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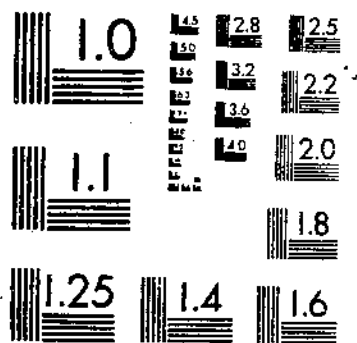
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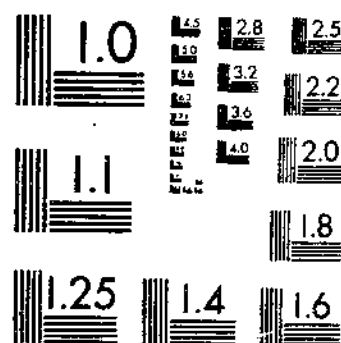
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ECONOMETRIC MODELS OF CASH & FUTURES PRICES OF SHELL EGGS  
ROY, S. K.; JOHNSON, P. N. 1 OF 1

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MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A

# ECONOMETRIC MODELS OF CASH & FUTURES PRICES OF SHELL EGGS

ECONOMIC RESEARCH SERVICE  
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## ABSTRACT

A series of econometric models which analyze economic relationships in the egg industry and provide short-term predictions of egg prices were developed for this study. The major emphasis of these models is formulating and estimating shortrun supply-demand relations which are believed to be the basic price-determining forces in the cash and futures market for eggs. Data for 1961-69 were used in developing the multiequation models.

Forecasting performance of the two-stage and three-stage least squares models and the ordinary least squares estimate of modified first-round price equations were examined. Also, 35 recent futures contracts were examined for the relation or spread between futures and cash price quotations. The spread was found to vary substantially, even within the short span of a delivery month. Ordinary least squares equations were also developed for weekly cash and futures quotations for shell eggs.

Keywords: Eggs, Models, Prices, Predictions, Futures, Cash, Spreads, Supply, Demand, Least squares.

Washington, D.C. 20250

August 1974

## PREFACE

Texas Tech University conducted this study during 1970-72 under a research contract with the Commodity Exchange Authority, U.S. Department of Agriculture. The basic purpose of the research project was to develop econometric models to predict or estimate shell egg prices. The models, based on basic supply-demand forces, were designed to help the Commodity Exchange Authority in regulating shell egg futures trading. Although this study was developed primarily for the benefit of the Authority, the findings of the project may be of interest to economists, traders, and other Government agencies involved with the egg industry. The models and results of the study may provide an updated understanding of the most recent structure of the supply-demand relations and the price-determining process within the shell egg sector.

Allen B. Paul, National Economic Analysis Division, Economic Research Service, USDA, was the contracting officer, and he offered valuable help in all phases of the project. Special appreciation is extended to Richard J. Foote, Texas Tech University, for his helpful comments and suggestions throughout the research.

## CONTENTS

SUMMARY AND HIGHLIGHTS .....	v
INTRODUCTION .....	1
The Egg Industry: General Characteristics and Recent Changes .....	1
Supply, Demand, and Price Structures of the Shell Egg Sector .....	2
FORECASTING MODELS FOR AVERAGE QUARTERLY PRICES .....	4
Basic Model .....	4
Econometric Considerations .....	6
Two-Stage and Three-Stage Least Squares Estimates of Equations (Q-1) and (Q-3) .....	7
Reduced-Form Price Equations .....	8
Ordinary Least Squares Estimates of Equations (Q-5), (Q-6), and (Q-7) .....	9
Modified First-Round Price Equations .....	10
Predictive Accuracy of Alternative Models .....	11
FORECASTING MODELS FOR AVERAGE MONTHLY PRICES .....	13
Basic Model .....	13
Two-Stage and Three-Stage Least Squares Estimates of Equations (M-1) and (M-3) .....	14
Reduced-Form Price Equations .....	15
Ordinary Least Squares Estimates of Equations (M-4), (M-5), and (M-6) .....	16
Modified First-Round Price Equations .....	17
Predictive Accuracy of Alternative Models .....	18
ANALYSIS OF AVERAGE WEEKLY CASH PRICES .....	20
ANALYSIS OF FUTURES QUOTATIONS FOR FRESH SHELL EGGS .....	22
Relations Between Futures and Cash Price Quotations for Shell Eggs .....	22
Weekly Prediction Equations for Price Quotations for Nearby Futures .....	23
LITERATURE CITED .....	25
APPENDIX I .....	26
APPENDIX II .....	27

## SUMMARY AND HIGHLIGHTS

A series of econometric models which analyze economic relationships in the egg industry and provide short-term predictions of egg prices was developed for this study. Major emphasis was placed on formulating and estimating short-run supply-demand relations which are believed to be the basic price-determining forces in the cash and futures market for eggs. The increasing importance of the breaking-egg sector and a substantial decline in storage movements of shell eggs are recent changes within the egg industry which have altered the

price-determining process. Such changes were incorporated into the models to reflect the most recent supply-demand structure of the industry.

Multiequation models were developed independently for each calendar quarter and month using data for 1961-69. The basic part of each model included a simultaneous equation system with two stochastic relations and a closing identity. Shell egg price and disposable income were related to consumption of shell eggs in one of the stochastic relations, while in the other

function the quantity of eggs used for breaking was postulated to depend on shell egg price and relevant lagged variables. Two-stage and three-stage least squares procedures were applied to these two structural equations to obtain the estimates of coefficients which were found to be consistent in sign with theoretical expectations. Additional ordinary least squares prediction equations for total production of eggs and the quantity of eggs used for hatching were developed by quarter and month to close the model for forecasting prices one period ahead.

Forecasting performance of the two-stage and three-stage least squares models and the ordinary least squares estimates of modified first-round price equations was examined by using Theil's U-coefficients for price estimates both within and beyond the sample period. The quarterly models performed reasonably well in predicting prices during the sample period and up to the middle of 1971. Prediction errors, on the average, for the three-stage least squares structural models were smaller than those for the two-stage least squares models. On the other hand, the modified first-round price equations seemed to have some edge over the structural models during the period. With regard to monthly price predictions, both two-stage and three-stage least squares models exhibited substantial errors. However, the modified first-round price equations yielded reasonable forecasts for most months from 1961 through the middle of 1971. While the two-stage and three-stage least squares structural equations provide a more satisfactory explanation of the underlying economic relationships, the final choice among alternative models for forecasting remains to be determined.

Price forecasts from both quarterly and monthly models involved large errors during the latter part of 1971. The effect of the newly introduced Marek's disease vaccine at this time on the rate of lay and the death loss of layers may have amounted to a substantial change within the industry, thereby outdating portions of the models. Experience with the new vaccine was not of long enough duration to permit the revisions needed to take these changes into account within the models.

A number of equations were formulated to estimate the relation between weekly cash prices of shell eggs and the factors which affect such prices. The quantity of

eggs moving through commercial channels (commercial egg movement report), net storage movements of shell eggs, and the price of shell eggs on the preceding Friday were the basic independent variables in the weekly cash price equations. The lagged weekly average of daily prices paid for eggs delivered to breaking plants was also included as an additional factor. Data for November 18, 1970, through February 26, 1972, were used to obtain the ordinary least squares estimates of the equations. The signs of the estimated coefficients appeared to be logically consistent, and the test statistics indicated a reasonably good fit of the equations.

Futures trading in fresh shell eggs has been fairly active at the Chicago Mercantile Exchange in recent years. Futures quotations for recent contracts revealed considerable fluctuations in prices. The relation or spread between the futures and cash price quotations on several specified days of the delivery month was examined for each of 35 recent contracts. The futures-cash basis was found to vary substantially, even within the short span of the delivery month. The spread between futures and cash prices changed from negative to positive or vice versa within the delivery month for more than half of all contracts examined. The futures-cash spreads for each of the 12 contracts of the year over a period of 3 years (excluding January 1969), 1969-71, also revealed unstable relations between futures and cash prices for most of the contracts. Some degree of consistency in the basis or spread over the years was found for only three contracts—May, August, and December contracts.

Weekly equations were developed to predict highs and lows of the quotations for nearby futures contracts. Futures prices are essentially determined by traders' anticipations of market forces which are expected to exist at the time of delivery. Such anticipations are considerably influenced by information on major price-determining factors in the immediate past. Accordingly, lagged values of weekly commercial egg movement reports, storage stocks, prices of breaker eggs, and the last week's closing futures quotations were used to predict price quotations for nearby futures. The estimated equations, based on data for a 66-week period, indicated relations which were logically consistent and accounted for about 68 percent of the variations in the weekly futures quotations.

# ECONOMETRIC MODELS OF CASH & FUTURES PRICES OF SHELL EGGS\*

Sujit K. Roy and Phillip N. Johnson<sup>1</sup>

## INTRODUCTION

In recent years, significant changes have occurred in the basic price-determining factors in the U.S. egg sector. The growing importance of the breaking-egg sector, increasing commercialization and integration of production and marketing operations, and continuing technological improvements have had a considerable impact on the price-determining process. Wide shortrun variations in shell egg prices persist even though shortrun fluctuations of the major supply-determining factors such as production, hatching, and breaking of eggs have significantly diminished during the past decade.

To provide a quantitative foundation for understanding these shortrun variations in shell egg prices, econometric models were developed. These models should be of interest to traders, producers, and Government agencies involved with analyzing and predicting cash and futures prices of shell eggs.

### The Egg Industry: General Characteristics and Recent Changes

In 1971, cash receipts for U.S. eggs totaled \$1.8 billion. This amount accounted for 3.5 percent of the cash receipts for all farm commodities sold and about 46 percent of cash receipts for poultry products (20, p.60).<sup>2</sup>

The shell egg, or table egg, market accounted for 82 percent of 1971 egg production. The remainder went to the markets for breaking and hatching eggs.

Shell egg consumption increased from 4.4 billion dozen in 1960 to 4.8 billion dozen in 1971, reflecting

the population growth. However, per capita shell egg consumption declined from 306 in 1960 to 277 in 1971 (22, 24). This decrease can be attributed to a shift from heavy breakfast foods to lighter food items and a general emphasis on controlling diets.

Egg production, once centered in the Midwest, has in recent years shifted to the South. In 1960, the Midwest produced 42.2 percent of the eggs, and the South produced about 27.5 percent (12, p. 2). In 1971, the Midwest produced only 28 percent, while the South produced 41 percent (22). Lower wage rates, an adequate supply of feed, improved transportation methods, and lower building and land costs in the South were the primary causes of the regional shift (12, pp. 64-65).

The evolution of the egg industry in recent years has been marked by a major shift in production from small farms to large specialized producing units. Technological improvements related to poultry breeding, nutrition, disease control, housing, and other areas have increased production efficiency and have necessitated a higher degree of specialization (11, p. 2). Also, improved transportation methods have reduced the need for local production, thus enabling large specialized units to develop.

The recent trend in the egg industry has also been characterized by vertical integration of various functions such as hatching, production, packing, and marketing. Such integrations have: (1) facilitated the adoption of new or improved production technology, (2) enhanced the efficiency of capital utilization, and (3) improved product standardization (12, pp. 58-65).

Seasonal variations in egg production do still persist, although fluctuations have become somewhat less severe in recent years. Production generally reaches a peak in April or May and declines to a low point in September.

The breaking-egg sector has gained in importance as a secondary market for eggs. The percentage of total egg production absorbed by this sector increased from 8.6

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<sup>2</sup>Italicized numbers in parentheses refer to items in Literature Cited on page 25.

percent in 1960 to 11 percent in 1971. This increase was due primarily to a growing demand for convenience food items in which processed eggs are used. In fact, per capita consumption of processed eggs rose from 29 in 1960 to 37 in 1971 (22, 24).

The level of egg-breaking activity, which is highly seasonal, generally reaches its peak during the spring months when egg prices are relatively low. Egg breaking thus provides an outlet for the seasonal surplus and, to some extent, helps support shell egg prices during the surplus production period (6, p. iv).

Hatching eggs are obtained from hatchery-owned flocks, primary breeders, and other hatcheries. The hatcheries do not serve as an outlet for normal egg production, although the surplus of hatchery eggs can be diverted to the shell egg or breaking-egg markets (12, pp. 52-53).

Cold storage holdings of shell eggs have significantly declined in recent years. Average stock: on the first of the month decreased from 15 million dozen in 1960 to only 3.1 million dozen in 1971 (22, 24). This decline can be attributed to diminishing seasonal variations in egg production and increasing egg-breaking activity. In a sense, the breaking-egg sector has largely taken over the previous role of storage holdings.

Since cold storage stocks of fresh eggs are only a meager portion of the total egg production, they do not significantly affect the aggregate market supply of shell eggs. Also, net exports and Government purchases of shell eggs comprised only 1.5 percent of the total egg production in 1971 (22).

Prices of shell eggs vary considerably in the short run, even though variations in production have moderated in recent years. Prices are usually lowest during the spring when production is at its seasonal high and highest in the fall and winter when production is at its seasonal low. Besides the variations in production or net supply of shell eggs, changes in seasonal demand also affect the price movements. The demand for table eggs generally increases in the winter and declines during the summer. Short-lived spurts in demand also occur during the Easter, Passover, Thanksgiving, and Christmas holidays. It appears, however, that the price fluctuations are due primarily to variations in the market supply of shell eggs and only secondarily to the less volatile consumer demand.

Significant changes have occurred in the egg marketing system during the past decade. In the late 1950's, 57 percent of the commercial supply was handled by assembler-packers; 35 percent was handled by wholesale distributors; and about 5 percent went directly to retailers and institutional buyers. In contrast, in the late 1960's, assembler-packers handled 75 percent of the

total commercial egg supply; wholesale distributors handled 14 percent; and 7 percent went to retailers and institutional buyers. This shift in marketing channels resulted in a substantial reduction in the share of the commercial egg supply moving through wholesale channels. The share declined from 69 percent in the late 1950's to 28 percent in the late 1960's (12, p. 4).

The present egg-pricing system depends on base price quotations for selected wholesale grades and sizes of eggs at several terminal markets such as Boston, Chicago, New York City, and Los Angeles. Base prices at Chicago and New York City are by far the most widely used quotations in the egg industry. The price quotations at the wholesale level are of crucial importance to the sector since retail as well as farm prices are generally determined on the basis of these wholesale price quotations.

The current egg-pricing system has come under increasing criticism in recent years. It has been observed, for instance, that the price quotations are established at the wholesale level even though the role of the wholesalers has significantly declined. Consequently, the price quotations may become much less representative of the entire market than they are expected to be. Some also believe that the wide short-run price fluctuations are not consistent with the existing supply and demand conditions in the sector. The criticisms, in general, are based on the opinion that the present pricing system has failed to adjust to important changes in the egg industry. Alternative pricing methods which have been suggested to replace or supplement the existing pricing system include: (1) quotations at another level of trading such as prices paid by retailers, (2) committee pricing, (3) futures-oriented pricing, and (4) marketing agreements and orders (13, 26).

### Supply, Demand, and Price Structures of the Shell Egg Sector

The demand and supply structures of the shell egg industry are based on the interrelationships among a large number of variables. Such variables include those simultaneously determined within the structural system during the current period and others either predetermined externally or determined prior to the current period within the system. A brief schematic representation of the supply and demand structures of the sector is presented in figure 1. The variables which represent physical quantities are shown in rectangular outlines, while the variables representing prices and values are presented in circles. The arrows indicate the relation and direction of influence among relevant variables.

The quantity of shell eggs reaching consumers for

# Supply and Demand Structures of the Shell Egg Sector

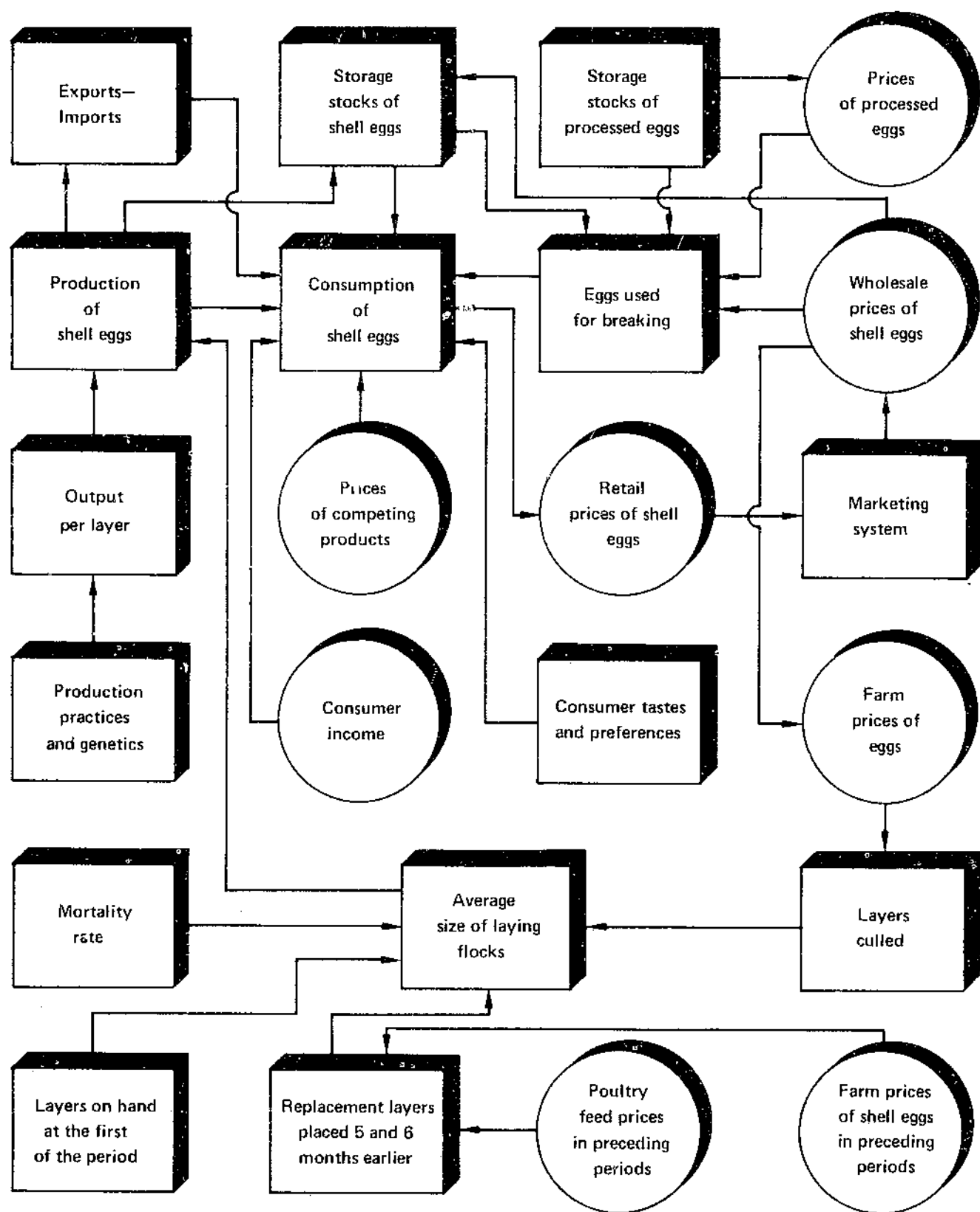


Figure 1

table egg consumption may be equated with the total production of eggs minus the quantity of eggs used for hatching, eggs broken for commercial use, and net storage stocks for the period. Net exports and non-civilian purchases of eggs are only a negligible portion of total egg production, and therefore can be discounted. The demand for shell eggs, as that for many other agricultural products, is fairly stable. Wide fluctuations in shortrun prices are due primarily to variations in supply. Shell eggs, a perishable product, must reach the consumer without much time lapse, irrespective of the existing demand situation in the market.

