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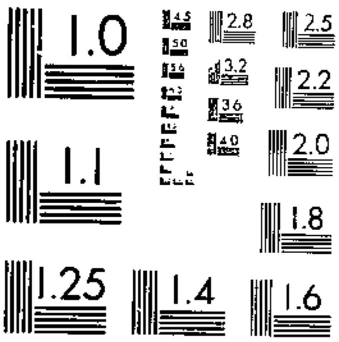

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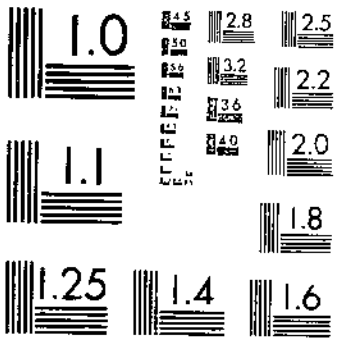

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November 1959

The Demand, Supply, and Price Structure for EGGS

by Martin J. Gerra

Agricultural Economic Statistician

Agricultural Marketing Service

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The Demand, Supply, and Price Structure for EGGS

By Martin J. Gerra, Agricultural Economic Statistician, Agricultural Marketing Service

Highlights

The principal contribution of this bulletin is the presentation of detailed analyses of the major factors that affect the demand for and supply of eggs in the United States and the quantification in a statistical model of the relationships among those factors.

Analysis of the factors that influence the supply of eggs indicates that the supply of eggs in a calendar year is influenced by price movements within the same period through two methods of adjustment under the control of producers—chick replacements and layers sold and consumed on farms where produced. If the egg-feed ratio in the first half of the year when producers are starting chicks for future flock replacement is lower than the ratio for the corresponding period in the previous year, producers generally start fewer replacements. If the egg-feed ratio is higher than a year earlier, they tend to increase the number of chicks started for flock replacement. The number of layers sold and consumed on farms where produced is related to the egg-feed ratio prevailing in that year as well as to the number of potential layers on farms on January 1. When the egg-feed ratio is above the previous year, the number of layers sold and consumed on farms where produced is less than when the egg-feed ratio in the current year is below the ratio in the previous year. This indicates an interaction between demand and supply within the 12-month span of January through December.

The interaction between the supply of eggs and the price of eggs leads to the formulation of 11 structural equations to explain the major relationships in the egg industry—2 demand, 2 supply, 2 price level, a storage, and 4 identity equations. Based on data for the years 1931–54, excluding the war years 1942–45, demand and supply coefficients are statistically obtained by the method of limited information, which allows for the simultaneous relationships in the egg industry, and by the method of least squares. Coefficients obtained by fitting demand relationships by the simultaneous approach differed more from the least squares results for the comparable demand relationships than did coefficients obtained for the supply relationships.

Measures of the elasticity of demand with respect to the price of eggs during the period studied ranged from −0.09 to −1.96. Larger demand elasticities were obtained from the equations fitted by the limited information method than by the least squares method. Based on the most statistically significant coefficient, a 1-percent change in the retail price of eggs, on the average, would be associated inversely with about a −0.4 percent change in the per capita consumption of eggs, after allowing for the effect of other economic factors. To increase per capita consumption by 1 percent requires a price concession at the retail level of about 2.5 percent, with an accompanying decline in consumers' expenditures for eggs. An elasticity of demand with respect to the price of eggs of −0.4 compares closely with the average of estimates derived in time series studies by other researchers. Estimates of demand elasticity in those studies ranged from −0.3 to −1.3, with an average for all the studies being about −0.5 to −0.6.

A measure of the elasticity of demand with respect to the price of eggs also was obtained from household expenditure data. Using pooled 1955 and 1942 survey data for urban households, a demand elasticity with respect to price of −1.5 was obtained. This measure is a great deal higher than the results obtained from time series data. We would expect a higher elasticity, however, because the variation in the price of eggs among income classes, especially for urban households, is due mainly to variations in the grade and size of eggs used. The price effect on consumption in a pooled cross section study mainly reflects this influence.

