
Beef & buffalo meat	Supply	2.5	3.10	4.82	7.79	4.70
	Demand	0.49	0.61	0.84	1.15	3.39
	Surplus	2.01	2.49	3.98	6.64	
Chicken	Supply	0.45	0.68	1.65	4.20	9.50
	Demand	0.25	0.33	0.52	0.81	4.72
	Surplus	0.2	0.35	1.13	3.39	
Egg	Supply	24.2	36.86	78.80	175.50	8.10
	Demand	9.30	13.88	24.79	44.05	6.12
	Surplus	14.9	22.98	54.01	131.45	

· The units in million tones in case of Milk, Mutton & goat meat, Beef & buffalo meat, & chicken and billion numbers in case of egg.

4 CONCLUSIONS AND POLICY IMPLICATIONS

Livestock products being high-valued commodities involve high expenditure and exhibit high price elasticities. The consumption behaviour has revealed that rural population on an average consumes less quantities of livestock products than the urban population. The cross-price elasticities suggested the view that most livestock products were substituted to each other in consumption.

The expenditure elasticity for milk is estimated as 1.36 for rural households and 1.07 for urban households. The demand for beef and buffalo meat, chicken and eggs are more elastic in the rural households (ranges from 0.74 to 2.35) than urban households (ranges from 0.57 to 1.24). Interestingly, the expenditure elasticity for mutton and goat meat is more (3.19) in urban households than in rural households (0.52). This implies that mutton and goat meat has tremendous demand in urban India.

The expenditure elasticities for livestock products are high with tilt in favour of rural areas compared to urban areas. It implies that increase in per capita income of rural population would lead to acceleration in demand for livestock products. Further, the expenditure elasticities of livestock products are higher than other food expenditure elasticities. This implies that there is a shift in the consumption behaviour towards livestock products and a need to diversify agriculture.

High expenditure elasticities suggest favourable environment for the growth of livestock sector and diversification of Indian agriculture. Further growth in per capita income and shift in consumption behaviour towards livestock products would lead to acceleration in demand for livestock products and thus is expected to give a jump to this sector.

High price elasticities of livestock products reveal that high instability in consumption. The cross price elasticities illustrated that most livestock products are substitutes in consumption. While high cross price elasticities

suggest that consumers are highly price responsive. In all the three categories milk and eggs were found to be price elastic. Thus increase in prices of these commodities would reduce the demand.

A 5 per cent GDP growth rate is considered to be the most likely in India in the future and hence has been used in this study. Population projections made by the Technical Group on Population Projections (GOI, 1996) are used. The actual consumption in the year 1993 was 45.02 million tonnes milk, 9.30 billion eggs, 0.78 million tonnes for mutton and goat meat, 0.49 million tonnes for beef and buffalo meat and 0.25 million tonnes for chicken. The projected figures for the year 2020, for these items are 147.26 million tonnes of milk, 12.72 million tones of mutton and goat meat, 1.15 million tones of beef and buffalo meat, 44.05 billion eggs, 0.81 million tones of chicken.

During 1993-2020, the weighted average growth rate for the total Indian domestic demand of livestock products will grow at the rate of 4.88% (milk), 13.68% (mutton & goat meat), 3.45% (beef & buffalo meat), 4.77% (chicken), and 6.18 % (egg). These growth rates foresee that meat, poultry meat and eggs have tremendous demand in the country. Major share of this increase could be attributed to by growth in population and also to growth in per capita income. If the projected demand were to be met entirely from domestic production, the annual growth rate of these commodities should increase at these rates. This necessitates technological break throughs in production in these commodities to achieve self-sufficiency.

Some countries have experimented expansion of smallholder livestock production in the rural areas, particularly of dairy animals and poultry. Though in the long run this path of development may be slower and more difficult to organize, it has greater benefits in increasing self-reliance, rural employment, incomes, and nutrition. Such small-scale operations are particularly suitable for India with high density of population, surplus labour, and high rural unemployment or under employment.

Irrespective of the type of organizational structure adopted, it is necessary to reorient livestock policies with a view to providing improved access to institutional credit, production inputs, and marketing facilities. In general,

because livestock yields in several developing countries including India are much lower compared to the developed countries, scope exists for rapid yield improvement through adoption of improved breeding and feeding practices, provision of veterinary services, and initiation of appropriate incentive policies and institutions. This emphasizes the need for more allocation of financial resources for livestock research, including research on feeds.