Egg production in the short run, specifically during a month or quarter, is essentially a predetermined variable, for it is the product of the size of the laying flock and the average output of eggs per layer. The size of the laying flock at the beginning of a period is predetermined through prior adjustments made by the producers. Since pullet replacements reach the productive age in about 6 months, the number of pullets entering the laying flock is essentially predetermined during the preceding quarters. Although the number of layers culled may be adjusted during the current period in response to the existing cost-return relationships in the industry, such adjustments in the short run may be assumed to be minor relative to the size of the laying flock. The average rate of lay is predetermined because it depends on existing production practices and genetics, which do not vary significantly in the short run.

The quantity of eggs broken for processing depends on the demand for convenience food items in which processed eggs are used. Current shell egg prices may also affect egg-breaking activity. For instance, in the spring, when shell egg prices are low, a relatively larger volume of eggs is broken than in the fall when prices are relatively high. Furthermore, the quantity of eggs

broken during the current quarter or period is influenced by the carryover of storage stocks of processed or frozen eggs from the previous period.

Net storage stocks of shell eggs depend on the level of production and the demand for shell eggs and eggs used for breaking. Storage of shell eggs generally increases during high production periods and declines during low production. Since shell eggs from storage may move into the markets for shell eggs or breaking eggs, storage holdings of shell eggs depend on existing demand situations or price levels in the two markets. Since storage holdings have declined substantially in recent years, variations in storage stocks eventually may not have a significant impact on shell egg prices.

Production of shell eggs, as reported by USDA, includes eggs used for hatching. Hence, consumption of shell eggs is determined by subtracting, among other factors, the quantity of hatching eggs from total production. The quantity of eggs used for hatching is dependent on the demand for both layer replacement chicks and broiler chicks. In fact, the hatching-egg sector involves a complex and almost independent supply-demand structure of its own.

Retail prices of shell eggs and disposable consumer income influence the demand for shell eggs. Furthermore, prices of substitute and complementary products may also affect the demand. However, past studies did not indicate any significant effect of such variables on the demand for shell eggs (7, pp. 70-71, 8, p. 40). While retail prices are determined directly by the interaction of market supply and demand forces, wholesale prices are essentially dependent on existing retail prices and the marketing system. Wholesale prices, in turn, influence farm prices. Thus, the demand for eggs at the wholesale or farm level is essentially derived from the demand at the retail level.

## FORECASTING MODELS FOR AVERAGE QUARTERLY PRICES

### Basic Model

Multiequation forecasting models for quarterly average shell egg prices were formulated on the basis of the supply and demand structure of the egg sector discussed earlier. Although price forecasting was the primary objective, these models also provide an updated analysis of the current supply, demand, and price-determining processes in the egg sector. Specifications of the structural relations in the hypothesized models were influenced by the observed recent changes in the egg industry. The following models, however, did not

include certain structural relations or variables which were believed (or found to be) minor within the system.

The postulated forecasting models contained the following seven equations, including two identities and five stochastic relations:

$$\begin{aligned} (Q-1) \quad Q_t &= f(P_t, I_t, T) \\ (Q-2) \quad Q_t &= Y_t - H_t - B_t \\ (Q-3) \quad B_t &= f(P_t/P_{t-1}, PF_{t-1}, SF_{t-1}, B_{t-1}, T) \\ (Q-4) \quad Y_t &= (\bar{L}_t \times E_t/100) \div 12 \end{aligned}$$

$$(Q-5) \quad \bar{L}_t = f [L_{t-1}, (R_{t-2} + R_{t-3}), (R_{t-6} + R_{t-7})]$$

$$(Q-6) \quad E_t = f (E_{t-1}, T)$$

$$(Q-7) \quad H_t = f (PB_{t-1}, P_{t-1}/P_{t-5}, T)$$

where,

the subscript  $t$  represents the current calendar quarter and  $(t-i)$  relates to a lagged time period, and

$Q$  = aggregate consumption of shell eggs during the quarter derived from the identity, equation (Q-2), million dozen;

$P$  = simple average of Chicago daily cash prices, prices paid delivered, 80-percent grade A large white eggs, during the quarter, cents per dozen;

$I$  = disposable consumer income, seasonally adjusted annual rates for the quarter, billion dollars;

$T$  = time variable, where  $T = 1$  for 1961,  $T = 2$  for 1962, and so forth;

$T'$  = alternative time variable, where  $T = 61$  for 1961,  $T = 62$  for 1962, etc;

$Y$  = total shell egg production during the quarter, million dozen;

$B$  = quantity of eggs broken commercially during the quarter, million dozen;

$H$  = quantity of eggs used for hatching during the quarter, million dozen;

$E$  = number of eggs laid per 100 layers during the quarter,

$\bar{L}$  = average number of layers on hand during the quarter, million;

$L$  = number of layers on hand on the first day of the quarter, million;

$PF$  = average price of frozen whole eggs, light colored, at New York during the quarter, cents per pound;

$SF$  = all frozen eggs in storage on the first day of the quarter, million pounds;

$R$  = number of chicks placed for laying-flock replacements during the quarter, million;

$PB$  = average price of U.S. and plant grade A broilers at Chicago during the quarter, cents per pound.

Consumption of shell eggs, as presented in equation (Q-1), depends on price of shell eggs and disposable income. The effect of prices and supplies of competing and complementary products on the demand for shell eggs was assumed to be insignificant. Consumption of shell eggs,  $Q_t$ , in equation (Q-2) was estimated by subtracting the quantity of eggs used for commercial breaking,  $B_t$ , and hatching,  $H_t$ , from total egg production during the quarter,  $Y_t$ . Net storage movement,

Government purchases, and net export of shell eggs during the period were not allowed for separately in the identity, equation (Q-2), since these items comprise only a minor portion of total shell egg supply.

The amount of eggs broken for commercial use, as presented in equation (Q-3), was hypothesized to be dependent on current shell egg prices. If shell egg prices are relatively low, a larger quantity of eggs may be moved through the breaking plants provided that the demand situation in the alternative market is sufficiently strong. The carryover of frozen eggs in storage from the preceding quarter,  $SF_{t-1}$ , may be expected to inversely affect the quantity of eggs broken during the quarter. Furthermore, the quantity of eggs broken during the quarter may also depend on frozen egg prices during the most recent past,  $PF_{t-1}$ .

Production of shell eggs during a given quarter, as described in the identity, equation (Q-4), is the product of the average number of layers on farms,  $\bar{L}_t$ , and the number of eggs per layer,  $E_t/100$ , during the quarter. Division by 12 is required to convert the number to dozens. Equation (Q-4) necessitated the introduction of equations (Q-5) and (Q-6), which yield estimates of  $\bar{L}_t$  and  $E_t$ . The average number of layers on farms during the quarter is primarily determined by the number of layers on farms at the beginning of the period,  $L_t$ , the number of chicks which enter the laying flock, and the number of older hens withdrawn from the flock during the quarter. Since pullets generally reach the productive age in about 5 or 6 months, the number of chicks placed for layer replacements two quarters ago,  $R_{t-2}$ , was considered an appropriate variable to estimate the number of young hens which enter the laying flock during the current quarter. By similar logic, the number of older hens withdrawn from the flocks may be estimated by the number of chick replacements six quarters ago,  $R_{t-6}$ , since layers are productive for about 18 months. The postulated relation can then be presented as follows:

$$\bar{L}_t = f (L_t, R_{t-2}, R_{t-6})$$

The number of layers at the beginning of the quarter,  $L_t$ , which is expressed as a predetermined variable in the function, is not available from published sources at the beginning of the quarter. Thus, the following function is needed to obtain the estimate of  $L_t$ :

$$L_t = f (L_{t-1}, R_{t-3}, R_{t-7})$$

The logic underlying the relation is similar to that offered earlier. The lagged variables have been appropriately adjusted in the function. A combination of the

preceding two functions results in equation (Q-5) of the model. An alternative method of estimating the removal of hens from the laying flock would be to incorporate the rates of culling and mortality. Reliable data on such variables are not available from published sources.

Since layer productivity has consistently increased during the past several years, the number of eggs per layer,  $E_t$ , in equation (Q-6) was expressed as a function of time. The lagged value of the variable  $E_{t-1}$  was also included to represent the most recent level of layer productivity.

The quantity of eggs used for hatching, one of the factors affecting the amount of shell eggs for consumption, depends primarily on the demand for layer replacement chicks and broiler chicks, which are in turn influenced by the cost-return relationships in the shell egg and broiler industries, respectively. It was initially assumed that the egg-feed price ratio and the broiler-feed price ratio for the preceding quarter would serve as the prime indicators of such return-cost relationships. However, least squares estimates of equations involving lagged values of egg-feed and broiler-feed price ratios produced inconsistent and insignificant coefficients for these variables in relation to hatching activities. This situation necessitated the present formulation of the function, as presented in equation (Q-7), in which lagged egg and broiler prices are the major explanatory variables.

No attempt was made in the study to develop a complete structural specification for the hatching-egg sector, which by itself may involve one or more multiequation models of supply and demand. The hatching-egg use equation, (Q-7), is essentially unrelated to the other structural relations in the model. However, since the reported total production of eggs includes the quantity of eggs used for hatching, it was necessary to subtract the latter from total production to obtain the estimate of shell egg consumption. The equation for quantities of hatching eggs was therefore introduced into the model.

### Econometric Considerations

A separate model was developed for each of the calendar quarters. The quarterly or monthly econometric models in some of the earlier studies were developed by pooling all quarters or months in one model (14, p. 1). Zero-one or dummy variables were introduced in the equations to take into account the seasonal shifts in the intercepts. However, for the present study, it was assumed that separate models for each quarter are more appropriate since such models may more accurately reflect the seasonal or quarterly

differences in the schedules in terms of both the intercept and the slope.

Data for the 9-year period 1961-69 were used to estimate the equations.<sup>3</sup> The sample time period was restricted to the past decade to reflect the recent structure of the egg sector. In view of the differences in the sector between the 1960's and earlier decades, the exclusion of data for earlier years was deemed necessary for an accurate estimate of the existing structural parameters.

The stochastic relations, equations (Q-1) and (Q-3), and the identity, equation (Q-2), comprise a simultaneous equation system including three endogenous variables,  $Q_t$ ,  $P_t$ , and  $B_t$ . The remaining four equations in the model, (Q-4), (Q-5), (Q-6), and (Q-7), were considered independent of the simultaneous equation system. These relations were developed to predict  $Y_t$  and  $H_t$ , which were postulated as predetermined variables relative to the simultaneous equation system. It may be observed that these latter four equations were introduced into the model to develop it as a closed system for unconditional predictions for the immediately following quarter. The ordinary least squares procedure was valid for the estimation of equations (Q-5), (Q-6), and (Q-7) since these are independent equations in the model and each involves only a single dependent variable.

The stochastic relations, equations (Q-1) and (Q-3), in the simultaneous equation system are overidentified. These equations were estimated by using both two-stage and three-stage least squares procedures. The two-stage least squares procedure yields consistent estimates of structural parameters (9, pp. 380-384). The three-stage least squares procedure (27) involves the simultaneous estimation of coefficients of all stochastic equations by using Aitken's generalized least squares method with the error variance-covariance matrix from the two-stage least squares estimates (4, pp. 446-453, 9, pp. 395-400). Three-stage least squares estimators are consistent and relatively more efficient than the corresponding two-stage least squares estimators when the errors in structural equations are contemporaneously correlated (9, p. 398).

A computer program, prepared by Thorner and Zellner (16) and modified by USDA, was used to obtain the two-stage and three-stage least squares estimates of the relevant equations.

An examination of the consumption-price equation, (Q-1), and the equation for quantities of breaking eggs, (Q-3), would reveal that an endogenous variable,  $P_t$ , appears in two different forms in the simultaneous

<sup>3</sup>Sources of data are listed in appendix I.

equation model. The variable is included in equation (Q-3) in a nonlinear combination as  $P_t/P_{t-1}$ . The presence of an endogenous variable in a nonlinear combination complicates the estimating process. A linear approximation of the nonlinear variable, however, can be used to replace the original nonlinear variable. Linear approximations of nonlinear combinations of variables can be accomplished as follows (J0, pp. 120-121):

$$XY \approx \bar{Y}X + \bar{X}Y - \bar{X}\bar{Y}$$

$$X/Y \approx \bar{X}/\bar{Y} + X/\bar{Y} - (\bar{X}/\bar{Y}^2) Y$$

where  $\bar{X}$  and  $\bar{Y}$  are the sample means of the two variables  $X$  and  $Y$ . It may be noted that when both  $X$  and  $Y$  are predetermined or exogenous variables in the model, linearization of the product or the ratio is not required and the combination term can be used as a single composite variable.

The linear approximation of the ratio term  $P_t/P_{t-1}$  in the present model can be presented as follows:

$$P_t/P_{t-1} \approx \bar{P}_t/\bar{P}_{t-1} + P_t/\bar{P}_{t-1} - (\bar{P}_t/\bar{P}_{t-1}^2) P_{t-1}$$

$P_t$  and  $P_{t-1}$  now appear in two separate additive terms. Consequently,  $P_{t-1}$  can be treated as an additional and separate predetermined or exogenous variable in the system. Thus, the first-round price equation, in which the endogenous variable  $P_t$  was expressed as a function of the exogenous variables in the system, also included  $P_{t-1}$  as an additional exogenous variable.<sup>4</sup> Ordinary least squares estimates were obtained for the first-round price equation for each of the quarters. The estimated or calculated values of the endogenous variable  $\hat{P}_t$  obtained from the first-round equation were then used to develop the two-stage and three-stage least squares estimates of the two stochastic relations, equations (Q-1) and (Q-3), of the simultaneous equation system. The linearized form of  $P_t/P_{t-1}$  was used in equation (Q-3) to derive the reduced-form price equations which are presented in a later section.

The results in the following sections indicate that some variables were excluded from the estimated equations in the final form. The equations were estimated on the basis of a limited number of observations and, therefore, only the major variables appeared in the equations as statistically significant. While working with small samples, the criterion of including a variable should not be restricted only to statistical tests of significance. The judgment regarding the inclusion of variables in this study was based primarily on the logical

consistency of the signs of the variables. The variables which yielded signs reflecting relations which were not consistent with economic logic and prior knowledge were excluded from the equations. On the other hand, variables with statistically insignificant coefficients but consistent signs were retained in the estimated relations. Otherwise, many variables, which might have been statistically significant in equations based on larger samples, would be excluded from those based on small samples.

In this analysis, the first-stage equation involved  $P_t$  as the dependent variable and included some selected exogenous variables (for example  $Y_t$ ,  $PF_{t-1}$ ,  $P_{t-1}$ ,  $I_t$ , and  $T$ ) rather than all exogenous variables in the system. By this means, three degrees of freedom were generally made available in the first-stage equations. Specific exogenous variables were added or deleted based on the sign of the related coefficient and the relative contribution of the variable to regression sum of squares in the first-round equation.

## Two-Stage and Three-Stage Least Squares Estimates of Equations (Q-1) and (Q-3)

The two-stage and three-stage least squares estimates of the two stochastic relations, equations (Q-1) and (Q-3), of the simultaneous equation system are presented in tables 1 and 2. The consumption-price equation, (Q-1), in table 1 indicates that the signs of the coefficients of both two-stage and three-stage least squares estimates are consistent with the expected causal relations. It is interesting to note that the three-stage least squares coefficient of  $P_t$  in equation (Q-1) for each quarter is slightly larger in absolute value than the corresponding two-stage least squares coefficient. The hypothesized relations in the breaking-egg use equation, (Q-3), have been substantiated by the results presented in table 2. Most of the coefficients were also significantly different from zero at the 5- or 10-percent level. Inconsistency of signs and statistical insignificance led to the exclusion of one or two variables from the equations for the first and third quarters. The postulated inverse relation between the shell egg price ratio,  $P_t/P_{t-1}$ , and eggs used for breaking,  $B_t$ , has been confirmed by the results. Furthermore, the related parameters for each quarter, except the third, are highly significant. A significant aspect of the results of the equations for  $Q_t$  and  $B_t$ , equations (Q-1) and (Q-3), is the confirmation of the postulated relation between the shell egg and breaking-egg sectors. The simultaneity in the determination of shell egg consumption,  $Q_t$ , eggs used for breaking,  $B_t$ , and shell egg price,  $P_t$ , as evidenced in the present study, ought to be recognized in any realistic

<sup>4</sup>The effect of this linearization on the properties of the estimators is unknown.

Table 1—Least squares estimates of equations for quarterly consumption of shell eggs, ( $Q_t$ ), equation (Q-1)

Quarter	Constant term	Regression coefficients		
		P <sub>t</sub>	I <sub>t</sub>	Log T
Two-stage least squares estimates				
I	4190	-3.459 (1.217)	.8176 (.4605)	-1805 (2276)
II	-1773	-3.470 (.9659)	.2185 (.2226)	1612 (1121)
III	-1572	-1.917 (.6883)	.2272 (.2441)	1477 (1245)
IV	-1632	-2.223 (.7336)	.1182 (.3543)	1579 (1798)
Three-stage least squares estimates				
I	41.33	-3.575 (1.201)	.8111 (.2918)	-1770 (1445)
II	-2247	-3.998 (.9235)	.1642 (.2131)	1897 (1073)
III	-108.4	-2.432 (.6585)	.3949 (.2351)	636 (1201)
IV	635.6	-2.319 (.7323)	.2314 (.3511)	1001 (1781)

<sup>1</sup> Numbers in parentheses are the standard errors of regression coefficients.

