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# The Production and Consumption of Livestock Foods in Pakistan: A Look into the Future

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The supply response functions for beef, mutton, poultry meat, eggs, and fresh milk are estimated using the polynomial price lag model, and that of fish meat production using the stock adjustment model. Both the production and domestic consumption of these foods are then projected over the period 1993-94 through 2004-05 using the estimated supply response functions and the existing estimates of demand parameters assuming trend growth of exogenous variables. In the case of mutton and fresh milk there is excess demand, while in the rest of the cases surplus production is predicted. A significant proportion of the anticipated excess demand for mutton and fresh milk can be eliminated by increasing the rate of credit supply to these sub-sectors.

As a sub-sector of the agricultural sector, livestock plays an important role in the development process of a country, and it is an integral part of the agricultural sector of Pakistan's economy. First, it provides energy in the form of draught and traction power for agriculture and rural transport. Second, it provides raw materials in the form of wool, hair, hides, skins, etc., for the manufacturing sector. Third, this sub-sector has an enormous employment potential because livestock rearing is a highly labour-intensive phenomenon. Finally, it is a source of high protein food in the form of milk, milk products, meat, and eggs.

The contribution of the livestock sub-sector to the value-added in agriculture is indeed substantial. In 1992-93, for example, its contribution to total agricultural value-added was around 32 percent as compared to 29 percent in 1983-84. During the last ten years, i.e., between 1983-84 and 1992-93, the livestock value-added grew at an average annual rate of 5.7 percent (the overall agricultural sector at 4.7 percent) and it accounted for around 37 percent of the growth in agricultural value-added.[1] Moreover, the growth in the livestock sub-sector has been relatively smooth

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[1]For a brief discussion of the livestock sub-sector, see Naqvi and Burney (1992).

as compared with that of the overall agriculture sector, and has accelerated over time. At the same time, the production of important livestock foods including meat, eggs, and milk has increased at a reasonable rate. Over the last ten years (1983-84 through 1992-93), for example, the production of beef, mutton, poultry meat, eggs, and fresh milk has increased at the annual average rates of 5.9 percent, 6.3 percent, 7.1 percent, 3.9 percent, and 5.6 percent, respectively.

A number of studies have been conducted in the past to analyse the demand for livestock foods in Pakistan.[2] However, the modelling of the supply side of these foods has been a relatively neglected area in Pakistan.

This study aims at estimating the supply response functions for beef, mutton, poultry meat, fish meat, eggs, and fresh milk.[3] Then these estimates in combination with the existing estimates of demand parameters are used to project both the supply of and the demand for these products over the period 1993-94 through 2004-05. Finally, certain policy simulations are performed.

The rest of this paper is organised as follows: Section 2 discusses methodological issues concerning the formulation of the supply and demand functions; data and some of the estimation problems are discussed in Section 3; Section 4 reports results and evaluates the simulation performance of the supply model over the historical period; Section 5 is concerned with base-line projections; Section 6 deals with policy simulations; and Section 7 summarises the study.

## 2. THE LIVESTOCK MODEL

For the purposes of this study, the livestock model has been divided into two sub-models, the supply sub-model and the demand sub-model. Wide-ranging empirical evidence is available on the subject.[4] Some studies have analysed simultaneously the demand and the supply sides, and the others have either estimated the supply response functions or the demand functions.

However, in the case of Pakistan, very little empirical evidence is available which aims at explaining changes in the production of livestock foods. Anjum *et al.* (1989) have estimated a simple two-equation simulation model for milk production. The model includes a single price equation which explains price by per capita production and per capita income. The other equation aims at explaining changes in the total milk production with the help of changes in the retail price of milk. EAN (1987) have estimated the supply and demand functions for chicken as well as egg

[2]See, for example, Bouis (1992) and Burney and Akmal (1991).

[3]Although fish meat is not a livestock product, it has been added to complete the meat list.

[4]See, for example, Halvorson (1955, 1958); Kelley and Knight (1965); Ladd and Winter (1961); Nerlove (1956, 1958); Tryfos (1974); Bhati (1987); Chavas and Johnson (1982); Chavas and Klemme (1986); and Wilson and Thompson (1967).

production. The demand equations include the price and income variables among the set of regressors. The supply equation includes only current price variables as independent variables.

**The Supply Sub-model**

The quantity produced of a livestock food, like many other foods, is hypothesised to be a function of own prices, prices of inputs used in the production process, the existing state of production technology, and of government policy variables such as supply of credit. It is, however, observed that there is a lagged response to changes in prices. The lagged response 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 paper, we consider 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 detect this type of phenomenon. This model was originally suggested by Almon (1965) and then modified by Bischoff (1966); Modigliani and Sutch (1966); and Cooper (1972).

For the moment, assuming that the quantity produced of the *i*th livestock food is determined by its price variable alone, a general distributed lag model may be expressed as

$$Q_{it} = \alpha_i + \sum_{\tau=0}^{\kappa} \beta_{i\tau} P_{it-\tau} \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (1)$$

Where $Q_{it}$ is the quantity produced of the *i*th livestock food in the current period; $P_{it-\tau}$ is the price of the same food in period $t-\tau$; $\alpha_i$ and $\beta_{i\tau}$ are the parameters to be estimated; while $\kappa$ is the number of periods covered by the lag function.