The results of supply analysis of livestock products have indicated that the technological progress would be crucial to usher in livestock revolution. However, it has been observed that the rise in feed prices would reduce the production of these commodities, while higher prices of these products stimulate the production of these commodities. Thus, a favourable pricing policy to help farmers to increase investments in the livestock sector is warranted. On the other hand, feed supply has to be increased.

The estimates of the study on future demand-supply gap have indicated that in 2020, India would be generally self-sufficient in these products.

Policies towards increasing fodder supply, remunerative prices to livestock products, and above all investments in technology improvements in livestock sector, particularly in processing and value-addition are important and need to be given due attention.

Appendix I. Complete Systems of Demand Equations of Rural India

$C_r m$ = -0.467 -2.989 P_m -0.936 P_{mg} -0.068 P_{bb} +0.607 P_c +0.749 P_e +0.537 P_f R^2 = 0.78
(6.99) (1.19) (0.71) (0.68) (0.96) (1.25) (0.72)
-1.093 P_{of} + 0.938 P_{nf} + 1.365 I + 0.495 d_n + 0.860 d_s +0.735 d_e +0.283d_w R^{-2} = 0.62
(2.45) (1.16) (0.833) (0.46) (0.47) (0.44) (0.38)

$C_r mg$ = 7.628 -1.069 P_m -0.030 P_{mg} - 0.028 P_{bb} +1.256 P_c -0.900 P_e - 0.570 P_f R^2 = 0.46
(11.71) (1.99) (1.19) (1.13) (1.61) (2.10) (1.21)
-3.447 P_{of} -0.045 P_{nf} + 0.522 I + 0.310 d_n + 0.669 d_s +0.406 d_e +0.240d_w R^{-2} = 0.78
(4.10) (1.94) (1.40) (0.77) (0.79) (0.74) (0.64)

$C_r bb$ = -13.045 -3.597 P_m +1.965 P_{mg} +3.179 P_{bb} -0.416 P_c +0.241 P_e +2.198 P_f R^2 = 0.68
(15.21) (2.59) (1.55) (1.47) (2.09) (2.73) (1.57)
-0.085 P_{of} +1.036 P_{nf} +0.748 I +0.250 d_n -0.262 d_s +0.125 d_e +0.323 d_w R^{-2} = 0.44
(5.33) (2.52) (1.81) (0.99) (1.03) (0.96) (0.83)

$C_r c$ = 10.255 +3.797 P_m -1.726 P_{mg} -0.157 P_{bb} -0.432 P_c -2.619 P_e +0.301 P_f R^2 = 0.79
(7.21) (1.22) (0.73) (0.70) (0.99) (1.29) (0.74)
-0.922 P_{of} -3.897 P_{nf} +1.572 I - 0.429 d_n -1.115 d_s -0.952 d_e -0.371 d_w R^{-2} = 0.64
(2.53) (1.19) (0.86) (0.47) (0.49) (0.45) (0.39)

$C_r e$ = -4.899 +1.698 P_m -0.348 P_{mg} +0.273 P_{bb} -0.283 P_c -2.852 P_e -0.129 P_f R^2 = 0.77
(6.41) (1.09) (0.65) (0.62) (0.88) (1.15) (0.66)
+0.391 P_{of} - 0.660 P_{nf} + 2.354 I -0.435 d_n -0.969 d_s -0.655 d_e -0.285 d_w R^{-2} = 0.61
(2.25) (1.06) (0.76) (0.42) (0.435) (0.40) (0.35)

$C_r of$ = -0.139 -0.181 P_m + 0.347 P_{mg} - 0.003 P_{bb} +0.646 P_c + 0.136 P_e - 0.017 P_f - R^2 = 0.51
(1.75) (0.30) (0.18) (0.17) (0.24) (0.31) (0.18)
0.536 P_{of} - 0.310 P_{nf} + 0.0722 I +0.118 d_n + 0.168 d_s + 0.089 d_e +0.037 d_w R^{-2} = 0.16
(0.61) (0.29) (0.21) (0.11) (0.11) (0.11) (0.96)

$C_r nf$ = -0.923 -0.103 P_m - 0.180 P_{mg} - 0.046 P_{bb} -0.032 P_c - 0.208P_e -0.052 P_f + R^2 = 0.91
(1.01) (0.17) (0.10) (0.09) (0.14) (0.18) (0.10)
0.002 P_{of} - 0.847 P_{nf} + 1.277 I - 0.064 d_n - 0.064 d_s - 0.063 d_e -0.096 d_w R^{-2} = 0.85
(0.35) (0.17) (1.21) (0.07) (0.07) (0.06) (0.55)