Table 2—Least squares estimates of equations for eggs used for breaking during the quarter, ( $B_t$ ), equation (Q-3)

Quarter	Constant term	Regression coefficients				
		$P_t/P_{t-1}$	$PF_{t-1}$	$SF_{t-1}$	$B_{t-1}$	T
		<i>Two-stage least squares estimates</i>				
I	252.1	-187.4 (24.8)	-1.016 (.684)	- (.1422)	.8446 (.1422)	-2.441 (1.314)
II	482.1	-246.8 (37.8)	-2.986 (1.136)	-.0256 (.1692)	.3240 (.1211)	-6.857 (.763)
III	36.8	-37.36 (52.79)	- (.2297)	- (.2297)	.4944 (.2297)	7.308 (1.703)
IV	147.3	-78.18 (20.35)	- (.1237)	-.4462 (.1237)	.3035 (.1702)	4.532 (1.402)
		<i>Three-stage least squares estimates</i>				
I	232.9	-167.4 (18.9)	-.9902 (.5175)	- (.1072)	.8985 (.1072)	-3.133 (1.042)
II	439.1	-205.0 (31.2)	-2.679 (.961)	-.0269 (.1591)	.3101 (.1079)	-6.797 (.742)
III	54.5	-55.05 (51.41)	- (.2194)	- (.2194)	.5139 (.2194)	7.530 (1.664)
IV	151.6	-80.44 (20.20)	- (.1225)	-.4904 (.1225)	.3339 (.1689)	4.229 (1.391)

<sup>1</sup> Numbers in parentheses are the standard errors of regression coefficients.

study of the supply and demand structure of the egg industry.

Comparable estimates of equations (Q-1) and (Q-3) were also obtained, with all variables relating to quantity and income expressed in per capita terms. These alternative equations in some cases yielded coefficients with signs contrary to economic logic. Furthermore, calculated prices developed from the alternate equations for each quarter were considerably less accurate than those derived from the equations presented here.

### Reduced-Form Price Equations

The estimated stochastic relations, equations (Q-1) and (Q-3), and the identity, equation (Q-2), were solved algebraically to obtain the reduced-form equations for price. Two different reduced-form price equations were obtained for each quarter, since the stochastic relations were estimated by both two-stage and three-stage least squares methods.

The reduced-form price equations based on two-stage least squares estimates of equations (Q-1) and (Q-3) and the identity (Q-2) were as follows:

First quarter:

$$P_t = 517.64 - .1211 Y_t + .1211 H_t + .0990 I_t - 218.6 \log T' - .1230 PF_{t-1} - .2956 T + .5220 P_{t-1} + .1022 B_{t-1}$$

Second quarter:

$$P_t = -142.72 - .0950 Y_t + .0950 H_t + .0208 I_t + 153.1 \log T' - .2836 PF_{t-1} - .0024 SF_{t-1} - .6513 T + .5767 P_{t-1} + .0308 B_{t-1}$$

Third quarter:

$$P_t = -501.22 - .3167 Y_t + .3167 H_t + .0719 I_t + 467.8 \log T' + 2.315 T + .4981 P_{t-1} + .1565 B_{t-1}$$

Fourth quarter:

$$P_t = -366.61 - .2341 Y_t + .2341 H_t + .0276 I_t + 369.7 \log T' - .1044 SF_{t-1} + 1.061 T + .4978 P_{t-1} + .0710 B_{t-1}$$

Similarly, the reduced-form price equations derived algebraically from the identity (Q-2) and the three-stage least squares estimates of the two stochastic functions, equations (Q-1) and (Q-3), were as follows:

First quarter:

$$P_t = 536.30 - .1272 Y_t + .1272 H_t + .1232 I_t - 225.2 \log T' - .1260 PF_{t-1} - .3986 T + .4898 P_{t-1} + .1143 B_{t-1}$$

Second quarter:

$$P_t = -201.20 - .1014 Y_t + .1014 H_t + .0167 I_t + 192.4 \log T' - .2717 PF_{t-1} - .0021 SF_{t-1} - .6893 T + .5093 P_{t-1} + .0314 B_{t-1}$$

Third quarter:

$$P_t = -30.33 - .2348 Y_t + .2348 H_t + .0927 I_t + 149.3 \log T' + 1.768 T + .5407 P_{t-1} + .1206 B_{t-1}$$

Fourth quarter:

$$P_t = -128.21 - .2259 Y_t + .2259 H_t + .0523 I_t + 226.1 \log T' - .1108 SF_{t-1} + .9554 T + .4943 P_{t-1} + .0754 B_{t-1}$$

### Ordinary Least Squares Estimates of Equations (Q-5), (Q-6), and (Q-7)

As mentioned earlier, two variables,  $Y_t$  and  $H_t$ , were treated as predetermined variables in the simultaneous equation system. However, the values of these two variables must be known to obtain the estimates or forecasts of price ( $\hat{P}_t$ ) from the reduced-form price equations which were derived from the three equations in the simultaneous equation system. The equation for average number of layers on farms ( $\bar{L}_t$ ), equation (Q-5), and the layer productivity ( $E_t$ ) equation, equation (Q-6), were developed to estimate current total production ( $Y_t$ ). Finally, equation (Q-7) was formulated to predict the quantities of hatching eggs for the current period ( $H_t$ ). The introduction of the last three equations, therefore, made the model a closed one for predictive purposes. Since these three equations, (Q-5), (Q-6), and (Q-7), were independent of the simultaneous equation system as well as of each other, ordinary least square estimates of the equations were statistically valid. Statistical estimates of these three equations for each quarter are presented in tables 3, 4, and 5.

The ordinary least squares estimate of the logarithmic equations for the average number of layers on farm ( $\bar{L}_t$ ), equation (Q-5), as presented in table 3, yielded superior results in terms of statistical tests as well as predictive accuracy over similar equations formulated in linear terms. It may be observed that the two lagged replacement variables,  $(R_{t-2} + R_{t-3})$  and  $(R_{t-6} + R_{t-7})$ , representing the addition of new layers and removal of older hens, respectively, have generated expected signs.

Table 3—Ordinary least squares estimates of equations for quarterly average number of layers, ( $\bar{L}_t$ ), equation (Q-5)<sup>1</sup>

Quarter	Constant term	Regression coefficient			R <sup>2</sup>	SEE <sup>2</sup>
		$L_{t-1}$	$(R_{t-2} + R_{t-3})$	$(R_{t-6} + R_{t-7})$		
I	.1164	1.092 <sup>3</sup> (.155)	.0299 (.0789)	-.1832 (.0917)	.934	.00376
II	.6092	.6806 (.1265)	.0983 (.0289)	-.0146 (.0215)	.970	.00299
III	.2829	1.062 (.374)	.0902 (.0783)	-.0346 (.0810)	.962	.00339
IV	-.2357	.9341 (.0798)	.2347 (.0309)	-.0473 (.0263)	.974	.00208

<sup>1</sup> Expressed in logarithms of actual values.

<sup>2</sup> Standard error of estimate.

<sup>3</sup> Numbers in parentheses are the standard errors of regression coefficients.

Table 4—Ordinary least squares estimates of equations for quarterly number of eggs per 100 layers, ( $E_t$ ), equation (Q-6)

Quarter	Constant term	Regression coefficients		R <sup>2</sup>	SEE <sup>2</sup>
		$E_{t-1}$ <sup>1</sup>	T		
I	.8464	.7793 <sup>3</sup> (.2939)	-.00197 (.00186)	.741	.00608
II	1.729	.5459 (.1864)	-.00128 (.00070)	.589	.00409
III	-.0286	.9956 (.0225)	.00342 (.00005)	.999	.00035
IV	-.6197	1.162 (.166)	.00056 (.00067)	.976	.00259

<sup>1</sup> Expressed in logarithms of actual values.

<sup>2</sup> Standard error of estimate.

<sup>3</sup> Numbers in parentheses are the standard errors of regression coefficients.

Table 5—Ordinary least squares estimates of equations for quarterly number of eggs used for hatching, ( $H_t$ ), equation (Q-7)

Quarter	Constant term	Regression coefficients			R <sup>2</sup>	SEE <sup>1</sup>
		$PB_{t-1}$	$P_{t-1}/P_{t-5}$	T		
I	76.83	—	10.097 <sup>2</sup> (4.168)	1.208 (.443)	.669	3.418
II	39.20	1.359 (.706)	2.976 (3.498)	2.716 (.266)	.960	1.969
III	17.73	1.522 (.689)	—	3.326 (.454)	.971	2.282
IV	29.57	1.032 (.682)	3.088 (5.497)	3.411 (.575)	.967	2.717

<sup>1</sup> Standard error of estimate.

<sup>2</sup> Numbers in parentheses are the standard errors of regression coefficients.

The ordinary least squares equation for layer productivity ( $E_t$ ), equation (Q-6) in table 4, yielded better results, especially in terms of prediction, for the last two quarters than for the first two. Layer productivity of the preceding quarter,  $E_{t-1}$ , appeared to be the main predictor in all cases.

As mentioned earlier, the quantity of eggs used for hatching was initially hypothesized to be dependent on the egg-feed price ratio and the broiler-feed price ratio representing the return-cost relations in the egg and broiler sectors. The preliminary analysis indicated inconsistent signs and insignificant coefficients for the two ratios. However, lagged prices of shell eggs and broilers,  $P_{t-1}/P_{t-5}$  and  $P_{B,t-1}$ , respectively, in the final formulation as presented in table 5 yielded relations which are consistent with the basic initial specifications. The hatching-egg use equation, (Q-7), in the present model is probably an oversimplified formulation of the complex relationships underlying the decisionmaking process in the hatching-egg sector. Yet, the three explanatory variables seemed to have performed adequately in explaining the variations in the dependent variable, especially for the last three quarters of the calendar year.

The net storage movement of shell eggs during the period was included in the simultaneous equation system in an initial formulation. An equation for end-of-quarter storage stocks of shell eggs, an endogenous variable, was formulated with current price ( $P_t$ ) and relative level of production ( $Y_t/Y_{t-1}$ ) to form the basic explanatory factors. But, inconsistent signs, statistical insignificance of the coefficients, and large prediction errors led to the omission of the equation from the model.

### Modified First-Round Price Equations

Since the endogenous variable,  $P_t$ , in the first-round equations was expressed as a function of the exogenous variables in the system, the first-round equations could conceivably be used as alternative prediction equations. The first-round equations were, however, modified in this study to include only those predetermined variables which appeared to be the main predictors.

The modified first-round price-prediction equations for the four quarters were formulated as follows:

$$(Q-8) \quad P_t = f(Y_t, I_t, PF_{t-1})$$

where the variables are the same as those defined earlier. The equations were estimated in two alternative forms—linear in actual units and linear in logarithms. Although both production ( $Y_t$ ) and income ( $I_t$ ) relate to the current period, these two variables are in fact predetermined. As discussed earlier, while income forecasts are

available from other sources, production for the current period can be predicted from equations (Q-4), (Q-5), and (Q-6) of the models presented in the preceding sections. Lagged frozen egg prices ( $PF_{t-1}$ ) are available from existing sources mentioned earlier.

The ordinary least squares estimates of the price equations, obtained separately for each quarter, are presented in tables 6 and 7. All variables ( $Y_t$ ,  $I_t$ , and  $PF_{t-1}$ ) entered each equation with expected signs. Most of the regression coefficients were statistically significant at the 5- or 10-percent levels. An additional variable, the number of chicks placed for layer replacements two quarters ago ( $R_{t-2}$ ), was included in the price equations for only the first quarter. The variable significantly improved the fit of the equations for the quarter. It appears that the number of layer replacements does have an impact on egg prices during the first quarter, but the reason for the inverse relationship is not fully understood. The results indicate relatively high  $R^2$  values, ranging from .88 to .96, for the quarterly equations when variables were expressed in actual units (table 6). An examination of the standard errors of estimate reveals that the second-quarter equation had the smallest overall magnitude of errors. The error magnitude was

Table 6—Ordinary least squares estimates of equations for average quarterly shell egg prices, ( $P_t$ ), using equation (Q-8)

Quarter	Constant term	Regression coefficients				$R^2$	SEE <sup>1</sup>
		$I_t$	$PF_{t-1}$	$Y_t$	$R_{t-2}$		
I	122.0301	0.1318 (.0365)	0.6797 (.2793)	-0.1009 (.0301)	-0.5675 (.3208)	0.877	2.413
II	182.1678	.0676 (.0073)	.3004 (.0962)	.1347 (.0161)		.958	.752
III	137.6122	.1194 (.0193)	.8450 (.2542)	.1345 (.0268)		.928	1.568
IV	135.5708	.1405 (.0234)	1.443 (.3582)	-.1503 (.0341)		.910	2.631

<sup>1</sup>Standard error of estimate.

<sup>2</sup>Numbers in parentheses are the standard errors of regression coefficients.

Table 7—Ordinary least squares estimates of equations for average quarterly shell egg prices, ( $P_t$ ), equation (Q-8)<sup>1</sup>

Quarter	Constant term	Regression coefficients				$R^2$	SEE <sup>2</sup>
		$I_t$	$PF_{t-1}$	$Y_t$	$R_{t-2}$		
I	7.6215	1.774 (.6892)	0.5603 (.3054)	3.025 (1.440)	-0.9186 (.5629)	0.743	0.042
II	11.9694	.7511 (.2615)	.3386 (.2129)	-4.116 (1.599)		.698	.029
III	12.0411	1.591 (.4046)	.6205 (.2682)	4.993 (1.507)		.837	.027
IV	10.6364	1.613 (.3966)	1.054 (.3344)	4.750 (1.543)		.828	.038

<sup>1</sup>Expressed in logarithms of actual values.

<sup>2</sup>Standard error of estimate.

<sup>3</sup>Numbers in parentheses are the standard errors of regression coefficients.

largest for the first- and the fourth-quarter equations. The logarithmic equations indicate  $R^2$  values which range from .70 to .84 (table 7). The  $R^2$  values in table 7 should not be compared with those in table 6 since the dependent variable was expressed in different units.

### Predictive Accuracy of Alternative Models

The major criterion of predictive accuracy involves a measurement of the extent to which the predictions deviate from the actual or observed levels of the variable under consideration. The inequality coefficient (U), as proposed by Fheil (15, p. 28), can be used for this purpose. The coefficient is defined as follows:

$$U = \frac{\sqrt{\sum (P_{it} - A_{it})^2}}{\sqrt{\sum A_{it}^2}}$$

where  $A_{it}$  represents the actual or observed change of the  $i^{\text{th}}$  variable during the  $t^{\text{th}}$  period relative to the actual level in the preceding period, and  $P_{it}$  is the corresponding predicted or calculated change. An alternative presentation of the U-coefficient is as follows:

$$U = \frac{\sqrt{\sum [(P'_{it} - A'_{it-1}) - (A'_{it} - A'_{it-1})]^2}}{\sqrt{\sum (A'_{it} - A'_{it-1})^2}} \\ = \frac{\sqrt{\sum (P'_{it} - A'_{it})^2}}{\sqrt{\sum (A'_{it} - A'_{it-1})^2}}$$

where  $A'_{it}$  and  $P'_{it}$  represent the actual and predicted levels of the variable. Errorless forecasts for all observations would yield a value of zero for the coefficient. On the other hand, U equals 1.0 when no change is predicted ( $P_{it} = A_{it-1}$ ) for all observations.

Four alternative price-forecasting models were specified for each of the quarters. The models were different from each other basically in terms of the price equation used in each model. While each model comprised the same two ordinary least squares equations for  $L_t$  and  $E_t$ —equations (Q-5) and (Q-6) and the identity for  $Y_t$ , equation (Q-4) the first two models also contained the equation for hatching-egg use ( $H_t$ ), equation (Q-7). The last equation was not required in the other two models since  $H_t$  was excluded from the relevant price equations. The four alternative models may be identified more specifically as follows:

**Model (Q-I):** reduced-form price equation obtained on the basis of the two-stage least squares estimates of equation (Q-1) and (Q-3) and the identity (Q-2); ordinary

least squares estimates of equations (Q-5), (Q-6), and (Q-7) and the identity (Q-4).

**Model (Q-II):** reduced-form price equation obtained on the basis of the three-stage least squares estimates of equations (Q-1) and (Q-3) and the identity (Q-2); ordinary least squares estimates of equations (Q-5), (Q-6), and (Q-7) and the identity (Q-4).

**Model (Q-III):** ordinary least squares price equation (Q-8), linear in actual units (table 6); ordinary least squares estimates of equations (Q-5) and (Q-6) and the identity (Q-4).

**Model (Q-IV):** ordinary least squares price equation (Q-8), linear in logarithm (table 7); ordinary least squares estimates of equations (Q-5) and (Q-6) and the identity (Q-4).

Price forecasts were developed for each quarter for the sample period. The U-coefficients, as presented in table 8, were computed separately for each quarter and model for quarter-to-quarter changes in price. Predicted and actual values of quarterly prices and other variables are included in appendix II.

Table 8—U-coefficients for quarterly shell egg prices, ( $P_t$ )<sup>1</sup>

Quarter	Models			
	(Q-I)	(Q-II)	(Q-III)	(Q-IV)
I	.53	.55	.48	.54
II	.27	.25	.27	.21
III	.66	.51	.31	.37
IV	.97	.90	.72	.67

<sup>1</sup> Predictions based on predicted values of  $Y_t$  and  $H_t$ .

Prices of shell eggs fluctuated widely during the sample period. For instance, the observed quarterly average price declined to a low of 26.2 cents in the second quarter of 1967 and increased to 54.7 cents a dozen in the fourth quarter of 1969. Considering such wide variations in prices, all four models seemed to have performed with reasonable accuracy of forecasts. Predictions for the second quarter were generally most accurate. On the other hand, as indicated by the U-coefficients, forecasts for the fourth quarter involved the largest overall magnitude of errors.