None of the demand equations fitted to time series data gave an elasticity of demand with respect to income that differed significantly from zero when tested at the 10-percent level of statistical probability. Difficulty in obtaining a statistically significant income response from time series analysis appears to be due to the high degree of interrelationship among income, the price of eggs at retail, and the general price level. In addition, the per capita consumption of eggs has declined yearly from 1951 while income per capita has risen.

Based on the income elasticities that were larger than their standard errors but did not differ significantly from zero at the 10-percent probability level, the elasticity of demand with respect to income derived from time series analysis probably falls within a range of zero to 0.2, after allowing for the effect of other economic factors. This range compares with an income elasticity obtained from cross-section data for all urbanizations in the spring of 1955 of 0.02, which differed significantly from zero at the 5-percent probability level. In addition, an elasticity of demand with respect to income of 0.18, statistically significant at the 5-percent level of probability, was obtained from pooled cross-section data for urban households in 1955 and 1942. Although measures of income elasticities obtained from cross-section data tend to be smaller than measures from time series data, it appears reasonable to assume from the analyses presented in this bulletin that the elasticity of demand with respect to income for eggs for the period 1931–41 plus 1946–54 is very low, perhaps in the neighborhood of 0.1. This would imply that if income per person increased about 10-percent, and the price of eggs and other variables remained unchanged, egg consumption per person would rise about 1-percent.

Other researchers have estimated elasticities of demand with respect to income ranging from 0.3 to 1.1, values substantially larger than those obtained in the analyses presented in this study. Part of the differences in income elasticities obtained in other analyses and the income elasticities obtained in this study arises from the different time periods used. Only 2 of the 13 analyses by other researchers included observations more recent than 1941; those two covered the period 1921–50. Intuitively, we expect that income elasticity would be greater in the pre-World War II period when income levels were much lower than in the post-World War II period. As the analyses in this bulletin included both pre- and post-World War II periods, we would expect a lower income elasticity than those obtained for pre-World War II analyses.

Measures of the elasticity of supply with respect to the price of eggs were not derived in this analysis because production responses were formulated with respect to the ratio of the farm price of eggs to the price of poultry ration. It was possible, however, to derive estimates of the elasticity of supply with respect to the price of poultry ration. These estimates indicate that for the period 1931–41 plus 1946–54 the relationship between changes in the price of poultry ration and the quantity of eggs produced was zero to −0.3.

Elasticities of supply of pullets raised with respect to the January-June average egg-feed ratio and of layers sold with respect to the annual average egg-feed ratio were obtained for the years 1931–54 (excluding 1942–1945). On the average, a 1-percent increase in the January-June average egg-feed ratio is associated with about a 0.4-percent increase in the number of pullets raised. A 1-percent increase in the annual average egg-feed ratio is associated, on the average, with a 0.4- to a 0.7-percent decrease in the number of layers sold and consumed on farms where produced.

In the studies of supply response by other researchers, presented in table 25, no supply elasticities were obtained that differed significantly from zero at the 10-percent level of probability. However, based on elasticities whose values were larger than their respective standard errors, it appears that in about two-thirds of the time we could expect between a zero to 0.4-percent increase in production following a 1-percent increase in the average price received by farmers for eggs. No conclusions from those studies can be made about the magnitude of the elasticity of supply with respect to the price of feed because either data to establish error ranges were not given or else the standard errors were larger than their regression coefficients.