Figures in parentheses are standard errors

Appendix II. Complete Systems of Demand Equations of Urban India

$C_r m$ = 0.189 - 2.766 P_m - 0.655 P_{mg} - 0.347 P_{bb} + 0.346 P_c - 0.288 P_e + 0.319 P_f R^2 = 0.61
(8.47) (1.90) (1.44) (0.63) (0.39) (1.52) (0.91)
+1.215 P_{of} - 1.163 P_{nf} + 1.070 I + 0.309 d_n + 0.554 d_s + 0.598 d_e +0.058 d_w R^{-2} = 0.33
(3.14) (1.68) (0.89) (0.43) (0.41) (0.50) (0.35)

$C_r mg$ = 8.872 +2.364 P_m -3.308 P_{mg} -2.522 P_{bb} -0.059 P_c -0.955 P_e +0.877 P_f R^2 = 0.45
(15.87) (3.56) (2.72) (1.18) (0.74) (2.84) (1.71)
-5.246 P_{of} +1.390 P_{nf} +3.198 I +0.335 d_n -0.456 d_s -0.205 d_e -0.206 d_w R^{-2} = 0.47
(5.89) (3.16) (1.67) (0.80) (0.77) (0.93) (0.65)

$C_r bb$ = -28.56 - 0.290 P_m + 6.486 P_{mg} -0.476 P_{bb} - 0.449 P_c -3.277 P_e - 1.317 P_f R^2 = 0.47
(23.93) (5.37) (4.10) (1.78) (1.11) (4.29) (2.58)
+ 5.335 P_{of} + 0.879 P_{nf} + 0.570 I - 2.299 d_n - 1.693 d_s - 1.235 d_e -1.551 d_w R^{-2} = 0.09
(8.88) (4.76) (2.53) (1.21) (1.16) (1.40) (0.98)

$C_r c$ = -9.546 +0.994 P_m +1.413 P_{mg} -0.108 P_{bb} -0.328 P_c -2.54 P_e +0.804 P_f R^2 = 0.66
(11.67) (2.62) (1.99) (0.87) (0.54) (2.09) (1.26)
+5.155 P_{of} -4.696 P_{nf} +0.945 I +0.181 d_n -0.514 d_s -0.216 d_e +0.049 d_w R^{-2} = 0.41
(4.33) (2.32) (1.23) (0.59) (0.57) (0.68) (0.48)

$C_r e$ = -2.605 +1.478 P_m +1.433 P_{mg} +0.011 P_{bb} -0.122 P_c -1.841 P_e +0.212 P_f R^2 = 0.72
(5.30) (1.19) (0.91) (0.39) (0.24) (0.95) (0.57)
-1.643 P_{of} +0.416 P_{nf} +1.242 I -0.297 d_n -0.554 d_s - 0.448 d_e -0.234 d_w R^{-2} = 0.52
(1.97) (1.05) (0.56) (0.27) (0.258) (0.311) (0.22)

$C_r of$ = -0.724 -0.134 P_m - 0.297 P_{mg} - 0.059 P_{bb} +0.034 P_c - 0.262 P_e +0.009 P_f R^2 = 0.29
(2.11) (0.47) (0.36) (0.15) (0.98) (0.38) (0.22)
-0.239 P_{of} + 0.359 P_{nf} + 0.121 I - 0.055 d_n - 0.120 d_s - 0.128 d_e -0.107 d_w R^{-2} = 0.78
(0.78) (0.420) (0.22) (0.10) (0.10) (0.12) (0.08)

$C_r nf$ = -1.978 -0.271 P_m +0.112 P_{mg} -0.102 P_{bb} +0.043 P_c -0.055P_e +0.110 P_f R^2 = 0.96
(1.25) (0.28) (0.21) (0.09) (0.58) (0.22) (0.13)
-0.057 P_{of} -1.028 P_{nf} +1.689 I +0.028 d_n +0.028 d_s -0.009 d_e -0.016 d_w R^{-2} = 0.93
(0.46) (0.25) (0.13) (0.06) (0.06) (0.07) (0.05)