The U-coefficients for models (Q-III) and (Q-IV) were

smaller than those for models (Q-I) and (Q-II) for the third- and fourth-quarter predictions. This difference indicates that the predictions for these quarters, based on the ordinary least squares price equations, were relatively more accurate than those based on the reduced-form equations. However, conclusions with regard to predictive superiority of alternative models should not be entirely based on tests over the sample period. The ordinary least squares price equations may tend to yield poor forecasts when extended beyond the sample period. Such equations do not incorporate the price-generating mechanism in the same way as do the structural equations derived through two-stage or three-stage least squares procedures. Comparisons of predictive performance should, therefore, be based on predictions over a longer period outside the sample period. However, a comparison between models of similar nature can still be made. The second model, (Q-II), based on three-stage least squares equations, seemed to have a slight edge over model (Q-I), which was based on two-stage least squares equations. The third model, (Q-III), performed slightly better than model (Q-IV) in the first and third quarters. On the other hand, the latter yielded smaller U-coefficients for the other two quarters.

Another set of price estimates were developed using actual, rather than predicted, values of shell egg production ( $Y_t$ ) and the quantity of eggs used for hatching ( $H_t$ ). In other words, equations (Q-4), (Q-5), (Q-6), and (Q-7) were not used in estimating  $Y_t$  and  $H_t$ . The purpose was to examine the performance of the price equations when errors in predicting the predetermined variables were eliminated. A set of U-coefficients were developed from these price estimates based on actual values of  $Y_t$  and  $H_t$ . It may be recalled that  $H_t$  was not included in the ordinary least squares price equation (Q-8), and, hence, only the actual values of  $Y_t$  were needed to estimate prices from models (Q-III) and (Q-IV). The U-coefficients for each model are presented in table 9.

The U-coefficients in table 9 are considerably smaller in all cases relative to those for the price forecasts based on predicted values of  $Y_t$  and  $H_t$  (table 8). It clearly implies that errors in predicting total shell egg production ( $Y_t$ ) and the quantity of eggs used for hatching ( $H_t$ ) have to some extent magnified the errors in price forecasts from the models. The U-coefficients for the second quarter are the smallest among all coefficients for each model. On the other hand, price estimates from each model for the fourth quarter involved the largest overall magnitude of errors. The reduced-form price equation based on three-stage least squares equations, model (Q-II), yielded more accurate price estimates than those obtained from the corresponding price equation

based on two-stage least squares equations, model (Q-I). The U-coefficients for model (Q-III) are generally smaller than those for model (Q-IV).

Price predictions were also developed for eight quarters beyond the period of fit. These forecasts, based on predicted values of  $Y_t$  and  $H_t$ , are presented in table 10. Two different U-coefficients for each model are included in the table. The first coefficient was obtained for all eight observations considered together for each of the four models. The last two quarters were excluded from the computation of the second U-coefficient for each model. Price forecasts for the last two quarters of 1971 involved unusually large errors. Consequently, in the second set, the inequality coefficients were consid-

Table 9 U-coefficients for quarterly shell egg prices, ( $P_t$ )<sup>1</sup>

Quarter	Models <sup>2</sup>			
	(Q-I)	(Q-II)	(Q-III)	(Q-IV)
I	.35	.36	.29	.33
II	.09	.05	.09	.20
III	.34	.28	.14	.17
IV	.59	.50	.44	.44

<sup>1</sup> Estimates based on actual values of  $Y_t$  and  $H_t$ .

<sup>2</sup> These models excluded the last four equations in the system since actual values of  $Y_t$  and  $H_t$  were used.

Table 10 Actual and predicted quarterly shell egg prices outside the period of fit, 1970-71, and related U-coefficients.<sup>1</sup>

Quarter	Actual prices	Predicted prices using models			
		Q I	Q II	Q III	Q IV
Cents/dozen					
1970:					
I	52.2	49.0	48.6	51.9	51.4
II	34.4	40.9	39.9	39.1	37.0
III	41.3	47.4	46.8	45.8	43.1
IV	38.4	40.5	42.1	44.6	40.5
1971:					
I	35.6	41.7	41.9	45.1	41.8
II	32.2	33.4	32.8	35.3	31.7
III	34.2	48.2	47.6	47.3	42.7
IV	35.0	43.4	44.6	50.6	42.3

Inequality

coefficient (U):

Based on 8 quarters	.99	.99	1.22	.67
Based on first 6 quarters	.58	.56	.67	.37

<sup>1</sup> Predictions based on predicted values of  $Y_t$  and  $H_t$ .

erably smaller than the corresponding values in the first set. As indicated by the U-coefficients, the performances of models (Q-I) and (Q-II) were similar in forecasting prices outside the period of fit. Price forecasts based on model (Q-IV) yielded the smallest U-coefficient.

Predictions for the first six quarters (from the first quarter of 1970 through the second quarter of 1971) were reasonable, especially those from model (Q-IV). As mentioned earlier, the price forecasts from all models involved large errors for the last two quarters in 1971. It may be suggested that an important change which has become apparent since the last half of 1971 is the impact of the Marek's disease vaccine on the production

process and, subsequently, on the price-determining process. Reportedly, the vaccine has increased the rate of lay and reduced the mortality rate of both layers and replacements. These changes may have caused temporary disruptions in the price-determining process. Price forecasts, however, may be expected to be more accurate when the effect of the vaccine is fully realized and the process of adjustment stabilizes in the sector.

Another feature is also worth noting in relation to errors in price forecasts. The predicted prices obtained from all four models were consistently higher than the actual prices for all seven quarters beginning with the second quarter of 1970.

## FORECASTING MODELS FOR AVERAGE MONTHLY PRICES

### Basic Model

Prediction models for monthly average shell egg prices were structurally similar to the preceding quarterly models. The monthly structural models comprised the following six equations, one of which is an identity:

$$\begin{aligned} (M-1) \quad Q_t &= f(P_t, I_t) \\ (M-2) \quad Q_t &= Y_t - H_t - B_t \\ (M-3) \quad B_t &= f(P_t, B_{t-1}, T) \\ (M-4) \quad Y_t &= f(L_{t-1}, E'_{t-1}, R_{t-6}/R_{t-18}) \\ (M-5) \quad E'_{t-1} &= f(E'_{t-2}, T) \\ (M-6) \quad H_t &= f(P_{t-1}, PB_{t-1}, T) \end{aligned}$$

where the subscript  $t$  represents the current calendar month and  $(t-i)$  relates to a lagged time period, and

$Q$  = aggregate consumption of shell eggs during the month derived from the identity, equation (M-2), million dozen;

$P$  = simple average of Chicago daily cash prices, prices paid delivered, 80-percent grade A large white eggs, during the month, cents per dozen;

$I$  = disposable consumer income, seasonally adjusted annual rates for the quarter, billion dollars;

$Y$  = total shell egg production during the month, million dozen;

$H$  = quantity of eggs used for hatching during the month, million dozen;

$B$  = quantity of eggs broken commercially during the month, million dozen;

$T$  = time variable, where  $T = 1$  for 1961,  $T = 2$  for 1962, etc.;

$L$  = number of layers on hand on the first day of the month, million;

$E'$  = number of eggs laid per layer during the month;

$R$  = number of chicks placed for laying flock replacements during the month, million;

$PB$  = average price of U.S. and plant grade A broilers at Chicago during the month, cents per pound.

Monthly data were obtained from sources identified in appendix I.

The first three equations in the monthly model, similar to those in the quarterly model, comprise a simultaneous equation system. Three endogenous variables,  $Q_t$ ,  $P_t$ , and  $B_t$ , are simultaneously determined within the system. Two predetermined variables,  $Y_t$  and  $H_t$ , in the system necessitated the formulation of the other three equations of the model. These equations were developed to predict the values of  $Y_t$  and  $H_t$  and, hence, to close the model for predictive purposes. The logic underlying equations (M-1), (M-2), and (M-3) was essentially the same as that for the simultaneous equation system of the quarterly model. Certain variables which appeared in the corresponding quarterly equations were excluded from the stochastic relations, equations (M-1) and (M-3). In initial trial estimates, these omitted variables were found to have effects which were logically inconsistent and statistically insignificant.

The production equation, (M-4), in effect was considered as a substitute for two relations, equations (Q-4) and (Q-5), which appeared as separate equations in the quarterly model. The rate of lay during the preceding period,  $E'_{t-1}$ , represents the most recent trend in the variable. The ratio of the numbers of chicks placed for layer replacements 6 and 18 months ago,  $R_{t-6}/R_{t-18}$ , is a combination of two variables.

Replacement chicks placed 6 months earlier would enter the laying flock during the current month, while those placed 18 months ago would be culled or withdrawn during the current month. Hence, the variations in the ratio,  $R_{t-6}/R_{t-18}$ , would affect the current laying flock size and, subsequently, the production of shell eggs in the positive direction.

Although the rate of lay for the past month,  $E'_{t-1}$ , is a predetermined variable in equation (M-4), the value of the variable is not available from published sources at the first of the month. Therefore, equation (M-5), which in essence is the same as equation (Q-6) of the quarterly model, was introduced for  $E_{t-1}$ . Similarly, the equation for hatching eggs ( $H_t$ ) is equation (M-6), which exactly corresponds to equation (Q-7) of the quarterly model.

Each stochastic relation in the model was estimated separately for each calendar month. The statistical estimates were based on data for 1961-69.

### Two-Stage and Three-Stage Least Squares Estimates of Equations (M-1) and (M-3)

Two-stage and three-stage least squares estimates were obtained for equations (M-1) and (M-3), which belonged to the simultaneous equation system. The last three equations were, however, independent relations within the model.

The results of equations (M-1) and (M-3) are presented in tables 11 and 12, respectively. Both two-stage and three stage least squares estimates of the consumption-price equation, (M-1), yielded coefficients with expected signs. Furthermore, coefficients of price and income were significant at the 5- or 10-percent level for most months. The two-stage least squares coefficients were very similar in magnitude to the corresponding three-stage least squares coefficients.

The estimates of equations (M-2) in table 12 produced the expected inverse relation between the price of shell eggs ( $P_t$ ) and the quantity of eggs broken commercially ( $B_t$ ) for all months except October and December. The two-stage least squares equation for an additional month (May) indicated an inconsistent sign for  $B_t$ . The coefficient of the time variable ( $T$ ) was negative in the equations for December, January, February, March, April, May, and June and positive in the equations for the remaining months. It may be observed that  $P_t$  was included in the monthly equations as a linear variable. Hence, the problem of linearization which appeared in the estimation of the quarterly model did not exist for the monthly equations.

Table 11—Least squares estimates of equations for monthly consumption of shell eggs, ( $Q_t$ ), equation (M-1)

Month	Constant term	Regression coefficients	
		$i_t$	$P_t$
Two-stage least squares estimates			
January	368.6	.1620 (.0179)	-1.033 (.3151)
February	347.1	.1365 (.0275)	-1.328 (.4892)
March	351.7	.1529 (.0179)	-.4072 (.3465)
April	348.4	.1509 (.0156)	.9271 (.3556)
May	345.7	.1856 (.0146)	-1.409 (.5584)
June	307.3	.1980 (.0164)	-1.205 (.5224)
July	308.9	.1934 (.0194)	-.6075 (.3466)
August	332.1	.1722 (.0144)	-.8526 (.3752)
September	321.1	.1644 (.0147)	-.5702 (.2408)
October	374.8	.1295 (.0181)	-1.081 (.3709)
November	347.0	.1285 (.0198)	.4598 (.2405)
December	372.4	.1571 (.0168)	-.9714 (.1915)
Three-stage least squares estimates			
January	367.8	.1643 (.0179)	-1.042 (.3150)
February	347.2	.1363 (.0275)	-1.328 (.4892)
March	351.7	.1527 (.0179)	-.4065 (.3465)
April	348.6	.1502 (.0154)	.9228 (.3552)
May	344.8	.1865 (.0146)	-1.409 (.5584)
June	307.5	.1974 (.0163)	-1.202 (.5223)
July	308.8	.1944 (.0193)	-.6194 (.3459)
August	331.5	.1751 (.0143)	-.8746 (.3750)
September	321.2	.1640 (.0147)	-.5677 (.2408)
October	374.6	.1300 (.0181)	-1.033 (.3709)
November	347.4	.1283 (.0198)	.4582 (.2405)
December	372.4	.1570 (.0168)	-.9712 (.1915)

<sup>1</sup>Numbers in parentheses are the standard errors of regression coefficients.

Table 12—Least squares estimates of equations for eggs used for breaking during the month, ( $B_t$ ), equation (M-3)

Month	Constant term	Regression coefficients		
		T	B <sub>t-1</sub>	P <sub>t</sub>
Two-stage least squares estimates				
January	20.77	.1168 (.8365)	.7788 (.2901)	.3136 (.3233)
February	30.36	.5546 (.5640)	.7167 (.2172)	.4414 (.2910)
March	34.41	-1.605 (.1685)	.8001 (.0775)	.2209 (.1236)
April	88.01	-1.117 (.5640)		.8883 (.3805)
May	22.70	-1.254 (.3965)	.8450 (.1656)	.1517 (.4086)
June	53.30	.4968 (.6708)	.4064 (.2174)	-.3737 (.4183)
July	22.51	2.407 (.2575)	.5957 (.1086)	-.6922 (.1197)
August	72.15	2.162 (.2773)		-1.198 (.2070)
September	22.80	1.594 (.3785)	.3908 (.1344)	-.3805 (.1321)
October	-14.44	.5276 (.6469)	1.009 (.2785)	.2943 (.2357)
November	12.61	.4869 (.7927)	.6630 (.2446)	.1937 (.1434)
December	-13.54	-1.127 (1.051)	1.225 (.3233)	.3316 (.2209)
Three-stage least squares estimates				
January	17.89	-.0971 (.7446)	.8489 (.2495)	-.2517 (.2984)
February	27.90	-.6348 (.5613)	.7682 (.2146)	-.4018 (.2899)
March	33.35	-1.623 (.1676)	.8156 (.0764)	-.2024 (.1226)
April	88.02	-1.114 (.5564)		.8887 (.3801)
May	34.74	-1.422 (.3878)	.7202 (.1564)	-.0022 (.4031)
June	61.21	-.6452 (.6095)	.3246 (.1816)	-.4296 (.4117)
July	25.22	2.379 (.2466)	.5638 (.0884)	-.7051 (.1177)
August	72.15	2.158 (.2759)		-1.198 (.2070)
September	23.30	1.607 (.3748)	.3802 (.1323)	-.3843 (.1315)
October	-18.07	.3706 (.5806)	1.093 (.2438)	.3431 (.2217)
November	14.10	.6683 (.7708)	.5937 (.2361)	-.2017 (.1430)
December	-13.61	-1.135 (1.051)	1.227 (.3233)	.3328 (.2209)

<sup>1</sup>Numbers in parentheses are the standard errors of regression coefficients.

## Reduced-Form Price Equations

The two-stage least squares estimates of equations (M-1) and (M-3) and the identity, equation (M-2), were solved algebraically to obtain the following reduced-form price equations by months.

$$\begin{aligned}
 \text{January: } P_t &= 289.1505 - .7426 Y_t + .7426 H_t \\
 &\quad + .1203 I_t + .8674 T + .5783 B_{t-1} \\
 \text{February: } P_t &= 213.3266 - .5652 Y_t + .5652 H_t \\
 &\quad + .0771 I_t - .3134 T + .4051 B_{t-1} \\
 \text{March: } P_t &= 614.7270 - 1.592 Y_t + 1.592 H_t \\
 &\quad + .2434 I_t - 2.555 T + 1.274 B_{t-1} \\
 \text{April: } P_t &= 240.3933 - .5508 Y_t + .5508 H_t \\
 &\quad + .0831 I_t - .6153 T \\
 \text{May: } P_t &= 292.6112 - .7954 Y_t + .7954 H_t \\
 &\quad + .1476 I_t - .9974 T + .6721 B_{t-1} \\
 \text{June: } P_t &= 228.4158 - .6334 Y_t + .6334 H_t \\
 &\quad + .1254 I_t - .3147 T + .2571 B_{t-1} \\
 \text{July: } P_t &= 254.9896 - .7694 Y_t + .7694 H_t \\
 &\quad + .1488 I_t + 1.852 T + .4583 B_{t-1} \\
 \text{August: } P_t &= 197.1374 - .4877 Y_t + .4877 H_t \\
 &\quad + .0840 I_t + 1.054 T \\
 \text{September: } P_t &= 361.7335 - 1.052 Y_t + 1.052 H_t \\
 &\quad + .1729 I_t + 1.677 T + .4111 B_{t-1} \\
 \text{October: } P_t &= 458.0653 - 1.271 Y_t + 1.271 H_t \\
 &\quad + .1646 I_t + .6706 T + 1.283 B_{t-1} \\
 \text{November: } P_t &= 550.5891 - 1.530 Y_t + 1.530 H_t \\
 &\quad + .1966 I_t + .7451 T + 1.015 B_{t-1} \\
 \text{December: } P_t &= 560.8940 - 1.563 Y_t + 1.563 H_t \\
 &\quad + .2455 I_t - 1.762 T + 1.915 B_{t-1}
 \end{aligned}$$

The reduced-form price equations derived from the three-stage least squares estimates of equations (M-1) and (M-3), and the identity, equation (M-2), were as follows:

$$\begin{aligned}
 \text{January: } P_t &= 289.1294 - .7730 Y_t + .7730 H_t \\
 &\quad + .1270 I_t - .0750 T + .6562 B_{t-1} \\
 \text{February: } P_t &= 216.8459 - .5781 Y_t + .5781 H_t \\
 &\quad + .0788 I_t - .3670 T + .4441 B_{t-1} \\
 \text{March: } P_t &= 632.3698 - 1.642 Y_t + 1.642 H_t \\
 &\quad + .2508 I_t - 2.666 T + 1.340 B_{t-1} \\
 \text{April: } P_t &= 241.0268 - .5520 Y_t + .5520 H_t \\
 &\quad + .0829 I_t - .6150 T \\
 \text{May: } P_t &= 268.9675 - .7087 Y_t + .7087 H_t \\
 &\quad + .1322 I_t - 1.008 T + .5104 B_{t-1} \\
 \text{June: } P_t &= 225.9806 - .6129 Y_t + .6129 H_t \\
 &\quad + .1210 I_t - .3954 T + .1989 B_{t-1} \\
 \text{July: } P_t &= 252.1857 - .7550 Y_t + .7550 H_t \\
 &\quad + .1468 I_t + 1.796 T + .4257 B_{t-1} \\
 \text{August: } P_t &= 194.7554 - .4825 Y_t + .4825 H_t \\
 &\quad + .0845 I_t + 1.041 T
 \end{aligned}$$

September:	$P_t = 361.8697 - 1.050 Y_t + 1.050 H_t + .1723 I_t + 1.688 T + .3994 B_{t-1}$
October:	$P_t = 481.8624 - 1.352 Y_t + 1.352 H_t + .1757 I_t + .5009 T + 1.477 B_{t-1}$
November:	$P_t = 547.8108 - 1.515 Y_t + 1.515 H_t + 1.944 I_t + 1.013 T + .8997 B_{t-1}$
December:	$P_t = 562.0144 - 1.566 Y_t + 1.566 H_t + .2459 I_t - 1.778 T + 1.922 B_{t-1}$

### Ordinary Least Squares Estimates of Equations (M-4), (M-5), and (M-6)

The last three equations, (M-4), (M-5), and (M-6), of the basic model were independent of the simultaneous equation system. Ordinary least squares estimates of these three equations for each month are presented in tables 13, 14, and 15.