Measures of long-run supply elasticities that are 10 times greater than the comparable short-run elasticities are reported in the study by Fisher (*14*).[1] Some caution is warranted, however, in considering short-run versus long-run relationships in the egg industry. The two measures differ, depending upon the period of time needed for an industry to adjust from a given level of production to some

[1] Italic numbers in parentheses refer to Literature Cited, page 130.

desired long-run equilibrium level. If a complete adjustment is made in one time period, the short-run and long-run elasticities would be equal. The long-run elasticity exceeds the short-run elasticity when more than one time period is required to adjust to the long-run equilibrium level. As producers can adjust so rapidly in the egg industry, it seems unlikely that the long-run elasticity would be so different from the adjustment producers can make in one year to a price change, except in response to a price increase that might encourage expansion beyond the existing capacity of the industry.

Equations fitted by both the simultaneous and least squares approaches, as well as alternative formulations, were used to forecast values of variables in the egg industry beyond the years for which the equations were fitted. Based on a comparison of the simultaneously estimated reduced form equations with the least squares structural equations, better estimates of the annual quantity variables (domestic egg consumption, farm egg production, average number of layers on farms, and number of layers sold) appear to be obtained from the simultaneous approach. But better estimates of the January-June quantity variables (domestic egg consumption, January-June, and net into-storage movement, January-June) and the price variables (annual retail price, annual farm price, average January-June retail price, and average January-June farm price) appear to be obtained by the least squares structural equations.

The simultaneously estimated reduced form equations express the variable to be estimated as an algebraically derived weighted sum of the variables in a model that are taken as known. In making the algebraic transformation to the reduced form equations, the coefficients obtained from fitting each structural equation by the method of limited information are used. Consequently, the reduced form equation contains more variables than appear in a structural equation. For example, the estimated values of egg consumption (presented in table 26) based on the simultaneous approach reduced form equations for model II of the egg industry are a weighted sum of 13 variables while the estimates from the least squares structural equations are based directly on the three variables specified as known in the least squares structural relationship. Other comparisons that can be made are discussed on page 95 and some indication of the results of those comparisons are made.

Introduction

This bulletin discusses the principal economic forces that affect the demand for and supply of eggs and quantifies these forces in a statistical model so that estimates of the effect on price of variations in the factors affecting demand and supply can be obtained. Such estimates aid producers and marketers of food in estimating price trends and future income, so that necessary decisions regarding production and marketing can be made.

In the years 1948–57, the value of cash receipts from farming and the value of home consumption of eggs on farms where produced averaged $2.0 billion for the country as a whole, a value equaled or exceeded only by cotton lint ($2.3 billion), hogs ($3.6 billion), dairy products ($4.8 billion), and cattle and calves ($5.7 billion). In these years, year-to-year variation in gross income from eggs averaged $0.2 billion.

Variation in gross income from eggs reflects changes in the average price received by farmers and in the quantity of eggs produced. For the 10 years under consideration, the average price was 41.6 cents per dozen, and the average year-to-year change in price was 5.7 cents. Production from farm flocks during this period averaged 58.4 billion eggs annually, with an average year-to-year change of 1.0 billion eggs.

The customary technique for obtaining measures of the relationship between price and consumption on the demand side, and price and supply on the supply side of a market, has been the use of single-equation least squares regression analysis. In the last 10 to 15 years, however, the pioneering work of Haavelmo, and the subsequent elaboration by staff members of the Cowles Commission for Research in Economics [see, for example, (*28*) and (*29*)], has pointed out that under certain conditions, which may here be inadequately grouped into the term "simultaneity," single-equation least squares regression analysis may not give unbiased estimates of the structural coefficients in economic models. If simultaneity of certain types is present, a system of simultaneous equations should be used to obtain estimates of the coefficients in the economic model. There is some agreement, however, that the single-equation analysis may serve satisfactorily as a forecasting model for a single variable when it is known, or can be assumed, that structural relations have not changed. Comparisons of forecasted values for several variables in the egg industry from both the simultaneous approach and the single-equation least squares method are discussed on pages 86 to 96.