Figures in parentheses are standard errors

Appendix III. Means of Quantities and Prices for Different Commodities

Dependent/ Independent variables	Rural		Urban		Pooled	
	Quantity[1]	Prices [2] (Rs/unit)	Quantity[1]	Prices [2] (Rs/unit)	Quantity[1]	Prices [2] (Rs/unit)
Milk (litres)	3.94	6.32	4.89	7.99	4.42	7.16
Mutton & goat meat (kg)	0.06	50.5	0.11	56.54	0.09	53.52
Beef & buffalo meat (kg)	0.04	16.0	0.06	17.17	0.05	16.59
Chicken (kg)	0.02	40.0	0.03	41.33	0.03	40.67
Egg (number)	0.64	1.20	1.48	1.19	1.06	1.20
Other-food	0.38	1309.59	0.64	1375.13	0.51	1342.36
Non-food	0.43	809.6	0.46	999.6	0.45	904.6
Expenditure (Rs)	-	281.4	-	458.04	-	369.72

GOI (1997) 'consumption of some important commodities' NSS, 50th Round, 1993-94.

1. Quantity consumption per person for 30 days.
2. Price per unit (prices derived from NSS data)

Appendix IV. Quantity and Prices of Live stock Products of Rural India per person for 30 days

Sl. No	State	Milk:liquid (liters)		mutton& goat		Beef& buff		Chicken		eggs(no)		Total
		quan-tity (Kg)	price	quan-tity (Kg)	price	quan-tity (Kg)	price	quan-tity (Kg)	price	quan-tity No.	price	Expen
1	Andhra Pradesh	2.62	5.52	0.13	52.46	0.04	15.75	0.05	38.60	1.44	1.09	288.70
2	Arunachal Pradesh	0.43	7.07	0.02	47.00	0.16	23.81	0.12	47.67	1.02	1.55	224.17
3	Assam	1.21	8.20	0.03	51.33	0.04	22.75	0.08	40.13	1.12	1.52	258.11
4	Bihar	2.39	6.49	0.05	49.00	0.01	19.00	0.01	31.00	0.14	1.29	218.30
5	Goa	2.59	9.30	0.04	63.25	0.15	25.07	0.05	50.60	3.69	1.16	384.81
6	Gujarat	5.07	7.44	0.03	50.00	0.01	13.00	0.01	52.00	0.17	1.47	303.32
7	Haryana	13.82	6.36	0.02	50.00	0.04	9.00	0.0016	37.00	0.08	1.75	385.01
8	Himachal Pradesh	7.52	6.37	0.09	41.22	0.001	11.30	0.0011	37.00	0.22	1.23	286.87
9	J&K	7.26	6.26	0.05	43.00	0.001	11.30	0.04	35.00	0.63	1.30	302.38
10	Karnataka	2.88	6.07	0.09	51.11	0.02	24.00	0.02	44.50	0.89	1.10	269.38
11	Kerala	2.61	7.50	0.02	53.00	0.19	26.63	0.03	44.00	2.00	1.10	390.41
12	Madhya Pradesh	2.76	6.69	0.04	39.75	0.001	14.00	0.02	50.00	0.15	1.33	252.01
13	Maharashtra	2.50	6.96	0.10	46.20	0.01	14.00	0.01	40.00	0.61	1.16	272.66
14	Manipur	0.12	7.58	0.00019	51.30	0.19	24.95	0.06	49.17	0.84	1.77	263.67
15	Meghalaya	1.32	6.62	0.01	71.00	0.37	33.11	0.05	44.80	1.04	1.62	287.25
16	Mizoram	0.69	9.00	0.01	27.00	0.15	44.33	0.15	68.73	0.91	2.05	269.82
17	Nagaland	0.25	10.20	0.01	77.00	0.43	23.51	0.13	52.38	1.74	1.71	342.91
18	Orissa	0.77	5.91	0.03	56.33	0.01	11.00	0.02	50.00	0.29	1.34	219.80
19	Punjab	14.33	6.05	0.05	47.80	0.001	11.30	0.01	37.00	0.47	1.36	433.00
20	Rajasthan	10.41	6.20	0.05	39.60	0.003	13.00	0.0027	37.00	0.07	1.86	322.39
21	Sikkim	4.77	5.37	0.08	53.13	0.21	23.48	0.04	56.50	1.73	1.51	228.08
22	Tamilnadu	2.12	6.02	0.11	58.00	0.04	19.00	0.02	37.50	1.06	1.07	293.62
23	Tripura	1.43	8.27	0.02	64.50	0.005	22.80	0.06	44.67	1.48	1.95	286.72
24	Uttar Pradesh	5.44	6.00	0.05	49.80	0.06	11.33	0.0035	37.00	0.21	1.48	273.83
25	West Bengal	1.54	6.15	0.04	53.50	0.06	19.83	0.03	43.00	1.69	1.18	278.78
26	A&N Island	1.63	8.12	0.05	54.80	0.01	23.00	0.20	39.10	3.35	1.65	376.84
27	Chandigarh	8.64	7.77	0.06	52.00	0.001	11.30	0.02	56.00	0.31	1.23	360.43
28	Dadar & Nagar Haveli	1.08	8.11	0.04	46.75	0.001	13.00	0.03	48.67	0.35	1.23	156.52
29	Daman & Diu	3.35	8.35	0.20	47.45	0.001	25.10	0.04	45.50	0.90	1.73	340.37
30	Delhi	8.69	9.54	0.24	51.88	0.001	11.30	0.02	67.50	1.85	1.50	470.40
31	Lakshadweep	0.29	8.93	0.04	60.60	0.29	31.59	0.01	50.00	2.20	1.42	450.94
32	Pondichery	2.99	6.87	0.12	58.58	0.06	21.17	0.02	44.00	1.09	1.03	300.03