The estimated production equation, (M-4), indicated high  $R^2$  values and low standard errors of estimate. All variables entered the monthly equations with expected signs. However, the regression coefficient of  $E'_{t-1}$  in the equation for May was negative. The lagged chick replacement ratio,  $R_{t-6}/R_{t-18}$ , for all months except February and September indicated an expected positive

Table 13—Ordinary least squares estimates of equations for monthly shell egg production, ( $Y_t$ ), equation (M-4)

Month	Constant term	Regression coefficients			$R^2$	SEE <sup>1</sup>
		$L_{t-1}$ <sup>2</sup>	$E'_{t-1}$ <sup>3</sup>	$R_{t-6}/R_{t-18}$ <sup>4</sup>		
January	-1.3933	1.077 (.2804)	1.097 (.2396)	.100 (.0837)	.956	.006
February	-1.2123	1.180 (.4078)	.7194 (.3029)		.860	.009
March	.0429	.9103 (.1184)	.3082 (.1024)	.0260 (.0256)	.962	.003
April	-.8445	1.0796 (.1917)	.6562 (.1168)	.0025 (.0357)	.999	*
May	.9361	1.028 (.1796)	.6276 (.1221)	.0257 (.0355)	.879	.006
June	-1.6028	1.304 (.0024)	.7975 (.0104)	.0326 (.0005)	.915	.006
July	-2.2424	1.355 (.0024)	1.221 (.0104)	.0120 (.0005)	.999	.0003
August	-1.9111	0.8644 (.4199)	1.911 (.6502)	.0328 (.0174)	.999	*
September	-.8977	.7756 (.1420)	1.288 (.1407)		.965	.005
October	-1.0824	1.206 (.3356)	.6095 (.2463)	.0617 (.0685)	.997	.002
November	-.1392	.6503 (.2632)	.9410 (.0300)		.926	.007
December	-.3109	1.263 (.0350)	.6732 (.1579)		.999	*

<sup>1</sup> Expressed in logarithms of actual values.

<sup>2</sup> Standard error of estimate.

<sup>3</sup> Numbers in parentheses are the standard errors of regression coefficients.

<sup>4</sup> The standard errors for these equations were extremely low and rounded to zero within the computer program.

Table 14—Ordinary least squares estimates of equations for number of eggs laid per layer during the preceding month, ( $E_{t-1}$ ), equation (M-5)

Month	Constant term	Regression coefficients		$R^2$	SEE <sup>1</sup>
		T	$E'_{t-2}$		
January	-.3428	-.0393 (.0500)	1.101 (.0276)	.973	.086
February	-2.1297	-.0424 (.0979)	1.148 (.4811)	.893	.212
March	1.9386	-.0386 (.1048)	.8440 (.5124)	.585	.371
April	15.6636	-.0149 (.0171)	.2124 (.0941)	.483	.103
May	13.9902	-.0222 (.0100)	.2670 (.2187)	.483	.075
June	6.2043	.0087 (.0154)	.7044 (.4650)	.292	.096
July	-2.4908	.0392 (.0055)	1.066 (.1520)	.936	.042
August	4.1215	.0677 (.0130)	.7608 (.2476)	.942	.077
September	.4088	.0608 (.0184)	.9293 (.1814)	.987	.055
October	-1.1368	.0433 (.0360)	.9958 (.2357)	.986	.073
November	2.2245	.0505 (.0136)	.8790 (.0697)	.999	.025
December	1.5524	-.0163 (.0350)	.8883 (.1579)	.992	.051

<sup>1</sup> Standard error of estimate.

<sup>2</sup> Numbers in parentheses are the standard errors of regression coefficients.

effect on the dependent variable. Most of the coefficients were significant at the 5- or 10-percent level. The standard errors of the equations for April, August, and December are not included in the result. The error variances were extremely low and, in effect, were rounded to zero. Hence, the standard errors of estimate and the standard errors of the regression coefficients were reported as zero.

It may be observed parenthetically that the monthly equation might possibly approach the production identity, where total production, by definition, is the product of the average number of layers on hand and the layer productivity  $Y_t = \bar{L}_t \times E_t$ . The  $Y_t$  equation, (M-4), estimated as a logarithmic equation in the study, may be represented in the following general form:

$$Y_t = AL_{t-1}^{b_1} E_{t-1}^{b_2} (R_{t-6}/R_{t-18})^{b_3}$$

The equation would tend to be an identity as  $b_1$  and  $b_2$  approach unity,  $L_{t-1}$  and  $E_{t-1}$  approach  $\bar{L}_t$  and  $E_t$ , respectively, and either  $(R_{t-6}/R_{t-18})$  approaches unity or  $b_3$  approaches zero.

Table 15—Ordinary least squares estimates of equations for monthly number of eggs used for hatching, ( $H_t$ ), equation (M-6)

Month	Constant term	Regression coefficients			$R^2$	S.E.E. <sup>1</sup>
		$PB_{t-1}$	$P_{t-1}$	$T$		
January	17.4202		.1378 (.0735)	.6958 (.1401)	.845	1.066
February	15.8833	.4358 (.5302)	.0943 (.1250)	.3944 (.2595)	.476	1.783
March	12.0600	.6632 (.2510)	.1159 (.0670)	.1010 (.1105)	.795	.850
April	18.1139	.4093 (.1868)	.1098 (.0595)	.3302 (.0825)	.898	.625
May	15.9024	.1921 (.5003)	.1330 (.1143)	.9667 (.1453)	.951	.861
June	12.6258	.1984 (.3140)	.1612 (.1764)	.1087 (.2040)	.958	.873
July	17.7412	.0123 (.3042)	.0381 (.1475)	1.340 (.2473)	.955	1.022
August	5.9365	.3711 (.2931)	.1001 (.0906)	.8497 (.2863)	.958	.980
September	5.1575	.4713 (.3237)	.0424 (.1303)	1.074 (.2185)	.960	1.006
October	8.0676	.2510 (.1800)	.0930 (.0489)	1.271 (.1135)	.978	.743
November	10.1251	.0819 (.1492)	.1673 (.1434)	1.358 (.0692)	.991	.483
December	12.0716	.1832 (.3075)	.1140 (.0606)	1.190 (.1646)	.957	1.023

<sup>1</sup> Standard error of estimate.

<sup>2</sup> Numbers in parentheses are the standard errors of regression coefficients.

The equation for rate of lay, (M-5), yielded high  $R^2$  values for all months except March, April, May, and June. However, the standard errors for the latter equations were reasonably small. The rate of lay during the preceding month ( $E'_{t-2}$ ) appeared to be the main predictor. The coefficient for the time variable ( $T$ ) was positive in the equations for June through November and negative for the remaining months. This represents a decline in the seasonal fluctuations of the rate of lay in recent years.

The results of the last equation, (M-6), of the monthly model indicate satisfactory fit for all months except February. The  $R^2$  values of the equations for all other months ranged from .80 to .99. As expected, both broiler prices and shell egg prices in the preceding period,  $PB_{t-1}$  and  $P_{t-1}$ , respectively, had a direct effect on the quantity of eggs used for hatching,  $H_t$ . It may be recalled that  $PB_{t-1}$  and  $P_{t-1}$  were hypothesized to represent the prevailing strength in the respective markets. In spite of the oversimplification of the hatching-egg use equation, (M-6), this equation yielded reasonably accurate forecasts within the sample period.

## Modified First-Round Price Equations

The first-round price equations used to estimate the two-stage and three-stage least squares equations (M-1) and (M-3) were modified to develop additional monthly price prediction equations. The modified first-round equations were estimated in the following two forms:

$$(M-7) \quad P_t = f(Y_t, I_t, P_{t-1})$$

$$(M-8) \quad P_t = f(Y_t, I_t, PB_{t-1})$$

The variables in the equations are the same as those defined under the basic model of the monthly analysis. Ordinary least squares estimates were obtained for each equation where the variables were expressed in actual units. The estimated price equations, based on data for 1961-69, are presented in tables 16 and 17.

All independent variables in both equations entered with expected signs in relation to the dependent variable  $P_t$ . With the exception of the monthly equations for June, September, and October, the first price equation (M-7), yielded high coefficients of determination

Table 16 Ordinary least squares estimates of equations for monthly shell egg prices, ( $P_t$ ), equation (M-7)

Month	Constant term	Regression coefficients			$R^2$	S.E.E. <sup>1</sup>
		$I_t$	$P_{t-1}$	$Y_t$		
January	83.0459	.0502 (.0373)	.6198 (.3136)	.2033 (.1415)	.805	3.204
February	96.9356	.0273 (.0170)	.4748 (.1725)	-.2143 (.0714)	.861	2.437
March	31.0793	.0254 (.0059)	.7901 (.0741)	-.0731 (.0437)	.981	0.822
April	167.6085	.0460 (.0153)	.4015 (.1734)	-.3577 (.1153)	.903	1.682
May	50.7334	.0065 (.0221)	.4580 (.1886)	.0808 (.1352)	.864	1.154
June	132.2984	.0600 (.0335)	.2869 (.4396)	.3018 (.1795)	.686	2.094
July	61.6773	.0747 (.0769)	.7291 (.8465)	-.1862 (.3131)	.842	2.691
August	129.2553	.0784 (.0344)	.3283 (.2161)	.3178 (.1110)	.856	1.847
September	103.7099	.0919 (.0651)	.5674 (.5446)	-.2953 (.2411)	.670	4.294
October	90.5031	.0442 (.0439)	.4656 (.2727)	-.2064 (.1608)	.697	3.325
November	-14.9093	.0440 (.0295)	1.322 (.2458)	.0392 (.1329)	.927	2.792
December	75.2152	.0700 (.0119)	.6923 (.0724)	.2108 (.0482)	.987	1.254

<sup>1</sup> Standard error of estimate.

<sup>2</sup> Numbers in parentheses are the standard errors of regression coefficients.

Table 17—Ordinary least squares estimates of equations for monthly shell egg prices, ( $P_t$ ), equation (M-8)

Month	Constant term	Regression coefficients			$R^2$	SEE <sup>1</sup>
		$I_t$	$PI_{t-1}$	$Y_t$		
January	156.0116	.1059 (.0293)	.4931 (.3447)	-.3967 (.1133)	.754	3.603
February	107.7758	.0518 (.0175)	.7155 (.3493)	-.2713 (.0759)	.810	2.850
March	72.7497	.0555 (.0078)	1.155 (.1703)	-.1959 (.0573)	.955	1.254
April	189.0551	.0624 (.0116)	.4409 (.1835)	-.4149 (.0984)	.906	1.649
May	96.3985	.0320 (.0153)	.4105 (.1902)	-.1913 (.1087)	.846	1.226
June	171.5781	.0754 (.0272)	.0083 (.4268)	-.3857 (.1570)	.659	2.182
July	96.9615	.1142 (.0300)	.7736 (.4865)	-.3012 (.1395)	.879	2.350
August	130.7655	.1036 (.0257)	.4939 (.3694)	-.3522 (.1043)	.845	1.916
September	146.4066	.1311 (.0505)	.4492 (.6181)	-.4181 (.1990)	.638	4.498
October	47.7671	.0259 (.0160)	1.072 (.1543)	-.1159 (.0618)	.955	1.281
November	59.1447	.0538 (.0239)	1.234 (.1892)	-.1823 (.1019)	.948	2.357
December	120.6034	.1007 (.0124)	.8304 (.1065)	-.3326 (.0535)	.980	1.518

<sup>1</sup> Standard error of estimate.

<sup>2</sup> Numbers in parentheses are the standard errors of regression coefficients.

ranging from .81 to .99. The standard errors of the equations for September, October, and January were large. Similarly, high  $R^2$  values were estimated for the second price equation, (M-8), for all months except January, June, and September. It may be recalled that income forecasts for the period and lagged prices of shell eggs or frozen eggs are available from outside sources. The estimate of current production ( $Y_t$ ), however, can be developed from equations (M-4) and (M-5) presented earlier.

#### Predictive Accuracy of Alternative Models

Four alternative models for each month were compared with regard to accuracy of price forecasts. The first two models were based on the reduced-form price equations obtained from the two-stage and three-stage least squares equations (M-1) and (M-3) and the identity, equation (M-2). The reduced-form price equations were replaced by the two modified first-round price equations, (M-7) and (M-8), in the other two models. Each of the models contained the same ordinary least squares equations, (M-4) and (M-5). The first two models also included the equation for hatching eggs,

equation (M-6). The content of each model can be specifically described as follows:

Model (M-I): reduced-form price equation based on two-stage least squares estimates of equations (M-1) and (M-3) and the identity, equation (M-2); ordinary least square estimates of equations (M-4), (M-5), and (M-6).

Model (M-II): reduced-form price equation based on three-stage least squares estimates of equations (M-1) and (M-3) and the identity, equation (M-2); ordinary least squares estimates of equations (M-4), (M-5), and (M-6).

Model (M-III): ordinary least squares modified first-round equation, (M-7); ordinary least squares estimates of equations (M-4) and (M-5).

Model (M-IV): ordinary least squares modified first-round equation, (M-8); ordinary least squares estimates of equations (M-4) and (M-5).

All variables relating to the current period were predicted within the models. The U-coefficients, as presented in table 18, were computed from the price forecasts obtained separately from each model and for each month. The coefficients were based on price forecasts for the sample period. The actual and predicted values of monthly prices and other major variables are presented in appendix III.

Table 18—U-coefficients for monthly shell egg prices, ( $P_t$ )<sup>1</sup>

Month	Models			
	M-I	M-II	M-III	M-IV
January	1.70	2.80	.81	.99
February	.54	.54	.61	.50
March	3.70	3.90	.34	.44
April	.61	.66	.57	.59
May	1.20	1.00	.25	.31
June	.90	.89	.62	.65
July	.46	.45	.37	.35
August	.44	.41	.37	.35
September	.46	.46	.49	.46
October	.93	.96	.52	.16
November	1.90	1.80	.45	.48
December	2.60	2.90	.48	.78

<sup>1</sup> Predictions based on predicted values of  $Y_t$  and  $H_t$ .

Price forecasts obtained from models (M-I) and (M-II) were not satisfactory for January, March, May, November, and December, since the corresponding U-coefficients were greater than or equal to 1.0. As mentioned earlier, a U-coefficient of 1.0 can be obtained when no change is predicted:  $\hat{P}_t = P_{t-1}$ . Hence, in terms of the overall magnitude of errors, a "naive, no-change" model would have performed better than or as good as the two models for the specified months. Price predictions from the models (M-I) and (M-II) for the remaining months, especially for July, August, and September, were reasonably accurate. The other two models, (M-III) and (M-IV), based on ordinary least squares price equations, (M-7) and (M-8), respectively, were superior to the first two models with regard to predictive accuracy for all months except September. The U-coefficients of all four models for the month of September were very similar to each other. However, the U-coefficients of model (M-III) for 7 months were smaller than the corresponding coefficients of model (M-IV). On the other hand, model (M-IV) yielded smaller coefficients than those of model (M-III) for the remaining months.

Another set of price estimates was developed on the basis of actual, instead of predicted, values of the predetermined variables  $Y_t$  and  $H_t$ . Prices were estimated from the reduced-form price equations used in models (M-I) and (M-II) and from the ordinary least squares price equations used in models (M-III) and (M-IV). The other equations—(M-4), (M-5), and

(M-6)—which are required to predict  $Y_t$  and  $H_t$  within the system were excluded from the models. Actual values of  $Y_t$  and  $H_t$  were obtained from published sources. The related U-coefficients based on these estimated prices and computed for each model and month are presented in table 19.

The U-coefficients of models (M-I) and (M-II) are greater than 1.0 for January, February, March, October, November, and December. Price estimates from models (M-III) and (M-IV) were superior to those obtained from the first two models for all months except August. Thus, the U-coefficients in both tables 18 and 19 indicate that models (M-III) and (M-IV) performed consistently better than the other two models based on reduced-form price equations. A comparison between models (M-III) and (M-IV) reveals that the overall magnitude of errors in estimating prices from model

Table 19—U-coefficients for monthly shell egg prices, ( $P_t$ )<sup>1</sup>

Month	Models <sup>2</sup>			
	M-I	M-II	M-III	M-IV
January	1.55	2.76	.70	.78
February	1.14	1.19	.44	.52
March	4.13	4.29	.34	.51
April	.33	.38	.34	.34
May	.82	.65	.23	.25
June	.84	.76	.56	.59
July	.43	.42	.34	.30
August	.34	.34	.35	.36
September	.68	.69	.51	.53
October	1.13	1.19	.51	.20
November	1.85	1.85	.43	.37
December	2.83	2.40	.33	.40

<sup>1</sup> Estimates based on actual values of  $Y_t$  and  $H_t$ .

<sup>2</sup> These models excluded the last three equations, (M-4), (M-5), and (M-6), of the system since actual values of  $Y_t$  and  $H_t$  were used.