The reasons for specifying a simultaneous model are well known to econometricians; nevertheless, to the investigator of a particular economic problem, the extent to which simultaneous relationships are involved in the economic structure being studied is not always readily apparent. Investigators of the demand for eggs in the United States have used both single-equation and multi-equation models. Fox (*16*) fitted a single-equation model, Cromarty (*12*) simultaneously fitted demand and supply equations, and Judge (*35*), Nordin, Judge, and Wahby (*37*), and Fisher (*14*) fitted both single-equation and multi-equation models. Measurements of demand and supply elasticities from these studies are given on page 81.

Major Relationships in the Egg Economy

The major economic relationships and variables that constitute the egg economy are shown in figure 1. Items that represent physical quantities are shown in boxes; factors representing price and value appear in circles. The solid lines connecting the various items indicate the more important factors; the broken lines indicate factors that are relatively minor or operate only occasionally. Arrows indicate the principal directions of influence of each factor. Double-pointed arrows indicate factors that are believed to be simultaneously related. The symbols in some of the boxes and circles refer to the variables listed on pages 62 and 63, and to the equations listed on page 64. Not all the factors that appear in the diagram are in the equations because of limitation of data and the requirement that economic models be statistically manageable.

In the diagram, simultaneous relationships are indicated between price and consumption. In turn, consumption is closely tied to production; annual differences in end-of-year storage, exports, and hatching requirements are of minor importance in the distribution of eggs (table 1). Approximately 96 percent of egg production during the years 1909-40 was consumed domestically as food. In the subsequent period 1941-56, the proportion consumed as food by United States civilians and by our Armed Forces was 91 percent. Excluding those eggs which were consumed by the military either in this country or overseas, 88 percent of egg production was consumed domestically as food in either shell or processed form.

Use of liquid, frozen, and dried eggs, however, is relatively small except during periods of war. Based on data available since 1938, liquid, frozen, and dried egg production, converted to shell equivalent, ranged from 3 percent to a high of 23 percent of total shell egg production. However, per capita use of processed eggs varied from 3 percent to 7 percent of per capita civilian egg consumption of both shell and processed eggs (table 2) as a large part of liquid, frozen, and dried egg production in the war years was shipped abroad or used by the military. Consumption of eggs in shell form by final consumers, therefore, is the major outlet for our egg production.