Using an *n*-degree polynomial lag model, $\beta_{i\tau}$ can be written as

$$\beta_{i\tau} = a_{0i} + a_{1i}\tau + a_{2i}\tau^2 + \dots + a_{ni}\tau^n \quad \dots \quad \dots \quad \dots \quad \dots \quad (2)$$

Substituting Equation (2) in (1), we get

$$Q_{it} = \alpha_i + \sum_{\tau=0}^{\kappa} (a_{0i} + a_{1i}\tau + a_{2i}\tau^2 + \ldots + a_{ni}\tau^n)P_{it-\tau} \ldots \quad \ldots \quad \ldots \quad (3)$$

For the purposes of this study, we employ a second-order polynomial because most of the studies on the subject have considered a second-order polynomial.[5] Moreover, a relatively lower order polynomial lag model is much easier to handle computationally. Due to this simplification, Equation (3) becomes

$$Q_{it} = \alpha_i + \sum_{\tau=0}^{\kappa} (a_{0i} + a_{1i}\tau + a_{2i}\tau^2)P_{it-\tau} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

where

$$\beta_{i\tau} = a_{0i} + a_{1i}\tau + a_{2i}\tau^2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

Further, following the suggestion of Almon (1965), we impose an "end point constraint" on $\beta_{i\tau}$. More specifically, we restrict $\beta_{i\kappa+1}$ to be equal to zero. This restriction is imposed on the basis of the assumption that beyond some length of time period $\kappa$, changes in prices do not affect the current production level. For $\tau = \kappa + 1$, Equation (5) may be written as

$$\beta_{i,\kappa+1} = a_{0i} + a_{1i} + a_{1i}\kappa + a_{2i} + 2a_{2i}\kappa + a_{2i}\kappa^2 \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

Equating this expression to zero, solving for $a_{0i}$, and substituting the resulting expression in Equation (5), we arrive at

$$\beta_{i\tau} = -a_{1i} - a_{2i} - 2a_{2i}\kappa - a_{1i}(\kappa - \tau) - a_{2i}(\kappa^2 - \tau^2) \quad \ldots \quad (7)$$

Equation (1) can then be written as

$$Q_{it} = \alpha_i - a_{1i}\sum_{\tau=0}^{\kappa} P_{i,t-\tau} - a_{2i}\sum_{\tau=0}^{\kappa} P_{i,t-\tau} - 2a_{2i}\kappa\sum_{\tau=0}^{\kappa} P_{i,t-\tau}$$
$$- a_{1i}\sum_{\tau=0}^{\kappa} (\kappa - \tau) P_{i,t-\tau} - a_{2i}\sum_{\tau=0}^{\kappa} (\kappa^2 - \tau^2) P_{i,t-\tau} \ldots \quad \ldots \quad \ldots \quad (8)$$

Equation (8) may also be expressed as

[5]See, for instance, Chavas and Kraus (1990) and Chen *et al.* (1972).

$$Q_{it} = \alpha_i - a_{1i}\ [\sum_{\tau=0}^{\kappa} P_{i,t-\tau} + \sum_{\tau=0}^{\kappa} (\kappa - \tau)\ P_{i,t-\tau}]$$
$$- a_{2i}\ [(1 + 2\kappa)\sum_{\tau=0}^{\kappa} P_{i,t-\tau} + \sum_{\tau=0}^{\kappa} (\kappa^2 - \tau^2)\ P_{i,t-\tau}] \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

For estimation purposes, we expand Equation (9) to incorporate non-price variables. The non-price variables considered in this study include credit availability and time variable–a proxy for technological change. Equation (9) thus becomes

$$Q_{it} = \alpha_i - a_{1i}\ [\sum_{\tau=0}^{\kappa} P_{i,t-\tau} + \sum_{\tau=0}^{\kappa} (\kappa - \tau)\ P_{i,t-\tau}]$$
$$- a_{2i}\ [(1 + 2\kappa)\sum_{\tau=0}^{\kappa} P_{i,t-\tau} + \sum_{\tau=0}^{\kappa} (\kappa^2 - \tau^2)\ P_{i,t-\tau}]$$
$$+ a_{3i}\ CRED_{it} + a_{4i}\ TIME + U_{it} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

where

$Q_{it}$ = annual production (thousand tonnes) of *i*th livestock food.[6]

$P_{it-\tau}$ = ratio of the average wholesale price of *i*th food to consumer price index.[7] (The prices have been indexed using 1971-72 as the base period.)

$CRED_{it}$ = real credit (million rupees) provided for the development of *i*th food by the Agricultural Development Bank of Pakistan (ADBP).[8]

$TIME$ = a proxy for the trend technological advancements which will assume a value of zero for the first period.

$U_{it}$ = error term, which is assumed to be distributed normally with zero mean and constant finite variance.

In addition to the explanatory variables discussed above, a dummy variable is introduced in the supply response functions for chicken and eggs in order to capture the impact of changes in the incentive structure that become available to the poultry

[6] *i* ranges from 1 through 6; 1 = beef, 2 = mutton, 3 = chicken, 4 = fish, 5 = eggs, and 6 = fresh milk. Egg production is in million numbers.