Table 20—Actual and predicted monthly shell egg prices outside the period of fit, 1970-71, and related U-coefficients<sup>1</sup>

Month	Actual prices	Predicted prices of models			
		M-I	M-II	M-III	M-IV
Cents/dozen					
1970:					
1	59.75	56.86	40.90	52.58	51.77
2	50.18	39.38	39.54	45.39	45.90
3	46.71	53.86	54.33	50.65	50.88
4	36.20	37.06	37.01	39.33	37.30
5	31.85	31.26	30.95	29.73	28.84
6	34.82	38.57	38.42	35.51	35.45
7	40.48	57.43	57.10	48.37	48.71
8	38.88	46.42	46.60	44.94	46.75
9	44.64	58.04	57.96	51.54	53.50
10	35.30	39.16	39.89	38.64	33.76
11	38.45	62.42	61.80	43.67	39.95
12	41.67	48.32	48.24	43.51	42.36
1971:					
1	38.55	48.42	33.50	40.16	39.57
2	34.47	33.74	33.98	32.43	32.09
3	34.07	48.76	49.16	38.73	38.90
4	32.73	34.41	34.32	33.00	34.27
5	29.46	40.44	38.68	28.81	29.71
6	30.32	32.23	42.71	36.98	38.12
7	33.65	53.35	53.14	45.56	48.52
8	35.38	45.10	45.36	41.90	45.79
9	33.61	58.49	58.42	50.16	54.79
10	33.28	59.40	61.58	37.02	34.27
11	34.50	73.38	72.93	43.01	41.00
12	37.25	88.51	88.57	46.60	49.40

Inequality coefficient (U) 4.01 4.07 1.43 1.69

<sup>1</sup> Predictions based on predicted values of  $Y_t$  and  $H_t$ .

(M-III) was smaller than that from the latter model for all months except July, October, and November.

Prices were predicted for each month of 1970 and 1971, beyond the sample period. The predicted monthly prices obtained from each of the four models are included in table 20. These prices are obtained by using predicted, rather than actual, values of  $Y_t$  and  $H_t$ . The related U-coefficients in table 20 were computed for all 24 observations considered together for each of the four

models. The predictions from models (M-I) and (M-II) generally involved considerably larger errors than the predictions from models (M-III) and (M-IV). These two models seemed to have performed adequately in predicting prices during the second and fourth quarters of 1970 and the first and second quarters in 1971. Price predictions during the second half of 1971 involved significant overestimation of the existing actual price levels.

## ANALYSIS OF AVERAGE WEEKLY CASH PRICES

Single-equation models were developed to analyze factors which affect average weekly cash prices of shell eggs. The basic objective was to estimate the existing relationships between shell egg prices and the major causal factors rather than to predict weekly prices.

Considerable week-to-week variations in shell egg prices are quite evident although less pronounced than the fluctuations in monthly or quarterly average prices. Barring some unusual circumstances, including the weather, the changes in the price-determining factors are, however, less drastic or conspicuous from one week to the next.

Weekly price models, similar to the quarterly or monthly models, could have been developed with production, eggs used for hatching, or breaking eggs as the major factors in price determination. Weekly data on such variables are, however, not available from existing sources. In view of this limitation, the data on weekly commercial egg movements—weekly receipts of eggs by assemblers—were used in the study to represent weekly trends in the market supply of eggs. Although the reported movement of eggs through commercial channels is only a fraction of total production or market supply, variations in commercial egg movement would reflect the variations in total market supply due to varying levels of shell egg production, hatching, and other factors (14, pp. 53-54).

In an initial attempt, a three-equation, simultaneous equation model was formulated for weekly shell egg prices. The model contained three endogenous variables: shell egg price, retail or commercial egg movements and net storage movements. The estimates of the model, however, yielded several relations which were clearly inconsistent with economic logic. It was, therefore, concluded that the hypothesized mutual dependence of the relations did not apply to a shortrun or weekly analysis. It is possible that the short span of time does not lend itself to such simultaneous

determination of variables instantaneously within a week.

A reconsideration of the model led to the following general specification involving a single equation:

$$P_t = f(C_t, \Delta S_t, P_{t-1})$$

where,

$P_t$  = simple average of daily weighted average prices, prices paid delivered to Chicago, 80-percent grade A large white eggs, cents per dozen; source: *Daily Egg Report, Dairy and Poultry Market News* (17);

$C_t$  = quantity of eggs moving through commercial channels (commercial egg movements) during the current ( $t^{\text{th}}$ ) week, weekly receipts from farmers by assemblers, U.S. total, 100 cases (30 dozen eggs per case); source: *National Weekly Egg and Poultry Market News* (21) and *Egg Report, Dairy and Poultry Market News*, Thursday issues (19);

$\Delta S_t$  = storage stocks on hand at the beginning (usually Monday morning) of the following week minus storage stocks on hand at the beginning of the current week, total 10 markets, 1,000 cases; source: *Egg Report, Dairy and Poultry Market News* (19).

It was assumed that for a week-to-week analysis, the variations and effects of the demand-shifting factors were insignificant. Hence, weekly variations in prices were caused primarily by shortrun variations in the market supply of shell eggs. The quantity of eggs moving through commercial channels ( $C_t$ ) representing the market supply eggs was assumed independent of weekly prices ( $P_t$ ). While  $P_t$  was a function of  $C_t$ , the reverse relation did not hold. Commercial egg movements cannot respond instantaneously to changes in price

situations during the same week. This inflexibility of egg movements can be explained by the fact that production or market supply is essentially determined through production decisions made several months earlier. Hence, the market supply cannot be increased substantially during a week in response to a buoyant demand situation which may occur during that week. On the other hand, when the market is weak, any significant quantity of eggs cannot be held back since eggs are a highly perishable product. Commercial egg movements during the week can therefore be considered independent of the current week's price.

Although the weekly net storage movement is only a minor proportion of the total market supply, variations in the factor may have a significant effect on a weekly analysis. The lagged weekly price ( $P_{t-1}$ ) as a determinant of the current weekly price seems to be a logical specification because prices of the immediate past play an important role as a reference in the process of price determination. Since week-to-week changes in the market forces are usually gradual and slow, prices during the preceding week may reflect the existing short-term trend of the market strength.

Several alternative weekly price equations were estimated on the basis of weekly data for November 28, 1970, through February 26, 1972. The statistical results of the first selected equation were as follows:

$$\begin{aligned} \text{(W-1)} \quad P_t &= 11.65689 - 0.00037 C_t - 0.21724 \\ &\quad (0.00034) \quad (0.08103) \\ &\quad \Delta S_t + 0.82399 P_{t-1} \\ &\quad (0.05468) \\ R^2 &= 0.8282, \text{SEE}^5 = 1.57839, F\text{-ratio} = \\ &\quad 98.0282 \end{aligned}$$

The signs of the regression coefficients substantiated the expected relationships among the variables. The coefficients of both  $P_{t-1}$  and  $\Delta S_t$  were significant at the 5-percent level. The standard error of estimate is fairly low relative to the observed variations in prices which ranged from 27.1 cents to 42.0 cents per dozen. The average price in the preceding week was clearly the most important variable in the equation. The corresponding partial correlation coefficient was 0.88.

The accuracy of an estimating equation is partly reflected in its ability to estimate the direction of change for the variable under consideration. The accuracy can be enhanced when most recent information or indicators are used in the equation. It is conceivable in this context that the average price in the preceding week might be at

a relatively high level, although the price toward the end of the week may weaken substantially. Such weakening trends may tend to continue over the following week, since day-to-day changes are generally quite gradual. Thus, the week-to-week trend may be represented more accurately by last Friday's price than the average of the daily prices for the entire week ( $P_{t-1}$ ). Accordingly, the following equation was estimated by replacing  $P_{t-1}$  by last Friday's price ( $FP_{t-1}$ ):

$$\begin{aligned} \text{(W-2)} \quad P_t &= 8.36038 - 0.00027 C_t - 0.15718 \\ &\quad (0.00029) \quad (0.07073) \\ &\quad \Delta S_t + 0.87554 FP_{t-1} \\ &\quad (0.04879) \\ R^2 &= 0.8708, \text{SEE} = 1.36895, F\text{-ratio} = \\ &\quad 137.0163 \end{aligned}$$

In terms of signs and magnitude, the regression coefficients in equation (W-2) were similar to those in equation (W-1). The test statistics for equation (W-2) indicate some improvements over the first equation. More specifically, the coefficient of determination for the second equation increased and, subsequently, the standard error of estimate decreased. Replacing the lagged average price ( $P_{t-1}$ ) with the preceding Friday's price ( $FP_{t-1}$ ) improved the accuracy of the price equation to some extent.

The third alternative equation was developed by introducing an additional variable,  $BP_{t-1}$ , which was defined as follows:

$BP_{t-1}$  = simple average of daily prices, during the preceding week, paid for eggs to be delivered to breaking plants, case exchanged, Missouri, Kansas, and Illinois, dollars per case.

The price series was obtained from the daily issues of the *Egg Report* (19). Since a range of prices is reported, the middle of the range was used to represent the daily price. It was expected that the prices paid for eggs for breaking plants during the preceding week ( $BP_{t-1}$ ) would reflect the existing strength of the breaking-egg market, a secondary market for eggs. Furthermore, since the markets for table eggs and breaking eggs are closely related, a positive correlation was expected to exist between breaking-egg prices ( $BP_{t-1}$ ) and weekly shell egg prices ( $P_t$ ). The third alternative weekly price equation was estimated as follows:

$$\begin{aligned} \text{(W-3)} \quad P_t &= 6.94490 - 0.00021 C_t - 0.15932 \\ &\quad (0.00032) \quad (0.07134) \\ &\quad \Delta S_t + 0.86241 FP_{t-1} + 0.46302 BP_{t-1} \\ &\quad (0.05671) \quad (0.30853) \end{aligned}$$

<sup>5</sup>Standard error of estimate.

$R^2 = 0.8712$ ,  $SEE = 1.37785$ ,  $F - \text{ratio} = 101.4924$

The results of equation (W-3) are quite similar to those of equation (W-2). The  $R^2$  value for the third equation indicates only a minor improvement over the corresponding value for equation (W-2). On the other hand, the results of equation (W-2) in terms of the standard error of estimate and the  $F$  ratio were slightly superior to those of the last equation, (W-3). The differences between the last two equations with regard to the test statistics were, however, not significant. It appears that the latter two equations may be preferred to the first

equation, (W-1), in terms of relative accuracy of estimates.

Several other price equations were also developed under different specifications. For instance, the weekly egg movement through retail channels, as reported by USDA in the *Egg Report* (19), was used in the equation to replace commercial egg movements. The estimated equations, however, indicated results inferior to those of the equations presented here. Furthermore, the equations were reestimated by using first differences of variables. For example, the dependent variable was expressed as  $P_t - P_{t-1}$  rather than  $P_t$ . These equations generally produced considerably larger error sums of squares.

### ANALYSIS OF FUTURES QUOTATIONS FOR FRESH SHELL EGGS<sup>6</sup>

Trading in shell egg futures at the Chicago Mercantile Exchange has been fairly active, particularly since the latter part of 1968. Since that time, futures price quotations have fluctuated widely. For instance, the closing quotations for June 1969 and November 1969 contracts were 29.0 and 65.2 cents per dozen, respectively. Such fluctuations generally coincided with the trend in cash prices in the corresponding periods.

The shell egg futures contract has changed several times in recent years. Until the February 1967 contract, the contract was in terms of refrigerator eggs which have been in cold storage more than 29 days. Prior to 1967, refrigerator eggs could be delivered at par, while fresh eggs could be delivered at a premium. The contract was modified to fresh shell eggs—eggs which have not been in cold storage over 29 days—beginning with the March 1967 contract. Under this contract, fresh eggs could be delivered at par and refrigerator eggs were still permitted at a discount. Finally, with the February 1969 contract, the egg futures contract was changed to only fresh eggs (2).

The quality specification of fresh egg contracts is as follows: fresh shell eggs, U.S. extras, white large, 80-percent grade A. (The specification was modified to 85-percent grade A, beginning with the April 1971 contract.) The minimum price fluctuation specified by the Chicago Mercantile Exchange is .05 cent per dozen. The daily price fluctuations are limited to 2 cents per dozen above or below the settling price of the previous day (2). The Commodity Exchange Act specifies that "a

person shall not own or control a total of more than 150 contracts in any one contract month, nor shall his net long or short position in all contract months combined exceed 150 contracts" (2). Furthermore a person shall not buy or sell more than 150 units during a business day. Trading in shell egg futures terminates on the trading day prior to the last 7 business days of the delivery month.

#### Relations Between Futures and Cash Price Quotations for Shell Eggs

It is often assumed that cash and futures quotations are generally correlated. However, no systematic study of the relation or the spread between the futures and cash prices of shell eggs has yet been published, especially for quotations in the most recent past. In view of the recent changes in the egg contract, the analysis of the basis (the spread between the futures and cash price quotations) in this study began with the February 1969 contract.

The differentials between futures and cash price quotations for shell eggs in the delivery months are presented in table 21. These differentials or spreads were obtained by subtracting the cash from the closing futures quotation on the specified day. Three days in the delivery month were considered for each contract: the first trading day of the month, the middle trading day, and the last trading day. The cash quotations relate to daily wholesale prices at Chicago, 80-percent grade A large white eggs. Both futures and cash quotations for the past years were obtained from the Chicago Mercantile Exchange Yearbooks (2).

<sup>6</sup>Terry Sterling, a student at Texas Tech University, rendered valuable assistance in this section.

Table 21—Price differentials for fresh shell eggs, large white 80-percent grade A: closing futures quotations minus cash price on specified days in the month of delivery

Contract	1969			1970			1971		
	First trading day	Middle trading day	Last trading day	First trading day	Middle trading day	Last trading day	First trading day	Middle trading day	Last trading day
	<i>Cents/dozen</i>								
January	—	—	—	-3.85	-0.15	4.40	-5.7	-2.0	-7.85
February	-1.85	-2.85	0.50	-2.75	-5.8	-4.0	-1.50	0.90	2.35
March	1.85	1.50	-5.15	-0.05	0.25	-6.2	1.15	-0.45	4.95
April	-8.05	-1.00	2.00	-5.55	-2.65	-0.25	-7.45	-1.70	0.25
May	0.40	2.65	2.95	-0.85	0.85	2.50	-1.80	1.30	2.75
June	0	-0.75	-4.50	0.60	1.35	2.75	-0.75	1.55	2.00
July	-3.0	-2.55	-1.50	1.50	-1.65	-7.65	-3.25	1.60	0.05
August	-5.4	-0.3	-3.65	-2.20	-0.75	-1.0	0	-1.15	-4.50
September	-1.40	-1.50	-3.65	-1.10	-2.85	4.20	-2.65	2.70	2.00
October	0.15	0.15	3.45	-2.85	0.35	3.15	-0.80	-1.65	-0.25
November	2.55	0.70	3.20	0.75	-2.25	-5.75	-5.55	-1.80	-3.80
December	-3.25	1.15	-2.60	1.75	-0.80	-6.65	-0.55	-0.10	-4.85

Table 21 reveals substantial changes in the spread between futures and cash quotations for a given contract within the delivery month. For instance, the basis changed from -5.85 cents on the first trading day of the delivery month to 4.40 cents on the last day of trading for the January 1970 contract. The differentials or spreads changed from negative to positive, or vice versa, for 19 of the 35 contracts examined. No consistent patterns in the changes of the basis could be established. Furthermore, the futures-cash spreads on the last trading day were examined for each contract over the specified years. Only three contracts, those for May, August, and December, indicated some degree of consistency in a year-to-year comparison of the basis. The futures quotation for the May contract tended to remain 2.5 cents to 2.95 cents above the cash price on the last day of trading in the contract. On the other hand, the cash price was 2.6 cents to 6.65 cents above the futures price for the December contract. Similarly, the cash price remained 1.0 cent to 4.5 cents above the futures quotation for the August contract on the last trading day. However, the volume of trading for the August contract was negligible in all 3 years.

Spreads between the cash price and the corresponding futures quotation for the contracts in the recent past were generally not consistent. Substantial changes in the differentials were evidenced within the delivery month. Furthermore, the basis on the last trading day for most of the contracts was also found unstable during the 3 years under consideration. Future research efforts may be directed towards the investigation of the factors which contribute to such variations in the futures-cash spreads.

#### Weekly Prediction Equations for Price Quotations for Nearby Futures

Regression equations were estimated in an earlier section (pp. 20-22) to estimate weekly average cash prices of shell eggs. Similar equations were developed to predict the price quotations for nearby futures contracts for fresh shell eggs. The basic causal factors, or the independent variables in these prediction equations, were essentially similar to those included in the weekly cash price analysis. Cash prices in a given week normally are the results of the current market supply and demand situations. On the other hand, futures prices for the nearby contract are presumably determined by the anticipated supply and demand conditions in the market at the time of delivery. The traders' anticipations regarding the supply and demand determining factors in a future period may be assumed to depend on the information available for the immediate past the preceding week(s). It may be assumed for a short-term or a week-to-week analysis that the levels of the basic variables in the immediate past would to some extent reflect the longer run trends extending into the present as well as the near future. Furthermore, as new information on such variables becomes available, traders continually adjust their anticipations regarding the market's strength from one week to the next in the immediate future.

The prediction equations for the quotations of nearby futures contracts were developed on the basis of the preceding observations and assumptions. Separate equations were formulated for both low and high quotations for the nearby futures. The general

specification of the equations may be presented as follows:

$$P_{H_t} \text{ or } P_{L_t} = f(C_{t-2}, S_{t-1}, PF_{t-1}, BP_{t-1})$$

where,

$P_{H_t}$  = high quotation during the current ( $t^{th}$ ) week for the nearby fresh shell eggs futures contract, cents per dozen; source: Chicago Mercantile Exchange, *Daily Information Bulletin* (3), and *Chicago Mercantile Exchange Year Books* (2);

$P_{L_t}$  = low quotation during the current ( $t^{th}$ ) week for the nearby fresh shell eggs futures contracts, cents per dozen; source: same as those for  $P_{H_t}$ .

$C_{t-2}$  = quantity of eggs moving through commercial channels (commercial egg movements) during the ( $t-2$ )<sup>th</sup> week, weekly receipts from farmers by assemblers, U.S. total, 100 cases; source: *Egg Report, Dairy and Poultry Market News*, Thursday issues (19), and *National Weekly Egg and Poultry Review, Dairy and Poultry Market News* (21).

$S_{t-1}$  = storage stocks of shell eggs on hand at the beginning (usually Monday morning) of the current week, total 10 markets, 1,000 cases; source: *Egg Report, Dairy and Poultry Market News* (19);

$PF_{t-1}$  = closing quotation, on Friday of the preceding week, for the nearby fresh shell egg futures contract, cents per dozen; source: same as those for  $P_{H_t}$ ;

$BP_{t-1}$  = simple average of daily prices, during the preceding week, paid for eggs to be delivered to breaking plants, case exchanged, Missouri, Kansas, and Illinois, dollars per case; source: *Egg Report* (19), daily issues.