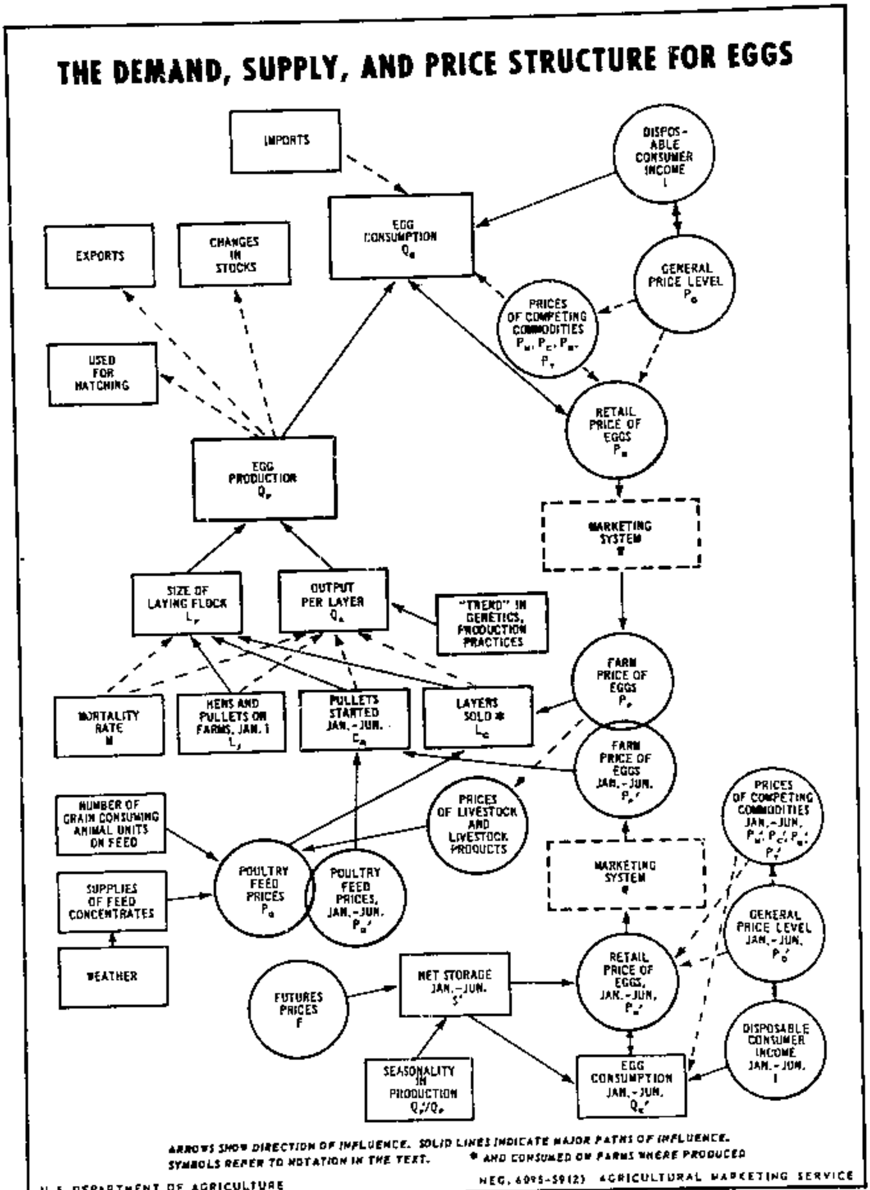

FIGURE 1.—The factors illustrated here—physical and economic—largely determine the basic economic relationships that exist in the egg economy.

TABLE 1.—*Eggs: Supply and distribution, 1909–58*

Year	Supply				Distribution				Domestic disappearance		
										Civilian	
	Production [1]	Beginning commercial stocks [2]	Imports [3]	Total	Ending commercial stocks [2]	Commercial exports and shipments [4]	Used for hatching	USDA net purchases for export	Military	Total	Per capita [5]
	Million dozen	*Million dozen*	*Million dozen*	*Million dozen*	*Million dozen*	*Million dozen*	*Million dozen*	*Million dozen*	*Million dozen*	*Million dozen*	*Number*
1909	2, 319	--------	--------	2, 319	--------	5	106	--------	--------	2, 208	293
1910	2, 475	--------	3	2, 478	--------	6	116	--------	--------	2, 356	306
1911	2, 695	--------	5	2, 700	--------	13	112	--------	--------	2, 575	329
1912	2, 594	--------	8	2, 602	--------	19	109	--------	--------	2, 474	312
1913	2, 576	--------	11	2, 587	--------	18	112	--------	--------	2, 457	303
1914	2, 557	--------	19	2, 576	--------	21	116	--------	--------	2, 439	295
1915	2, 741	--------	17	2, 758	--------	22	114	--------	--------	2, 622	313
1916	2, 640	45	26	2, 711	30	28	111	--------	--------	2, 542	299
1917	2, 539	30	40	2, 609	52	20	113	--------	--------	2, 424	281
1918	2, 567	52	29	2, 648	30	21	120	--------	--------	2, 477	284
1919	2, 796	30	49	2, 875	63	39	119	--------	--------	2, 654	303
1920	2, 722	63	50	2, 835	35	27	116	--------	--------	2, 657	299
1921	2, 823	35	52	2, 910	43	33	125	--------	--------	2, 709	300
1922	3, 025	43	54	3, 122	59	35	131	--------	--------	2, 897	316
1923	3, 208	59	31	3, 298	85	31	136	--------	--------	3, 046	326
1924	3, 171	85	41	3, 297	50	28	136	--------	--------	3, 083	324
1925	3, 205	50	58	3, 313	79	25	139	--------	--------	3, 070	318
1926	3, 414	79	53	3, 546	61	27	146	--------	--------	3, 312	339
1927	3, 541	61	36	3, 638	66	29	151	--------	--------	3, 392	342
1928	3, 544	66	35	3, 645	89	20	139	--------	--------	3, 397	338
1929	3, 476	89	53	3, 618	66	12	147	--------	--------	3, 393	334