[7] It would have been preferable to use input prices in the denominator. The number of inputs used in the production of each food is such that we are unable to use input prices due mainly to the limited number of observations (only 22 observations are available to estimate the equations). In the equations for chicken and eggs, however, feed price variable will be considered in place of the consumer price index (CPI) because it is the single most important input in the poultry sub-sector.

[8] Ideally, total credit should have been employed but such information is not available.

sub-sector. In 1988-89, an income tax was levied on those poultry farms which were operating for more than five years. The exemption limit was, however, raised to eight years in 1991-92. Assuming that the change in the incentive structure affects actual production with a lag of one year, a value of one is assigned to the dummy variable for the 1989-90 through 1991-92 period, and a value of zero for the remaining years.

## The Demand Sub-model

To analyse the demand side of livestock foods, we employ a systems approach using a cross-section of households.[9] More precisely, we consider Extended Linear Expenditure System (ELES) to model the demand for livestock foods in Pakistan.[10] We start with the following utility function

$$U(q) = \sum_{i=1}^{n} a_i \log (q_i - \gamma_i) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (11)$$

where $q_i$ is the quantity consumed of good $i$ and $\gamma_i$ may be interpreted as a basic need or the subsistence quantity of the same good if it is positive. Assuming the total expenditure to be exogenously determined, the budget constraint may be expressed as

$$P_i q_i = \sum_{i=1}^{n} e_i = E \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (12)$$

where $P_i$ is the price of the $i$th good. Maximising the utility function given in Equation (11), subject to the budget constraint of Equation (12), we get a system of $n$ linear expenditure equations called the Linear Expenditure System (LES). The system is depicted by the following equations

$$e_i = P_i \gamma_i + a_i (E - \sum_{j=1}^{n} P_j \gamma_j) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (13)$$

where $a_i$ represent marginal budget shares of different goods. $\sum P_j \gamma_j$ is the total subsistence expenditure and the expression within parenthesis may be interpreted as the supernumerary expenditure.

Following Lluch (1973), we endogenise total expenditure. This is done by replacing total expenditure ($E$) by total income ($Y$) in Equation (13). So, Equation (13) becomes

[9]Generally, the single equation approach is used to analyse the consumer's responsiveness due to its simplicity, but this approach omits interrelationships among the demand functions being estimated.

[10]The Extended Linear Expenditure System (ELES) was developed by Lluch (1973).

$$e_i = P_i\gamma_i + \beta_i(Y - \sum_{j=1}^{n} P_j\gamma_j) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (14)$$

where $\beta_i$ is the marginal propensity to consume out of income and the expression within parenthesis may now be interpreted as supernumerary income. Adding all the equations gives an aggregate consumption function associated with ELES

$$E = (1 - \mu)\sum_{i=1}^{n} P_i\gamma_i + \mu Y \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (15)$$

where $E$ is total consumption expenditure and $\mu = \Sigma\beta i$. Equation (15) enables identification of $\Sigma P_i\gamma_i$ in the absence of price data and helps obtain price elasticities from the cross-section data.

As $\gamma_i$ appears in all the Equations, the system of Equations given in (14) needs to be estimated simultaneously. This imposes cross-equation restrictions which, in general, require maximisation of the likelihood function. However, since in the case of cross-section data each household is assumed to face identical commodity prices, the term $P_i\gamma_i$ is independent of the unit of observation. Thus, it can be replaced by $\gamma_i^*$. The stochastic specification of ELES can thus be written as

$$e_{ih} = \alpha_i + \beta_i Y_h + u_{ih} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (16)$$

where $h = 1, 2, \ldots H$ for households; $\alpha_i = \gamma_i^* - \beta_i\Sigma\gamma_i^*$; and $u_{ih}$ is the error term with the usual classical properties.

Since identical regressor appears in all the equations, the OLS estimation of (16) is equivalent to the maximum likelihood estimation. The maximum likelihood estimates of $\mu$, $\gamma_i^*$, and $\Sigma\gamma_i^*$ can be obtained using the following relationships

$$\mu = \sum_{i=1}^{n}\beta_i$$

$$\sum_{i=1}^{n}\gamma_i^* = \sum_{i=1}^{n}\alpha_i / (1 - \mu) \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (17)$$

$$\gamma_i^* = \alpha_i + \beta_i\sum_{i=1}^{n}\gamma_i^*$$

The income ($\eta_{iy}$) and own-price ($\eta_{ii}$) elasticities can then be computed as follows

$$\eta_{iy} = \beta_i(Y/e_i)$$
$$\eta_{ii} = (1 - \beta_i)(\gamma_i^*/e_i) - 1 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (18)$$

In this study, instead of getting our own estimates of demand parameters, use is made of the existing estimates of the system described by (16). Burney and Akmal (1991), using Household Income and Expenditure Survey (HIES) data of Pakistan for the year 1984-85, obtain estimates of Equation (16) for a complete set of food items. The study obtains estimates of Equation (16) and the related demand parameters for six income groups of rural households.[11] The same exercise is done for six income brackets of urban households. For the purposes of the present study, however, we consider income and own price elasticities of beef, mutton, poultry meat, fish meat, eggs, and fresh milk only. The demand elasticities used for projections are given in the appendix to this study.