Appendix V. Quantity and Prices of Live stock Products of Urban India per person for 30 days

Sl. No	State	Milk:liquid (liters)		mutton& goat		Beef& buff		Chicken		eggs(no)		Total
		quan-tity (Kg)	price	quan-tity (Kg)	price	quan-tity (Kg)	price	quan-tity (Kg)	price	quan-tity No.	price	Expen
1	Andhra Pradesh	3.92	6.72	0.16	58.63	0.02	23.50	0.05	43.80	2.13	1.06	408.60
2	Arunachal Pradesh	2.43	8.44	0.23	61.39	0.14	24.64	0.16	48.31	2.52	1.67	400.7
3	Assam	1.66	9.49	0.12	62.17	0.01	25.00	0.11	44.27	2.49	1.51	458.57
4	Bihar	3.49	8.03	0.11	56.18	0.03	14.00	0.02	49.50	0.90	1.27	353.03
5	Goa	3.25	9.66	0.10	56.30	0.17	22.65	0.04	47.25	3.35	1.05	388.57
6	Gujarat	6.21	8.24	0.07	43.43	0.01	17.00	0.01	31.00	0.43	1.40	454.18
7	Haryana	9.10	8.32	0.05	49.80	0.0003	29.04	0.0032	56.00	0.49	1.22	473.92
8	Himachal Pradesh	8.95	7.52	0.12	42.17	0.001	24.04	0.01	40.00	0.96	1.28	605.89
9	J&K	9.11	7.12	0.17	48.00	0.001	29.04	0.05	36.80	1.73	1.36	425.9
10	Karnataka	4.42	7.15	0.16	52.69	0.04	19.50	0.03	40.33	1.59	1.09	423.14
11	Kerala	3.27	7.91	0.02	87.50	0.17	27.59	0.05	49.80	2.49	1.11	493.83
12	Madhya Pradesh	4.08	8.25	0.09	45.33	0.02	12.00	0.02	36.00	0.81	1.22	408.06
13	Maharashtra	4.72	9.83	0.14	55.14	0.07	18.57	0.03	40.00	1.50	1.19	529.80
14	Manipur	0.17	7.65	0.00016	62.17	0.05	33.00	0.02	48.50	0.81	1.79	272.93
15	Meghalaya	3.46	7.43	0.11	57.91	0.29	36.41	0.1	50.40	2.01	1.70	378.24
16	Mizoram	1.90	8.81	0.0017	62.17	0.31	50.94	0.09	66.00	1.76	1.81	370.90
17	Nagaland	0.81	8.81	0.07	63.14	0.24	23.88	0.11	58.00	2.80	1.60	385.83
18	Orissa	2.20	6.97	0.15	58.60	0.02	10.00	0.02	57.00	1.32	1.30	402.54
19	Punjab	9.70	7.75	0.06	52.67	0.001	29.04	0.01	56.00	0.73	1.27	510.73
20	Rajasthan	7.53	7.29	0.10	44.50	0.001	29.00	0.00017	56.00	0.37	1.51	424.73
21	Sikkim	5.41	6.86	0.09	58.44	0.30	24.87	0.08	54.38	2.10	1.48	352.42
22	Tamilnadu	3.80	6.81	0.14	69.21	0.03	21.33	0.03	50.33	2.54	1.05	438.29
23	Tripura	2.29	8.62	0.09	66.78	0.001	25.00	0.07	46.86	2.31	2.11	388.22
24	Uttar Pradesh	5.63	7.60	0.07	51.00	0.19	12.74	0.0039	56.00	0.64	1.36	388.97
25	West Bengal	2.73	7.81	0.09	65.11	0.06	18.83	0.06	43.83	2.91	1.26	474.19
26	A&N Island	1.93	9.34	0.13	72.08	0.02	27.00	0.24	45.21	4.62	1.50	646.53
27	Chandigarh	9.48	8.20	0.11	50.55	0.001	29.04	0.06	49.16	1.83	1.09	767.85
28	Dadar & Nagar Haveli	3.57	10.31	0.14	51.79	0.001	17.00	0.06	54.50	0.54	1.41	296.89
29	Daman & Diu	5.75	8.75	0.18	48.39	0.04	15.75	0.04	40.50	0.64	1.42	345.74
30	Delhi	8.64	9.07	0.17	55.47	0.25	29.04	0.04	55.50	2.22	1.36	612.06
31	Lakshadweep	0.39	9.23	0.05	60.60	0.02	32.50	0.03	43.00	2.36	1.29	396.98
32	Pondichery	4.10	7.10	0.12	60.42	0.001	21.33	0.03	44.00	1.90	1.09	340.02