The variables included in these equations are in essence similar to those used in the equations for weekly cash prices. These variables were, however, all lagged by 1 or 2 weeks, as data on variables are published with a time lag. As discussed earlier (p. 20), the commercial egg movement ( $C_{t-2}$ ) report was assumed to reflect the trend in the current market supply of shell eggs. A 2-week lag was needed for this variable since relevant data are published on Thursday of the following week. Futures prices would be inversely affected by the

quantity of eggs moving through the commercial channels in the immediate past ( $C_{t-2}$ ). The lagged prices of breaker eggs ( $BP_{t-1}$ ) was introduced into the equations to represent the most recent trend in the breaking-egg sector, a secondary market for shell eggs. Since a strong demand in the breaking-egg market would tend to support the shell egg market, the price of breaker eggs was assumed to influence directly the prices of nearby futures contracts. The closing quotation, on the preceding Friday, for the nearby futures contract ( $PF_{t-1}$ ) was expected to be directly related to  $P_{H_t}$  or  $P_{L_t}$ . Data for the 66-week period of November 18, 1970, through February 26, 1972 were used to estimate the following two equations for highs and lows of the price quotations for the nearby futures.

Equation for high quotations:

$$P_{H_t} = 16.6553 - 0.00048 C_{t-2} + 0.01654 BP_{t-1} + 0.01937 S_{t-1} + 0.74745 PF_{t-1}$$

(0.00050) (0.57494) (0.05938) (0.07984)

$R^2 = 0.6809$ , SEE = 2.0419, F-ratio = 32.5361

Equation for low quotations:

$$P_{L_t} = 9.27058 - 0.00021 C_{t-2} + 0.47981 BP_{t-1} + 0.01163 S_{t-1} + 0.67082 PF_{t-1}$$

(0.00046) (0.53622) (0.05538) (0.07446)

$R^2 = 0.6861$ , SEE = 1.9044, F-ratio = 33.3266

Both estimated equations indicated similar results with regard to the test statistics including the  $R^2$  values. The signs of the coefficients were also identical in both equations. The relations indicated by the signs of the estimated coefficients were consistent with the hypotheses. The closing quotation on the last day of the preceding week ( $PF_{t-1}$ ) was by far the most important variable in terms of its contribution to the coefficient of multiple determination. The storage stock on hand at the beginning of the week ( $S_{t-1}$ ) contributed least to the equations. The prediction errors of both equations within the sample period were generally larger than the errors of the comparable equations for the average weekly cash prices. It is worth noting that about 31 to 32 percent of the variations in  $P_{H_t}$  and  $P_{L_t}$  remained unexplained in the equations despite the inclusion of the most recent futures quotation,  $PF_{t-1}$ , as an independent variable.

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## SOURCES OF DATA FOR QUARTERLY AND MONTHLY MODELS

1. Daily Chicago cash prices, prices paid delivered, 80-percent grade A large white eggs (P): data for earlier years were obtained from *Chicago Mercantile Exchange Yearbooks* (2). Current cash quotations are reported by the USDA in *Daily Egg Report* (17). These quotations currently appear twice a week—Wednesdays and Fridays.

2. Disposable consumer income, seasonally adjusted annual rates, (I): data for the sample period were obtained from *Survey of Current Business* (25). Income forecasts are available from various sources including the Wharton model (5).

3. Production of shell eggs (Y): production estimates by months for earlier years were from *Poultry and Egg Situation* (22) and *Selected Statistical Series for Poultry and Eggs through 1968, Revised January 1970* (24). Current monthly estimates are reported by USDA in *Eggs, Chickens and Turkeys*, Statistical Reporting Service, Crop Reporting Board (18).

4. Quantity of eggs broken commercially (B): monthly data for earlier years were obtained from *Poultry and Egg Situation* (22) and *Selected Statistical Series for Poultry and Eggs through 1968, Revised January 1970* (24).

5. Quantity of eggs used for hatching (H): data for months for the sample period were obtained from *Poultry and Egg Situation* (22) and *Selected Statistical Series for Poultry and Eggs through 1968, Revised January 1970* (24).

6. Average number of eggs per 100 layers (E):

monthly data for earlier years were from *Poultry and Egg Situation* (23). Current monthly series on rate of lay is reported in *Eggs, Chickens and Turkeys* (18).

7. Average number of layers on farms during the period (L) and number of layers on farms first of month, (L): data by months for the sample period was obtained from *Poultry and Egg Situation* (22). Current estimates by months appear in *Eggs, Chickens and Turkeys* (18).

8. Average prices of frozen whole eggs, light colored, (PF): monthly average prices for past years were obtained from *Poultry and Egg Situation* (22). The simple average of the monthly prices was used to estimate the quarterly average price. Current prices of frozen whole eggs at New York are reported on Tuesdays by USDA in *Egg Report* (19).

9. Storage stocks of all frozen eggs (SF): data for earlier years were from *Poultry and Egg Situation* (22). Current estimates of storage stocks by months are reported by USDA in *Cold Storage*, Statistical Reporting Service, Crop Reporting Board.

10. Number of chicks placed for laying flock replacements (R): data by months were obtained from *Poultry and Egg Situation* (22).

11. Average prices of U.S. and plant grade A broilers at Chicago (PB): monthly average price series for past years were obtained from *Poultry and Egg Situation* (22). Quarterly average prices were developed by computing the simple average of the monthly prices.

# APPENDIX II

Table 1--Actual and predicted quarterly shell egg prices, 1961-71

Year and quarter	Actual <sup>1</sup> prices	Prices predicted from models			
		Q -I	Q -II	Q -III	Q -IV
		Cents/dozen			
1961:					
I	37.4	42.9	42.7	42.1	42.7
II	32.0	31.1	30.9	30.6	30.1
III	40.9	32.6	33.7	38.8	37.7
IV	37.0	34.2	35.1	40.0	39.0
1962:					
I	33.7	34.1	34.4	34.7	34.3
II	28.0	27.9	27.9	28.3	28.7
III	37.3	29.8	30.4	33.6	33.1
IV	38.6	39.3	39.5	35.6	35.2
1963:					
I	36.2	32.3	32.1	32.3	32.0
II	29.4	31.7	31.8	31.9	31.1
III	35.7	37.8	36.0	35.6	35.6
IV	37.5	37.5	37.4	35.3	35.5
1964:					
I	35.0	32.8	32.7	33.0	32.6
II	29.2	29.3	29.4	29.0	29.5
III	36.4	39.6	37.5	35.7	36.0
IV	33.6	35.7	35.6	34.4	35.0
1965:					
I	28.0	31.5	31.6	30.9	30.8
II	29.6	27.3	27.9	27.7	27.9
III	34.0	42.3	39.5	39.6	40.0
IV	40.7	30.9	31.4	33.7	34.8
1966:					
I	40.8	37.4	37.3	38.5	38.3
II	34.4	35.0	35.5	35.8	35.1
III	43.6	48.2	44.9	45.4	47.0
IV	42.5	43.6	43.9	45.1	46.1
1967:					
I	32.8	33.9	33.7	33.4	34.0
II	26.2	25.3	27.1	24.6	27.3
III	30.7	24.9	26.5	31.7	32.2
IV	30.0	24.3	24.8	28.2	30.2
1968:					
I	28.8	29.7	29.9	30.4	30.6
II	27.9	26.1	26.4	26.6	27.1
III	40.2	37.2	36.3	37.7	36.9
IV	42.5	45.9	45.9	44.1	42.1
1969:					
I	42.4	40.6	40.4	40.5	39.4
II	34.4	36.7	36.9	36.2	34.3
III	45.0	47.4	45.5	45.4	44.5
IV	54.7	52.2	52.7	52.8	51.8
1970:					
I	52.2	49.0	48.6	51.9	51.4
II	34.4	40.9	39.9	39.1	37.0
III	41.3	47.4	46.8	45.8	43.1
IV	38.4	40.5	42.1	44.6	40.5
1971:					
I	35.6	41.7	41.9	45.1	41.8
II	32.2	33.4	32.8	35.3	31.7
III	34.2	48.2	47.6	47.3	42.7
IV	35.0	43.4	44.6	50.6	42.3

Table 2--Actual and predicted quarterly production of shell eggs, eggs per 100 layers, and average layers on hand, 1961-71

Year and quarter	Production of shell eggs				Average layers on hand	
	Total		Per 100 layers			
	Actual	Predicted	Actual	Predicted	Actual	Predicted
	<i>Million dozen</i>		<i>Number</i>		<i>Million</i>	
1961:						
I	1322	1285	5256	5174	302.0	298.0
II	1365	1374	5687	5737	288.0	287.0
III	1234	1251	5164	5168	287.0	290.4
IV	1281	1281	4960	4955	310.0	310.3
1962:						
I	1346	1339	5229	5277	309.0	304.4
II	1398	1399	5730	5704	293.0	294.2
III	1264	1284	5242	5248	290.0	293.6
IV	1289	1284	5023	5043	308.0	305.6
1963:						
I	1316	1353	5189	5305	305.0	306.1
II	1397	1379	5726	5664	293.0	292.1
III	1278	1281	5286	5285	290.0	290.9
IV	1301	1308	5094	5099	307.0	307.7
1964:						
I	1375	1357	5410	5339	305.0	305.1
II	1416	1417	5755	5777	295.0	294.3
III	1309	1308	5333	5354	295.0	293.1
IV	1335	1341	5173	5158	310.0	312.1
1965:						
I	1381	1380	5411	5379	306.0	307.8
II	1422	1431	5744	5761	297.0	298.0
III	1332	1309	5396	5386	296.0	291.7
IV	1341	1392	5235	5236	307.0	319.1
1966:						
I	1358	1379	5344	5405	305.0	306.1
II	1417	1411	5728	5705	297.0	296.7
III	1350	1333	5419	5412	299.0	295.5
IV	1416	1394	5313	5268	320.0	317.6
1967:						
I	1452	1449	5459	5442	319.0	319.5
II	1493	1503	5764	5754	311.0	313.4
III	1456	1430	5525	5490	312.0	312.6
IV	1446	1469	5359	5359	326.0	326.8
1968:						
I	1482	1468	5490	5454	324.0	322.9
II	1482	1498	5694	5755	312.0	312.4
III	1407	1414	5472	5467	308.0	310.4
IV	1404	1406	5339	5342	317.0	315.8
1969:						
I	1416	1431	5471	5414	315.0	317.2
II	1476	1457	5717	5687	310.0	307.5
III	1419	1421	5502	5532	309.0	308.2
IV	1434	1435	5382	5370	320.0	320.7
1970:						
I	1443	1449	5351	5422	322.0	320.8
II	1485	1482	5613	5642	317.0	315.3
III	1446	1452	5466	5475	318.0	337.2
IV	1485	1503	5391	5349	330.0	337.2
1971:						
I	1497	1501	5468	5430	328.3	331.7
II	1518	1515	5706	5692	319.0	319.3
III	1473	1483	5588	5596	316.0	318.1
IV	1505	1499	5550	5495	325.7	326.9

<sup>1</sup> Simple average of Chicago daily cash prices, prices paid delivered, 80-percent grade A large white eggs

Table 3—Actual and predicted quantity of eggs used for breaking and eggs used for hatching, 1961-71

Year and quarter	Eggs used for breaking			Eggs used for hatching		Year and quarter	Eggs used for breaking			Eggs used for hatching	
	Actual	Predicted by models		Actual	Predicted		Actual	Predicted by models		Actual	Predicted
		Q-I	Q-II					Q-I	Q-II		
	Million dozen						Million dozen				
1961:						1967:					
I	110.3	81.3	82.4	96.3	94.1	I	142.7	140.0	139.3	99.8	95.8
II	203.4	213.7	213.8	85.5	84.5	II	197.6	205.8	190.4	97.9	95.8
III	97.2	107.2	103.8	58.5	57.7	III	154.6	148.6	145.8	82.2	79.4
IV	71.3	66.8	65.2	61.5	59.1	IV	113.9	123.1	122.7	81.6	81.9
1962:						1968:					
I	99.6	105.2	106.6	90.1	86.9	I	126.3	124.5	125.1	95.4	93.6
II	210.8	209.6	208.1	83.8	85.6	II	169.6	179.4	177.5	98.5	100.0
III	117.1	115.4	112.0	63.5	62.6	III	129.0	129.5	124.9	83.7	85.9
IV	55.6	60.2	59.7	65.8	66.9	IV	89.2	84.9	83.4	37.1	89.8
1963:						1969:					
I	81.6	107.3	107.0	87.1	91.0	I	88.3	98.2	98.4	100.8	102.0
II	198.4	208.1	187.3	85.4	86.3	II	161.8	151.7	153.5	104.3	105.7
III	104.4	108.9	106.2	63.8	66.7	III	127.8	130.5	126.7	91.3	92.0
IV	61.5	64.5	64.4	68.0	68.5	IV	108.4	107.5	106.4	97.7	95.5
1964:						1970:					
I	102.7	102.7	102.6	89.4	91.5	I	120.2	111.6	112.2	112.2	101.9
II	209.7	198.2	196.3	85.9	86.6	II	172.2	165.5	168.3	111.3	107.7
III	109.0	119.1	116.3	67.1	68.0	III	146.0	142.6	137.2	89.9	91.0
IV	79.1	74.6	74.3	69.6	73.0	IV	132.7	135.7	133.6	97.2	93.1
1965:						1971:					
I	124.6	106.3	106.7	88.0	91.0	I	145.1	109.5	111.5	105.2	97.4
II	163.1	183.9	182.7	92.2	90.6	II	174.5	150.0	155.3	106.1	107.3
III	116.9	100.7	97.0	74.2	74.7	III	143.4	147.0	139.4	90.8	96.6
IV	73.0	95.6	95.3	78.5	76.5	IV	139.8	112.4	109.4	95.0	102.2
1966:											
I	87.9	97.3	97.5	96.3	96.3						
II	170.1	162.7	163.7	100.5	98.8						
III	110.7	111.7	109.5	83.9	31.2						
IV	103.3	105.5	106.0	84.0	82.8						

Table 4—Actual and predicted monthly shell egg prices, 1961-71

Year and month	Actual prices <sup>1</sup>	Prices predicted from models				Year and month	Actual prices <sup>1</sup>	Prices predicted from models			
		M-I	M-II	M-III	M-IV			M-I	M-II	M-III	M-IV
		<i>Cents/dozen</i>						<i>Cents/dozen</i>			
1961:						1965:					
1	37.45	38.04	24.62	39.92	38.99	1	26.40	38.78	21.16	31.05	32.63
2	39.16	36.99	37.12	36.77	37.21	2	27.95	44.22	33.42	28.71	29.71
3	36.00	40.08	40.35	36.16	34.37	3	29.28	42.79	43.13	29.27	29.35
4	32.89	30.98	31.02	31.46	31.04	4	31.23	34.07	34.08	31.56	31.73
5	31.48	26.12	26.58	29.76	29.32	5	27.63	26.37	27.50	29.10	28.52
6	33.16	30.11	30.10	30.79	30.05	6	29.66	29.05	29.69	31.03	31.55
7	35.13	33.04	32.95	34.21	34.84	7	30.12	33.25	33.35	34.19	34.28
8	37.12	37.03	36.86	38.48	38.77	8	35.90	35.39	35.39	34.33	35.70
9	40.78	42.43	42.55	41.41	42.68	9	38.64	40.10	40.17	40.70	40.71
10	40.18	41.08	41.17	39.57	41.30	10	39.31	45.50	45.85	38.38	38.86
11	36.64	49.65	49.36	38.52	40.30	11	41.21	40.73	42.09	41.37	41.08
12	33.85	45.03	45.04	34.25	35.41	12	41.75	52.80	52.76	42.41	44.06
1962:						1966:					
1	36.23	35.60	25.89	32.15	32.53	1	37.99	48.41	34.03	40.91	42.20
2	33.34	32.47	32.47	34.39	33.93	2	41.68	40.16	40.21	37.63	38.90
3	31.41	21.04	20.51	31.57	31.93	3	42.63	47.76	47.85	46.69	42.79
4	31.03	26.81	26.84	27.26	27.42	4	38.60	39.87	39.88	39.69	40.69
5	27.27	20.54	21.53	28.21	26.80	5	32.17	34.68	34.52	32.67	33.69
6	27.14	26.71	26.64	25.62	27.69	6	32.82	37.20	37.37	35.17	35.18
7	28.81	31.00	30.80	28.74	29.26	7	40.53	42.58	42.52	39.41	41.29
8	34.93	37.15	36.83	35.73	35.80	8	42.11	40.74	40.74	40.49	40.88
9	42.11	42.82	42.89	39.22	39.22	9	47.98	46.04	46.14	46.59	46.48
10	38.43	40.69	40.71	39.53	38.06	10	43.40	33.29	32.91	40.60	42.42
11	40.18	24.37	24.89	36.19	35.26	11	46.00	30.66	32.15	47.60	46.11
12	37.28	27.54	27.48	36.47	34.48	12	40.24	32.62	32.55	41.91	41.71
1963:						1967:					
1	36.05	36.85	31.62	35.64	35.14	1	34.49	36.20	22.75	34.48	34.13
2	37.43	36.83	36.74	36.94	35.32	2	31.45	30.02	30.30	29.84	32.92
3	35.08	32.07	31.70	36.08	35.93	3	32.52	31.99	32.07	32.43	34.26
4	29.00	32.89	32.93	32.87	32.67	4	26.78	25.87	25.84	27.49	27.66
5	28.53	30.70	30.18	27.97	28.46	5	26.30	26.55	26.26	25.60	26.70
6	29.34	29.54	29.42	29.54	29.43	6	25.57	24.18	24.09	26.48	26.15
7	32.48	30.23	30.36	31.68	30.58	7	33.03	27.52	27.62	30.38	31.51
8	34.70	36.37	36.37	36.01	35.10	8	29.67	26.84	27.03	29.32	29.18
9	40.25	38.83	38.93	38.51	38.40	9	32.54	28.87	27.79	33.59	34.80
10	38.00	37.50	36.99	38.50	37.93	10	28.66	25.69	26.00	30.02	29.80
11	38.13	39.71	40.28	36.83	37.08	11	30.10	29.33	28.90	29.14	31.29
12	37.76	32.70	32.63	36.35	36.22	12	32.00	33.42	22.23	29.99	29.60
1964:						1968:					
1	39.39	40.57	27.98	36.27	35.93	1	30.98	37.80	19.81	31.17	31.81
2	32.40	34.24	34.10	37.26	36.34	2	27.82	26.36	26.35	27.61	26.93
3	32.93	29.48	39.32	31.89	32.63	3	30.05	23.11	22.31	30.15	28.90
4	29.36	30.54	30.56	30.82	30.64	4	28.68	27.07	27.03	26.99	26.99
5	28.08	37.27	35.57	28.27	28.88	5	25.93	25.73	26.03	26.42	26.55
6	30.09	30.72	30.47	29.24	30.06	6	31.60	32.53	32.50	31.16	32.18
7	32.91	32.72	32.63	32.72	30.75	7	36.36	38.74	38.89	39.87	38.58
8	38.33	36.30	36.24	35.91	35.28	8	37.38	39.00	39.12	38.15	38.27
9	36.50	38.27	38.42	41.52	39.58	9	50.85	47.42	47.41	45.18	44.70
10	36.57	36.45	36.07	36.19	36.33	10	38.52	43.76	43.70	43.96	37.62
11	33.08	38.37	38.59	36.07	35.30	11	42.74	49.70	50.27	44.57	41.41
12	31.05	38.37	38.33	33.41	34.31	12	46.76	49.68	49.61	45.72	44.06