## 3. DATA AND ESTIMATION

The supply response function for fish meat is estimated over the period 1959-60 through 1992-93, while the rest of the equations are based on the 1971-72 through 1992-93 period. In the latter case, 1971-72 is the earliest year for which data on the production of livestock foods are available. The main data sources are the *Economic Survey*, *Pakistan Statistical Year Book*, *Monthly Statistical Bulletins*, *Pakistan Poultry Data Book*, and *Agricultural Credit Indicators*. More precisely, data on the production of livestock foods are taken from the *Economic Survey* and *Pakistan Statistical Yearbook*, credit availability from *Agricultural Credit Indicators*, and prices from *Pakistan Statistical Yearbook*, *Monthly Statistical Bulletins*, *Economic Survey*, and *Pakistan Poultry Data Book*.

The specification given in Equation (10) is estimated using Cooper's (1972) procedure with, however, one exception. In the case of fish meat, the constructed price variables[12] are not only highly correlated with credit availability and time trend but also closely linked with each other in terms of correlation coefficient. This pattern of association among the set of regressors always resulted in the form of wrong signs of the price variable. Even the sequential removal of the time trend and credit availability from the specification could not help correct the signs. The response function, as a consequence, is estimated using the *stock adjustment model* of Nerlove (1956). The variables in this equation are used in the log-linear form.[13]

[11]For a brief discussion of survey data, income brackets, and the food items analysed, see [Burney and Akmal (1991), pp. 187–9].

[12]The constructed price variables are two, irrespective of the lag-length considered. The number of constructed variables depends upon the degree of the polynomial chosen and on the number of end-point restrictions. In general, if the polynomial chosen is of degree $m$, then $m+1$ variables are constructed. And, an end-point restriction reduces one constructed variable. We have employed a second-order polynomial and introduced one end-point restriction; so, in our case, the number of constructed price variables is two.

[13]Linear variables were experimented with but the results were found to be better in terms of significance of parameters in the log-linear case.

Credit availability and time are absent from the equation due, of course, to the multicollinearity problem.

## 4. EMPIRICAL RESULTS

The empirical results from the two models are summarised in Table 1. The estimated response functions incorporate price lags of three to seven years. We choose a lag length of three years for eggs. The equations for beef, poultry meat, and fresh milk are based on a lag length of six years. Finally, the estimated supply response function for mutton incorporates seven lags of mutton price. The selection of price lags in different equations is not arbitrary; it is rather based on Akaike's (1970) final prediction error (FPE) criterion, which is suggested by Hsiao (1981).[14]

The value of *R*-square Adjusted is fairly satisfactory in the supply response functions of beef, mutton, poultry meat, fish meat, and fresh milk. This suggests that bank credit, the relative prices as well as technological and biological developments (proxied by time trend), have played a significant role in enhancing the production of livestock foods in Pakistan. The value of the *R*-square adjusted is, however, relatively low in the case of eggs, and this is mainly due to the fact that time and credit availability is missing from the equation. The two variables were dropped due to the multicollinearity problem. The equation is also adjusted for first-order serial correlation using Cochrane-Orcutt procedure. The rest of the equations are, however, estimated using the standard OLS method.

Trend variable, which represents technological and other structural changes in the livestock sub-sector, is highly significant in four out of six equations. It is missing from the remaining equations mainly due to the multicollinearity reason. Credit availability is found to significantly enhance the supply of beef, mutton, poultry meat, and fresh milk. The dummy variable is highly significant in the equation for poultry meat but it is absent from the supply response function for eggs due to the wrong sign and lack of precision. This result indicates that changes in the incentive structure available to the poultry sub-sector have significantly affected the chicken production, but not the egg production.

The estimates of price coefficients generally assume expected positive signs

[14]In an exhaustive study, Thornton and Batten (1985) use FPE criteria alongwith the Bayesian estimation and Pagano-Hartley criteria in order to determine the optimal lag length of regressors. They conclude that the FPE criteria performs well as compared to the other criteria. In case of a single variable, the criterion is

$$FPE(\kappa) = [(NOB + \kappa + 1)/(NOB - \kappa - 1)]\ [SSR(\kappa)/NOB]$$

where $\kappa$ is the lag length of the regressor; *NOB* is the number of observations; and *SSR* is the residual sum of squares. The $\kappa$ which minimises the above expression is selected. The optimal lag length ensures only a local minimum.