Appendix VI. Systems of Supply Equations of Polynomial Price Lag Model

S_{pm} =	-6489.92	+2.367 mw_0	-1.259 mw_1	-0.135 mw_2	-12.136mfp	+ 3.34 t	R^{-2} 0.963
	(-4.522)	(2.419)	(-0.656)	(-0.21)	(-0.609)	(4.599)	
S_{pb} =	-101232	+79.743 bw_0	-17.839 bw_1	-4.424 bw_2	-0.0025bfp	+50.93 t	R^{-2} 0.829
	(-2.808)	(1.29)	(-0.131)	(-0.099)	(-0.18)	(2.836)	
S_{pc} =	-57093.5	+159.175cw_0	–147.167 cw_1	+43.211 cw_2	-1.02E+02cfp	+28.82t	R^{-2} 0.87
	(-4.652)	(1.131)	(-0.613)	(0.56)	(-0.54)	(4.72)	
S_{pe} =	-2310593	+22016.31ew_0	-20281.7ew_1	+4033.8ew_2	-8.54E+03efp	+1172.2t	R^{-2} 0.96
	(-11.54)	(2.995)	(-1.397)	(0.852)	(-2.299)	(11.76)	
S_{pml} =	-4514.93	+1.123 mlw_0	+0.598 mlw_1	-0.353 mlw_2	+6.83E+00mlfp	+2.29t	R^{-2} 0.96
	(-17.64)	(0.649)	(0.196)	(-0.361)	(1.284)	(18.344)	

Note: Figures in parentheses represent t- values.

t — time variable which represents technological and other structural changes in the livestock sector.

mw_2 = mutton two lag price

mlw_2 = milk two lag price

mlfp = feed prices (milk)

cw_2 = chicken two lag price

mfp = feed price (mutton)

Appendix VII. Systems of Supply Equations of Linear Model

S_{pm} =	-3112.34	+ 3.749 mp	- 42.06 mfp	+ 1.626 t	R^{-2} 0.954
	(-2.546)	(3.613)	(-0.293)	(2.637)	
S_{pb} =	-66865.2	+ 155.277 bp	-7.28E+02 bfp	+ 33.828 t	R^{-2} 0.817
	(-2.505)	(3.488)	(-1.145)	(2.549)	
S_{pc} =	-34165.1	- 57.368cp	+ 1.12E+02 cfp	+ 17.297 t	R^{-2} 0.858
	(-4.86)	(-0.371)	(0.616)	(4.909)	
S_{pe} =	-2140856	+ 21117.15ep	- 1.52E+03 efp	+ 1082.74 t	R^{-2} 0.965
	(-11.813)	(2.316)	(-0.342)	(12.01)	
S_{pmilk} =	-3443.99	- 5.01 mp	- 3.12E+00 mfp	+ 1.768 t	R^{-2} 0.977
	(-13.17)	(-1.747)	(-0.524)	(13.89)	