Continued

Table 4—Actual and predicted monthly shell egg prices, 1961-71—Continued

Year and month	Actual prices <sup>1</sup>	Prices predicted from models				Year and month	Actual prices <sup>1</sup>	Prices predicted from models			
		M-I	M-II	M-III	M-IV			M-I	M-II	M-III	M-IV
Cents/dozen						Cents/dozen					
1969:											
1	47.25	49.64	37.36	44.71	42.96	7	40.48	57.43	57.10	48.37	48.71
2	39.92	40.87	40.80	42.39	45.90	8	38.88	46.42	46.60	44.94	46.75
3	41.12	43.36	43.30	41.82	40.83	9	44.64	58.04	57.96	51.54	53.50
4	38.74	38.08	38.05	38.05	37.35	10	35.30	39.16	39.89	38.64	33.76
5	32.21	30.74	31.09	31.69	30.73	11	38.45	62.42	61.80	43.67	39.95
6	33.98	36.43	36.33	34.58	34.23	12	41.67	48.32	48.24	43.51	42.36
7	45.95	46.47	46.42	44.16	44.24	1971:					
8	42.07	43.55	42.66	43.63	42.14	1	38.55	48.42	33.50	40.16	39.57
9	47.45	53.26	53.26	50.41	48.92	2	34.47	33.74	33.98	32.43	32.09
10	45.89	45.71	46.02	42.20	46.65	3	34.07	48.76	49.16	38.73	38.90
11	58.16	61.83	61.64	56.01	58.66	4	33.73	34.41	34.32	33.00	34.27
12	58.52	58.14	64.51	58.63	59.29	5	29.48	40.44	38.68	28.81	29.71
1970:						6	30.32	43.23	42.71	36.98	38.12
1	59.75	56.86	40.90	52.58	51.77	7	33.65	53.35	53.14	45.56	48.52
2	50.18	39.38	39.54	45.39	45.90	8	35.38	45.10	45.36	41.90	45.79
3	46.71	53.86	54.33	50.65	50.88	9	33.61	58.49	58.42	50.16	54.79
4	36.20	37.06	37.01	39.33	37.30	10	33.28	59.40	61.58	37.02	34.27
5	31.85	31.26	20.95	29.73	28.84	11	34.50	73.38	72.93	43.01	41.00
6	34.82	38.57	38.42	35.51	35.45	12	37.25	88.51	88.57	46.60	49.44

<sup>1</sup> Simple average of Chicago daily cash prices, prices paid delivered, 80-percent grade A large white eggs.

Table 5—Actual and predicted monthly production of shell egg, eggs per layer, and eggs used for hatching, 1961-71

Year and month	Production of shell eggs				Eggs used for hatching		Year and month	Production of shell eggs				Eggs used for hatching	
	Total		Per layer		Actual	Predicted		Total		Per layer		Actual	Predicted
	Actual	Predicted	Actual	Predicted				Actual	Predicted	Actual	Predicted		
	Million dozen		Number		Million dozen			Million dozen		Number		Million dozen	
1961:													
1	433.50	429.17	16.98	16.74	25.3	24.0	7	435.83	438.41	18.40	18.40	21.7	21.8
2	410.42	408.85	16.34	16.23	34.0	32.0	8	421.33	419.50	17.56	17.63	20.3	20.1
3	477.83	477.18	19.24	19.12	37.0	36.2	9	406.50	405.80	16.46	16.44	21.5	21.3
4	464.92	467.43	19.02	19.10	34.5	33.9	10	426.50	425.68	16.79	16.79	21.4	21.0
5	467.83	475.37	19.52	19.63	26.8	26.2	11	421.67	430.39	16.37	16.43	21.4	21.3
6	432.67	438.13	18.33	18.35	24.2	23.6	12	441.25	445.44	17.07	17.10	23.0	23.6
7	423.25	424.61	18.15	18.14	21.5	20.6	1963:						
8	411.83	412.12	17.39	17.34	18.7	18.5	1	426.25	444.63	17.00	17.34	23.2	24.6
9	396.42	396.37	16.15	16.22	18.3	18.5	2	404.08	410.28	15.94	16.17	29.9	31.6
10	417.92	419.04	16.45	16.47	18.4	18.6	3	475.67	474.09	18.95	19.00	34.0	34.6
11	419.00	411.95	16.18	16.15	19.9	20.0	4	472.92	467.63	19.06	18.98	33.6	33.8
12	444.33	439.03	16.97	16.94	23.2	22.2	5	472.92	478.66	19.65	19.68	27.3	27.7
1962:							6	444.33	447.47	18.55	18.57	24.5	25.6
1	446.08	446.98	17.41	17.26	23.3	23.5	7	439.75	439.29	18.46	18.44	22.3	23.2
2	416.42	420.32	16.17	16.30	32.0	32.3	8	427.75	427.32	17.76	17.75	20.2	21.1
3	483.58	485.34	19.01	19.07	34.8	35.2	9	410.25	414.00	16.64	16.68	21.3	21.6
4	474.08	477.07	19.00	19.02	33.8	33.6	10	429.17	431.49	17.01	17.00	21.7	21.9
5	480.58	485.94	19.71	19.63	26.3	26.9	11	427.00	425.60	16.67	16.61	22.9	22.6
6	443.58	448.74	18.59	18.59	24.0	24.1	12	445.08	447.02	17.26	17.40	23.4	24.3

Continued

Table 5—Actual and predicted monthly production of shell eggs, eggs per layer, and eggs used for hatching, 1961-71—Continued

Year and month	Production of shell eggs				Eggs used for hatching		Year and month	Production of shell eggs				Eggs used for hatching	
	Total		Per layer		Actual	Predicted		Total		Per layer		Actual	Predicted
	Actual	Predicted	Actual	Predicted				Actual	Predicted	Actual	Predicted		
	Million dozen		Number		Million dozen			Million dozen		Number		Million dozen	
1964:							1968:						
1	450.17	449.70	17.57	17.51	25.0	25.4	1	498.00	494.51	18.31	18.29	28.3	27.4
2	438.42	419.65	17.27	16.61	31.4	32.0	2	471.00	465.27	17.44	17.08	33.0	32.9
3	486.00	486.41	19.26	19.27	33.0	32.7	3	513.00	513.28	19.15	19.25	34.1	34.5
4	475.92	475.48	19.10	19.04	32.6	33.2	4	498.00	502.56	18.88	18.93	35.2	35.4
5	485.33	479.83	19.74	19.71	27.7	28.4	5	507.00	511.30	19.46	19.59	32.4	32.6
6	454.33	452.69	18.71	18.70	25.6	26.3	6	477.00	476.98	18.60	18.56	30.9	30.9
7	448.83	451.18	18.56	18.63	23.4	24.5	7	483.00	479.90	18.88	18.81	29.5	30.0
8	436.67	437.03	17.87	17.90	21.4	22.3	8	471.00	471.16	18.37	18.44	26.4	27.0
9	423.58	422.04	16.90	16.83	22.3	23.1	9	453.00	455.27	17.47	17.50	27.8	28.5
10	442.42	441.83	17.29	17.28	22.0	22.8	10	471.00	470.04	18.01	17.98	28.3	29.1
11	434.08	436.60	16.80	16.85	23.1	23.7	11	459.00	460.82	17.41	17.42	28.9	29.5
12	458.75	456.17	17.64	17.50	24.5	25.0	12	474.00	481.47	17.97	18.02	29.9	31.1
1965:							1969:						
1	469.00	462.89	18.15	17.90	24.8	25.2	1	477.00	482.03	18.06	18.11	29.3	30.1
2	429.08	434.82	16.84	17.06	30.5	31.4	2	441.00	438.34	16.79	16.83	35.3	35.6
3	482.42	485.28	19.12	19.17	32.7	33.2	3	498.00	497.32	19.16	19.09	36.1	36.1
4	473.17	473.12	18.96	18.98	33.8	34.0	4	489.00	488.51	18.84	18.91	37.2	37.3
5	488.00	482.53	19.74	19.62	30.1	29.9	5	507.00	506.00	19.62	19.58	34.4	35.2
6	460.42	454.46	18.74	18.74	28.3	27.8	6	480.00	478.51	18.69	18.77	32.7	33.4
7	457.92	456.73	18.72	18.72	25.9	25.9	7	483.00	484.22	18.87	18.75	31.2	31.5
8	445.17	448.42	18.11	18.11	23.7	23.1	8	477.00	474.92	18.51	18.49	29.7	30.2
9	428.67	431.87	17.13	17.11	24.6	24.4	9	459.00	460.57	17.64	17.69	30.4	31.0
10	446.00	445.03	17.55	17.53	24.5	24.2	10	477.00	480.47	18.16	18.18	31.0	30.9
11	437.08	440.93	17.04	17.06	26.0	25.6	11	468.00	467.54	17.53	17.54	32.4	32.2
12	457.42	454.15	17.76	17.73	28.0	27.4	12	489.00	485.68	18.12	18.11	34.5	34.2
1966:							1970:						
1	458.83	457.81	17.92	18.00	27.3	27.4	1	492.00	492.33	18.12	18.24	33.0	32.4
2	419.33	424.51	16.51	16.83	33.1	34.1	2	447.00	457.51	16.53	16.85	39.4	37.8
3	479.58	479.17	19.01	19.08	35.9	36.4	3	504.00	505.90	18.83	19.02	39.8	36.9
4	473.17	470.52	18.94	18.93	36.7	36.9	4	495.00	499.00	18.56	18.80	39.9	37.9
5	485.00	483.49	19.64	19.62	33.0	32.3	5	507.00	520.70	19.23	19.39	37.0	35.5
6	458.08	453.13	18.70	18.67	30.8	30.1	6	483.00	487.17	18.34	18.39	34.4	33.9
7	456.83	454.96	18.68	18.76	28.4	27.4	7	489.00	485.93	18.68	18.75	31.0	32.8
8	450.75	448.31	18.17	18.13	27.2	25.9	8	486.00	478.10	18.42	18.38	28.8	28.1
9	442.75	434.63	17.34	17.22	28.3	26.6	9	471.00	466.91	17.56	17.64	29.5	29.5
10	466.67	462.60	17.79	17.77	27.2	26.2	10	492.00	501.36	18.06	18.16	30.8	31.1
11	462.50	457.66	17.32	17.26	27.7	27.5	11	483.00	477.41	17.57	17.76	32.1	31.7
12	486.42	483.47	18.02	18.00	29.1	28.6	12	510.00	508.14	18.31	18.11	34.3	32.9
1967:							1971:						
1	492.33	493.27	18.32	18.26	28.9	27.8	1	513.00	515.93	18.52	18.42	30.7	30.8
2	450.33	457.46	16.96	17.13	35.3	32.7	2	465.00	478.18	17.02	17.14	36.7	35.2
3	509.17	507.12	19.31	19.16	35.6	34.3	3	519.00	518.74	19.14	19.11	37.8	35.1
4	498.83	497.91	19.09	18.99	35.6	34.6	4	504.00	509.87	18.76	18.86	38.1	36.4
5	510.00	506.91	19.72	19.73	32.1	31.1	5	519.00	522.66	19.50	19.54	35.0	36.1
6	483.67	483.50	18.83	18.80	30.2	29.4	6	495.00	491.40	18.80	18.72	33.0	34.9
7	488.17	489.21	19.04	18.92	29.4	28.4	7	501.00	505.10	19.09	19.14	32.6	34.0
8	481.50	484.42	18.58	18.53	25.9	25.2	8	495.00	493.96	18.77	18.82	29.2	29.7
9	466.17	465.72	17.63	17.67	26.2	25.6	9	477.00	478.36	18.02	18.03	29.0	31.5
10	485.92	486.40	18.04	18.07	26.2	25.9	10	499.00	498.04	18.60	18.62	30.0	31.9
11	474.67	470.30	17.46	17.46	26.6	26.3	11	493.08	479.84	18.11	17.90	31.7	32.7
12	495.17	499.26	18.09	18.11	28.8	28.0	12	514.00	501.76	18.79	18.64	33.3	

Table 6--Actual and predicted eggs used for breaking during the month, 1961-71

Year and month	Eggs used for breaking			Year and month	Eggs used for breaking			Year and month	Eggs used for breaking		
	Actual	Predicted from models			Actual	Predicted from models			Actual	Predicted from models	
		M-I	M-II			M-I	M-II			M-I	M-II
	Million dozen				Million dozen				Million dozen		
1961:				1965:				1969:			
1	23.77	18.41	20.75	1	35.39	35.31	34.82	1	26.73	35.43	29.11
2	34.26	30.52	30.61	2	38.99	38.29	38.48	2	29.04	26.48	26.33
3	52.26	51.36	51.60	3	50.18	38.13	48.31	3	32.55	33.62	33.66
4	57.36	59.38	59.34	4	44.92	52.16	52.16	4	44.13	44.13	44.18
5	75.27	73.88	74.57	5	55.07	50.39	59.92	5	56.91	44.04	53.66
6	70.76	72.14	72.06	6	63.13	62.34	63.11	6	60.75	58.34	58.27
7	42.31	44.20	44.26	7	49.62	49.14	49.19	7	49.47	48.20	48.15
8	31.77	29.95	30.15	8	37.62	40.57	40.54	8	42.57	39.44	40.46
9	23.15	20.66	20.63	9	29.68	30.22	30.20	9	35.79	33.52	33.48
10	24.02	21.54	21.73	10	24.93	31.54	31.95	10	42.12	39.87	50.17
11	23.70	19.40	19.07	11	24.57	23.68	23.75	11	30.84	33.11	32.69
12	23.57	29.30	29.32	12	23.45	28.43	28.42	12	35.46	33.38	35.48
1962:				1966:				1970:			
1	24.37	30.30	31.19	1	26.74	30.86	28.65	1	37.38	42.24	36.73
2	28.13	32.38	32.30	2	24.81	28.47	28.48	2	38.79	34.22	34.38
3	47.08	49.06	48.89	3	36.34	34.08	34.16	3	44.07	37.50	37.76
4	57.07	61.96	61.94	4	48.26	45.90	45.90	4	50.13	43.92	43.99
5	76.64	71.53	72.95	5	59.11	50.69	60.89	5	57.78	47.78	56.56
6	77.04	73.47	73.35	6	62.75	60.44	60.51	6	64.26	57.40	57.01
7	55.53	49.68	51.70	7	44.99	44.86	44.89	7	53.10	45.11	44.98
8	37.15	31.97	32.34	8	34.91	36.31	36.30	8	48.18	38.15	37.90
9	24.44	24.21	24.15	9	30.79	28.49	28.48	9	44.73	35.49	35.41
10	21.12	23.25	23.35	10	31.03	29.59	29.10	10	48.63	47.49	48.21
11	17.52	22.87	22.95	11	33.58	30.17	29.51	11	40.05	37.63	37.19
12	16.01	14.80	14.76	12	38.65	31.55	31.61	12	44.04	40.28	40.23
1963:				1967:				1971:			
1	19.51	25.18	23.23	1	43.86	47.69	44.29	1	45.87	49.62	42.39
2	22.10	26.42	26.22	2	45.44	44.66	44.97	2	42.50	42.24	44.31
3	40.00	40.19	40.09	3	53.38	52.46	52.56	3	54.96	41.44	41.69
4	60.46	55.44	55.42	4	58.70	57.21	57.26	4	54.27	45.16	45.27
5	74.03	74.68	73.95	5	68.63	59.50	66.87	5	56.37	48.63	58.10
6	63.91	70.86	70.67	6	70.30	68.68	68.62	6	63.90	54.50	54.06
7	45.79	46.87	46.99	7	57.06	62.18	62.03	7	48.99	50.12	49.95
8	35.25	35.06	35.17	8	53.82	55.13	54.88	8	46.71	41.90	41.55
9	23.33	26.58	26.56	9	43.76	44.39	44.33	9	47.70	36.33	36.29
10	21.76	21.72	21.23	10	42.27	40.97	41.28	10	48.45	56.97	59.27
11	18.88	20.81	20.90	11	38.07	38.36	38.04	11	48.03	35.87	35.51
12	20.81	17.05	17.01	12	33.59	36.29	32.56	12	43.29	62.27	62.31
1964:				1968:							
1	21.23	28.93	28.12	1	38.42	44.42	40.64				
2	34.62	35.41	27.97	2	39.89	41.82	41.75				
3	46.88	49.18	49.16	3	47.98	48.38	48.39				
4	64.61	56.41	56.41	4	52.05	55.03	55.09				
5	73.83	66.63	75.51	5	59.79	52.75	60.79				
6	71.22	69.84	69.50	6	57.72	61.47	61.49				
7	51.14	51.91	51.88	7	52.67	49.34	49.37				
8	31.17	37.31	37.36	8	44.33	42.73	42.55				
9	26.72	26.79	26.81	9	31.98	34.83	34.79				
10	27.76	25.36	24.99	10	33.53	34.93	34.84				
11	25.09	25.53	25.47	11	30.21	29.11	29.21				
12	26.79	25.41	25.49	12	25.32	31.05	31.01				

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