Table 1

*Estimates of the Supply Response Model*

| Equations/ Variables | Beef | Mutton | Poultry Meat | Fish Meat | Eggs | Fresh Milk |
|---|---|---|---|---|---|---|
| CONSTANT | 57.049 | –635.440 | –348.110 | –0.565 | 278.150 | –12770.000 |
| | (0.83) | (11.61) | (4.81) | (1.38) | (0.46) | (3.71) |
| $PRICE_{t-0}$ | –0.786* | –0.674 | 0.522* | 0.409 | –0.235* | 33.659 |
| | (1.27) | (2.62) | (1.12) | (2.02) | (0.16) | (3.01) |
| $PRICE_{t-1}$ | 0.109* | 0.738 | 0.780 | – | 5.334 | 40.267 |
| | (0.41) | (6.14) | (3.03) | – | (6.74) | (5.29) |
| $PRICE_{t-2}$ | 0.698 | 1.711 | 0.899 | – | 5.413 | 41.988 |
| | (5.39) | (17.11) | (5.96) | – | (5.20) | (6.05) |
| $PRICE_{t-3}$ | 0.982 | 2.246 | 0.881 | – | – | 38.822 |
| | (5.40) | (15.30) | (6.06) | – | – | (5.51) |
| $PRICE_{t-4}$ | 0.960 | 2.343 | 0.726 | – | – | 30.768 |
| | (3.85) | (13.72) | (4.92) | – | – | (4.90) |
| $PRICE_{t-5}$ | 0.633 | 2.000 | 0.432 | – | – | 17.828 |
| | (3.55) | (12.82) | (4.18) | – | – | (4.45) |
| $PRICE_{t-6}$ | – | 1.219 | – | – | – | – |
| | – | (12.27) | – | – | – | – |
| $CREDIT_t$ | 175.100 | 232.630 | 47.762 | – | – | 894.180 |
| | (3.23) | (6.41) | (10.55) | – | – | (5.44) |
| $TIME_t$ | 24.888 | 12.057 | 9.236 | – | – | 578.650 |
| | (9.91) | (9.02) | (17.74) | – | – | (19.96) |
| D9092 | – | – | –20.154 | – | – | – |
| | – | – | (6.19) | – | – | – |
| $OUTPUT_{t-1}$ | – | – | – | 0.765 | – | – |
| | – | – | – | (7.14) | – | – |
| R– SQR. ADJ. | 0.990 | 0.999 | 0.995 | 0.975 | 0.736 | 0.994 |
| DW – STATISTIC | 1.886 | 1.975 | 2.503 | 1.760 | 2.112 | 2.666 |
| DEG OF FREEDOM | 11.000 | 10.000 | 10.000 | 30.000 | 15.000 | 11.000 |

*Note:* *Insignificant at 10 percent level (*t*-scores are in parentheses).

and exhibit a high degree of precision. Out of twenty-nine price coefficients, only four are insignificant at 10 percent level, implying that higher prices stimulate the production of foods from livestock. This price impact in the first period is, however, negligible and even incorrect in the cases of beef, mutton, and eggs mainly because of biological and technical factors. It is interesting to note that the dynamic price impacts (as depicted by the delayed price coefficients) increase first with lag, reach their maximum levels, and then start declining. So is the case with corresponding *t*-scores. This finding is consistent with the hypothesis that livestock food production, in response to a given change in the price level, first increases through time and then starts declining. It also suggests that the *stock adjustment model* would not have been an appropriate choice if the sole objective had been to analyse the dynamic impact of livestock food prices on livestock food production; the reason being that it imposes the same pattern of dynamic adjustment (geometrically declining) to changes in the price level.

The parameter estimates for the fish meat are also reported in Table 1. Both coefficients are significantly different from zero at 90 percent level of confidence. The short-run elasticity of supply with respect to price is 0.41; which implies that a 10 percent increase in the real price increases fish meat production by around 4 percent during the same year. The proportion of desired adjustment in the production of fish meat is 0.24. This implies that 24 percent of the desired adjustment in the production of fish is realised within one year. The long-run elasticity of supply with respect to price (obtained by dividing the price coefficient by that of lagged production) is 0.53. These results indicate an inelastic response of fish meat production with respect to the real price even in the long run.

## Validation of the Model

Although the estimated supply response function are rich in terms of the degree of explanation of livestock food production, yet there is a possibility that simulated production may not track closely the actual production even over the historical period. The model, therefore, has been simulated over the historical period before we use it for projections and policy simulations. Some selected simulation statistics[15] are reported in Table 2.

The results support the previous finding of a high degree of predictive efficiency. It is interesting to note that the TIC value is not only close to zero, but also that its percentage distribution is almost ideal. The bias component is zero, the variance component is nearly zero, and the covariance component is close to unity. The average TIC value is 0.023, which indicates an error margin of only 2.3 percent in tracking the actual series over the historical period. Moreover, the degree of associa-

[15]For a brief discussion of the simulation statistics, see [Pindyck and Rubinfeld (1981), p. 335].

Table 2

*Simulation Results*

| Food Products | THEIL'S INEQUALITY COEFFICIENT (TIC) | | | | Correlation Coefficient |
|---|---|---|---|---|---|
| | Value | COMPONENTS | | | |
| | | Bias | Variance | Covariance | |
| Beef | 0.02 | 0.00 | 0.02 | 0.98 | 1.00 |
| Mutton | 0.01 | 0.00 | 0.00 | 1.00 | 1.00 |
| Chicken | 0.02 | 0.00 | 0.02 | 0.98 | 1.00 |
| Fish | 0.02 | 0.00 | 0.00 | 1.00 | 0.99 |
| Eggs | 0.06 | 0.00 | 0.01 | 0.99 | 0.99 |
| Fresh Milk | 0.01 | 0.00 | 0.01 | 0.99 | 1.00 |

*Note:* Correlation coefficient is between the actual and the simulated series.

tion between the simulated and the actual series as measured by the correlation coefficient is quite satisfactory.