Note: Figures in parentheses represent t- values.
t — time variable which represents technological and other structural changes in the livestock sector.

bp = beef price
cp = chicken price
cfp = feed price (chicken)
mfp = feed price (milk)

Appendix VIII. Nominal and real prices of Livestock Products during 1970-98

Years	Nominal prices					Real prices				
	Milk Rs/100 lit	Mutton Rs/qtl	Beef Rs/qtl	Chicken Rs/kg	Egg Rs/100	Milk Rs/100 lit	Mutton Rs/qtl	Beef Rs/qtl	Chicken Rs/kg	Egg Rs/100
1970	161.2	557.0	210	31.44	25..75	3.92	13.56	5.11	0.77	0.63
1971	167.8	601.5	230	35.19	25.75	4.00	14.33	5.48	0.84	0.61
1972	178.8	649.5	224	36.81	26.25	4.00	14.51	5.01	0.82	0.59
1973	225.4	817.5	303	45.81	32.25	4.24	15.37	5.70	0.86	0.61
1974	254.0	983.0	470	46.63	36.5	3.70	14.57	6.97	0.69	0.54
1975	278.0	1120.0	389	50.25	39.0	3.95	15.92	5.53	0.71	0.55
1976	271.3	1173.0	404	43.50	40.0	4.25	18.45	6.35	0.68	0.63
1977	272.7	1228.0	390	51.44	40.75	3.87	17.42	5.53	0.73	0.58
1978	281.2	1296.5	445	60.94	41.75	3.89	17.92	6.15	0.84	0.58
1979	294.3	1401.0	431	65.81	41.25	3.88	18.49	5.69	0.87	0.54
1980	323.0	1508.5	450	61.56	42.25	3.85	18.00	5.37	0.73	0.50
1981	372.8	1752.0	478	69.31	43.25	3.89	18.3	4.99	0.72	0.45
1982	424.0	1954.0	490	81.33	52.33	3.84	17.72	4.44	0.74	0.47
1983	433.8	2029.0	491	68.75	53.0	3.54	16.54	4.00	0.56	0.43
1984	465.5	2141.5	491	66.31	56.25	3.57	16.44	3.77	0.51	0.43
1985	500.2	2508.5	679	66.63	57.5	3.73	18.70	5.06	0.50	0.43
1986	524.5	2802.5	700	73.06	61.25	3.61	19.3	4.82	0.50	0.42
1987	586.4	2996.0	775	77.50	71.0	3.76	19.20	4.97	0.50	0.46
1988	664.8	3239.5	1000	72.19	72.75	3.82	18.63	5.75	0.42	0.42
1989	731.8	3477.5	1000	65.58	73.75	4.03	19.16	5.51	0.36	0.41
1990	730.5	3866.5	1116	70.58	75.75	3.79	20.08	5.80	0.37	0.39
1991	809.0	4533.0	1400	104.17	92.5	3.54	19.81	6.12	0.46	0.40
1992	927.5	5070.0	1500	114.08	101.25	3.51	19.17	5.67	0.43	0.38
1993	959.0	5502.0	1567	114.92	105.75	3.40	19.53	5.56	0.41	0.38
1994	1013.0	6116.0	2429	132.56	126.67	3.22	19.43	7.72	0.42	0.40
1995	1081.0	7266.5	2648	161.00	131.0	3.38	22.73	8.28	0.50	0.41
1996	1175.6	8841.5	2867	87.50	135.5	3.46	26.05	8.45	0.26	0.40
1997	1211.0	9446.0	3000	95.67	152.0	3.21	25.07	7.96	0.25	0.40
1998	1299.7	10191.5	3583	98.42	148.25	3.30	25.9	9.11	0.25	0.38

Appendix IX. Growth rates of nominal and real prices of Livestock Products for different periods

Sl. No.	Products	Prices	Growth rates (%)		
			1970-98	1982-93	1982-98
1	Milk	Nominal	7.7	7.7	7.2
		Real	-0.6	-1.1	-0.9
2	Mutton	Nominal	10.9	9.9	10.9
		Real	2.3	0.9	2.4
3	Beef	Nominal	10.7	11.1	13.2
		Real	2.1	2.1	4.6
4	Chicken	Nominal	4.2	3.2	1.2
		Real	-3.9	-5.2	-6.6
5	Egg	Nominal	6.5	6.6	6.7
		Real	-1.8	-1.9	-1.3

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