## 5. BASE-LINE PROJECTIONS

The projection of production as well as domestic consumption into the future requires a knowledge of the future values of the exogenous variables. The variables exogenous to the model are projected[16] using their trend growth over the last ten-year period (1983-84 through 1992-93). The projected production as well as domestic consumption corresponding to this exercise are presented in Table 3.

The expected production growth rates of beef and fish meat exceed the corresponding consumption demand rates by more than one percentage point. As a result,

[16]Following are the growth rates which are used in the projections:

**Retail Prices** (P is short for price):

P1 = 11.44, P2 = 9.20, P3 = 7.44, P4 = 11.26, P5 = 7.03, P6 = 7.13,
Consumer Price Index = 7.49.

**Wholesale Prices:**

P1 = 11.61, P2 = 9.47, P3 = 7.44, P4 = 9.67, P5 = 5.45, P6 = 7.18.
GNP Deflator = 8.36, Per Capita Income = 1.68,
Real Credit to Dairy Sector = 6.90,
Real Credit to Poultry Sector = 6.90,
Real Credit to Meet Animals = 11.43,
Population = 3.00.

Table 3

*Projections of Livestock Food Production and Domestic Consumption under the Assumption that the Exogenous Variables Grow at the Trend Rate*

(000 Tonnes)
(Mln. Numbers)

| Years/ Food Products | 1994-95 | 1999-00 | 2004-05 | Growth Rate* |
|---|---|---|---|---|
| **Beef** | | | | |
| Production | 927 | 1150 | 1422 | 4.33 |
| Consumption | 900 | 1056 | 1240 | 3.26 |
| Surplus | 27 | 94 | 182 | – |
| **Mutton** | | | | |
| Production | 792 | 912 | 1161 | 3.60 |
| Consumption | 833 | 1037 | 1292 | 4.49 |
| Surplus | –41 | –125 | –131 | – |
| **Poultry Meat** | | | | |
| Production | 235 | 327 | 419 | 6.25 |
| Consumption | 208 | 270 | 350 | 5.32 |
| Surplus | 27 | 57 | 69 | – |
| **Fish Meat** | | | | |
| Production | 720 | 915 | 1108 | 4.58 |
| Consumption | 583 | 688 | 811 | 3.36 |
| Surplus | 137 | 227 | 297 | – |
| **Eggs** | | | | |
| Production | 5937 | 7658 | 9901 | 5.13 |
| Consumption | 5949 | 7651 | 9841 | 5.16 |
| Surplus | –12 | 7 | 60 | – |
| **Fresh Milk** | | | | |
| Production | 18079 | 20518 | 23281 | 2.59 |
| Consumption | 18566 | 22739 | 27849 | 4.14 |
| Surplus | –487 | –2221 | –4568 | – |

*Note:* *Average Annual Rate over the Period 1993-94 through 2004-05.

surplus production of beef is likely to increase from 27 thousand tonnes in 1994-95 to as high as 182 thousand tonnes by the year 2004-05. In the case of fish meat, the production surplus available for exports is expected to increase from 137 thousand tonnes in 1994-95 to 297 thousand tonnes by the end of the projection period. For mutton and fresh milk, roughly opposite is the case. Here, the consumption demand is expected to grow at rates which are considerably higher than their production counterparts. As a consequence, the excess demand for mutton is likely to increase from 41 thousand tonnes in 1994-95 to 131 thousand tonnes by the year 2004-05. And that of fresh milk from 487 thousand tonnes in 1994-95 to around 4.6 million tonnes by the year 2004-05. In the case of poultry meat, the expected production growth rate is 6. 3 percent while the consumption demand rate is around 5.3 percent. This will result in a production surplus, which is likely to increase from 27 thousand tonnes in 1994-95 to as high as 69 thousand tonnes by the end of the projection period. Finally, we discuss the production and demand balance situation in the case of eggs. Here, production is growing at a rate which is higher than the corresponding consumption demand rate as the egg production surplus grows upto five million dozens by the year 2004-05. But this finding is not consistent with the reported growth rates because the consumption demand rate is slightly higher than the corresponding production growth rate. Perhaps our model slightly overpredicts the egg production in 1993-94 relative to its trend prediction. The egg production growth rate, as a consequence, is underestimated because forecasts for the year 1993-94 are used as base values to calculate the annual average growth rates.[17]

## 6. POLICY SIMULATIONS

In the previous section we analysed the future production and domestic consumption demand of livestock foods in Pakistan under the assumption that variables exogenous to the model continue to grow at the trend rates. Now we go a step further, and instead of assuming trend growth, we assign time paths of our own choice to some of the important exogenous variables and see the resulting production and demand balance situation during the following twelve years. For the purposes of this study, we analyse following alternative policy scenarios:

What happens to the expected production and corresponding domestic consumption levels if instead of growing at the trend rate

(i) the population growth rate reduces to 2 percent by the year 2004-05;

[17]Our speculation that the egg production is relatively overpredicted in 1993-94 is supported by the fact that the estimated egg production response function overpredicts the regressant in 1991-92 and 1992-93. In order to avoid the confusion, the natural logarithms of predicted production and consumption series are regressed against time. Thus, calculated growth rates are consistent with the finding of surplus egg production.

(ii) the population growth rate reduces to 2.5 percent by the year 2004-05;
(iii) the household's real per capita income doubles by the year 2019-20;
(iv) the household's real per capita income doubles by the year 2009-10;
(v) the household's real per capita income doubles by the year 2004-05; and
(vi) the real credit availability to the poultry farming and meat animals grows at the rate of 15 percent, and to dairy farming at the rate of 30 percent per annum.

Expected growth rates of production and domestic consumption demand which correspond to these alternative simulation regimes, are presented in Table 4. For the sake of comparison, base-line growth rates are reproduced in the extreme left column of the Table. The first two simulations are basically *demand-discouraging,* the subsequent three are *demand-encouraging*, and the last simulation is *supply-*

Table 4

*Expected Growth Rates of Livestock Food Production and Domestic Consumption under Alternative Simulation Regimes*

| Livestock Foods | Base-Line | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|---|
| **Beef** | | | | | | | |
| Production | 4.33 | 4.33 | 4.33 | 4.33 | 4.33 | 4.33 | 4.72 |
| Consumption | 3.26 | 2.59 | 2.91 | 3.73 | 4.55 | 5.48 | 3.26 |
| **Mutton** | | | | | | | |
| Production | 3.60 | 3.60 | 3.60 | 3.60 | 3.60 | 3.60 | 4.22 |
| Consumption | 4.49 | 3.82 | 4.13 | 5.64 | 7.60 | 9.83 | 4.49 |
| **Poultry Meat** | | | | | | | |
| Production | 6.25 | 6.25 | 6.25 | 6.25 | 6.25 | 6.25 | 6.39 |
| Consumption | 5.32 | 4.61 | 4.95 | 6.55 | 8.63 | 10.99 | 5.32 |
| **Fish Meat** | | | | | | | |
| Production | 4.58 | 4.58 | 4.58 | 4.58 | 4.58 | 4.58 | 4.58 |
| Consumption | 3.36 | 2.70 | 3.00 | 3.86 | 4.72 | 5.68 | 3.36 |
| **Eggs** | | | | | | | |
| Production | 5.13 | 5.13 | 5.13 | 5.13 | 5.13 | 5.13 | 5.13 |
| Consumption | 5.16 | 4.49 | 4.81 | 6.23 | 8.05 | 10.12 | 5.16 |
| **Fresh Milk** | | | | | | | |
| Production | 2.59 | 2.59 | 2.59 | 2.59 | 2.59 | 2.59 | 3.58 |
| Consumption | 4.14 | 3.47 | 3.79 | 4.69 | 5.63 | 6.71 | 4.14 |

*Note:* Growth Rate is the Annual Average Rate over the Period 1993-94 through 2004-05.

*encouraging*. Expected growth rates of domestic consumption demand, which are based on the assumption that the population growth rate reduces to two percent by the year 2004-05, are reported in the second column of the Table alongwith the corresponding production growth rates. In this new environment, although the demand growth rates reduce relative to the base-line rates, even then the demand for mutton and fresh milk exceeds the supply of these products. The excess demand for mutton, for example, is likely to increase from 38 thousand tonnes in 1994-95 to only 41 thousand tonnes by the year 2004-05. It is interesting to note that corresponding figures for the base-line solution are 41 thousand tonnes and 131 thousand tonnes, respectively. And excess demand for fresh milk is likely to increase from 418 thousand tonnes in 1994-95 to around 2.6 million tonnes by the year 2004-05. Here, the corresponding figures for the base-line forecasts are, respectively, 487 thousand tonnes and around 4.6 million tonnes. It implies that a gradual reduction in the growth rate of population by one percentage point reduces excess demand ultimately by around 43 percent. Instead of explaining all the simulation solutions, we go on to simulation v. In this scenario, the demand for all the livestock foods is expected to grow at rates which are considerably higher than corresponding production growth rates. Expected demand growth rates of poultry meat and eggs enter into double digit. The growth rate of mutton demand is around 9.8 percent, which is much higher than the corresponding production growth rate. As a result, excess demand for mutton is likely to increase from 128 thousand tonnes in 1994-95 to around one million tonnes by the year 2004-05. Fish meat surplus, under this simulation regime, is likely to reduce from 110 thousand tonnes in 1994-95 to only 49 thousand tonnes by the end of the projection period.

Finally, we discuss the last simulation which is a really interesting one because we are anticipating excess demand for mutton and fresh milk and we know that the increased credit availability to these sub-sectors can help bridge the anticipated gap between the production and consumption of these foods. In this simulation regime, the production surplus of beef and chicken is likely to grow at rates which are higher than the corresponding base-line rates. This surplus production will not only reduce the real prices of beef and poultry meat but also help moderate the growth rate of the mutton price because these foods are close substitutes. In the case of mutton, expected production growth rate is 4.2 percent, which is now slightly lower than the demand rate. As a result, excess demand for mutton is likely to increase from 37 thousand tonnes in 1994-95 to only 49 thousand tonnes by the year 2004-05. It is interesting to note that the corresponding base-line figures are 41 thousand tonnes and 131 thousand tonnes, respectively. This result indicates that ultimately 63 percent of the excess demand for mutton is eliminated due to the increased rate of credit supply. In case of fresh milk, on the other hand, excess demand is expected to be around two million tonnes, which is only 44 percent of the excess demand in the base-line projections for the same year. This outcome has important policy implications. By increasing the rate of credit supply, the excess demand for mutton and fresh milk can be eliminated considerably and, as a result, expected growth rate of mutton and milk price can be brought down to a considerable extent.

## 7. SUMMARY AND CONCLUDING REMARKS

The purpose of this paper has been manifold: first, to estimate the supply response functions for livestock foods including beef, mutton, poultry meat, fish meat, eggs, and fresh milk; second, to project the production of these foods using the estimated supply response functions, and corresponding consumption using the existing estimates of demand parameters; and, thirdly, to perform certain policy simulations using the above estimated model.

So far as the first objective is concerned, the polynomial price lag function has been used to model the delayed response of livestock food producers to the changes in price variables. However, in the case of the supply response function for fish meat, the lag structure suggested by Nerlove (the stock adjustment model) has been employed. This technique has been applied because of a severe multicollinearity problem. Non-price variables included among the set of regressors are credit and technological advancements. The technology variable is proxied by time. These non-price variables, in general, are significant and exhibit good *t*-scores. The explanatory power of the estimated equations is also satisfactory.

As regards the second objective, the cross-section estimates of the income and the own-price elasticities have been used to project the demand for livestock foods. The demand parameters are given for six different income brackets across the rural and urban sectors. Before using the estimated supply response functions for forecasting, they are first evaluated over the historical period. The predictive efficiency of supply equations, as measured by Theil's Inequality Coefficient and its components, is found to be quite satisfactory. In the base-line projections, the demand for mutton and fresh milk is likely to grow at rates which are higher than the corresponding production rates. In the rest of the cases, however, the production growth rates exceed the corresponding consumption demand rates. Finally, both the supply and the demand sides have been projected under alternative policy scenarios.

## Appendix Table 1

*Income and Own-Price Elasticities Used for Projections*

| Elasticities/ Income Groups | Beef | Mutton | Poultry Meat | Fish Meat | Eggs | Fresh Milk |
|---|---|---|---|---|---|---|
| **INCOME** | | | | | | |
| GROUP I | | | | | | |
| URBAN | 0.260 | 0.680 | 0.920 | 0.240 | 0.900 | 0.360 |
| RURAL | 0.605 | 1.751 | 1.735 | 0.759 | 1.276 | 0.728 |
| GROUP II | | | | | | |
| URBAN | 0.258 | 0.713 | 1.022 | 0.058 | 0.837 | 0.386 |
| RURAL | 0.716 | 1.382 | 1.197 | 0.488 | 1.366 | 0.712 |
| GROUP III | | | | | | |
| URBAN | 0.289 | 0.946 | 1.317 | 0.500 | 0.763 | 0.477 |
| RURAL | 0.477 | 0.799 | 1.121 | 0.570 | 0.614 | 0.661 |
| GROUP IV | | | | | | |
| URBAN | 0.217 | 0.919 | 1.231 | 0.257 | 0.716 | 0.248 |
| RURAL | 0.632 | 1.319 | 1.215 | 0.728 | 2.314 | 0.480 |
| GROUP V | | | | | | |
| URBAN | 0.162 | 0.921 | 1.289 | 0.469 | 0.782 | 0.475 |
| RURAL | 0.419 | 1.234 | 1.348 | 0.473 | 0.623 | 0.521 |
| GROUP VI | | | | | | |
| URBAN | 0.312 | 0.494 | 0.631 | 0.737 | 0.362 | 0.296 |
| RURAL | 0.377 | 0.215 | 0.288 | –0.221 | 0.235 | 0.420 |
| **OWN-PRICE** | | | | | | |
| GROUP I | | | | | | |
| URBAN | –0.073 | –0.153 | –0.203 | –0.053 | –0.200 | –0.102 |
| RURAL | –0.119 | –0.324 | –0.315 | –0.140 | –0.234 | –0.191 |
| GROUP II | | | | | | |
| URBAN | –0.128 | –0.344 | –0.486 | –0.028 | –0.400 | –0.207 |
| RURAL | –0.256 | –0.482 | –0.416 | –0.170 | –0.475 | –0.297 |
| GROUP III | | | | | | |
| URBAN | –0.137 | –0.436 | –0.597 | –0.228 | –0.347 | –0.245 |
| RURAL | –0.120 | –0.196 | –0.271 | –0.137 | –0.149 | –0.211 |
| GROUP IV | | | | | | |
| URBAN | –0.103 | –0.427 | –0.561 | –0.117 | –0.328 | –0.128 |
| RURAL | –0.269 | –0.554 | –0.509 | –0.303 | –0.962 | –0.231 |
| GROUP V | | | | | | |
| URBAN | –0.102 | –0.578 | –0.796 | –0.291 | –0.485 | –0.314 |
| RURAL | –0.415 | –1.211 | –1.323 | –0.466 | –0.614 | –0.529 |
| GROUP VI | | | | | | |
| URBAN | –0.150 | –0.242 | –0.301 | –0.349 | –0.173 | –0.149 |
| RURAL | –0.564 | –0.322 | –0.431 | 0.329 | –0.350 | –0.632 |

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