1930	3, 581	66	44	3, 691	125	19	149	--------	--------	3, 398	331
1931	3, 532	125	34	3, 691	109	8	135	--------	--------	3, 439	333
1932	3, 327	109	10	3, 446	50	2	136	--------	--------	3, 258	313
1933	3, 255	50	9	3, 314	72	2	137	--------	--------	3, 103	296
1934	3, 156	72	8	3, 236	72	2	122	--------	--------	3, 040	289
1935	3, 081	72	22	3, 175	85	2	124	--------	--------	2, 964	280
1936	3, 166	85	27	3, 278	61	2	134	--------	--------	3, 081	289
1937	3, 443	61	32	3, 536	112	2	115	--------	--------	3, 307	308
1938	3, 424	112	6	3, 542	59	2	124	--------	--------	3, 357	310
1939	3, 561	59	5	3, 625	74	3	133	--------	--------	3, 415	313
1940	3, 640	74	7	3, 721	77	5	129	--------	--------	3, 510	319
1941	3, 840	77	15	3, 932	75	12	174	190	62	3, 419	311
1942	4, 456	75	3	4, 534	74	13	197	602	164	3, 484	318
1943	5, 000	74	1	5, 075	100	15	238	616	382	3, 724	347
1944	5, 366	100	1	5, 467	80	17	206	[6] 872	495	3, 797	354
1945	5, 154	80	2	5, 236	61	17	231	[6] 15	583	4, 329	402
1946	5, 130	61	1	5, 192	109	66	179	300	163	4, 375	379
1947	5, 077	109	1	5, 187	73	48	176	259	77	4, 554	383
1948	5, 032	73	2	5, 107	72	40	178	[6] —15	[7] 127	4, 705	389
1949	5, 148	72	8	5, 228	53	28	202	[6] 166	[7] 62	4, 717	383
1950	5, 404	53	20	5, 477	52	30	201	[6] 248	71	4, 875	389
1951	5, 322	52	8	5, 382	63	39	226	—44	155	4, 941	392
1952	5, 323	63	8	5, 394	54	54	218	—34	118	4, 984	390
1953	5, 307	54	7	5, 368	38	58	227	--------	117	4, 928	379
1954	5, 402	38	4	5, 444	69	64	224	--------	101	4, 986	376
1955	5, 404	69	2	5, 475	73	65	228	--------	91	5, 018	371
1956	5, 479	73	2	5, 554	88	64	256	--------	80	5, 066	368
1957	5, 389	88	1	5, 478	68	50	252	--------	83	5, 025	358
1958	5, 360	68	2	5, 430	49	43	287	--------	72	4, 979	349

[1] Farm production plus an allowance for backyard flock production of 10 percent, 1909–54; 9 percent, 1955; 8 percent, 1956; 7 percent, 1957; and 6 percent, 1958.

[2] Shell and frozen eggs prior to 1943; subsequently includes dried egg holdings.

[3] Shell eggs plus the shell equivalent of dried and frozen eggs.

[4] Includes shell eggs only prior to 1941.

[5] Civilian per capita only, beginning 1941. Based on population figures not adjusted for underenumeration.

[6] Includes following storage losses in million dozen: 1944, 16; 1945, 2; 1948, 4; 1949, 2; and 1950, 1.

[7] Includes quantities transferred from USDA stocks for civilian feeding of: 1948, 21 million pounds dried egg (63 million dozen); 1949, 703 thousand pounds dried egg (2 million dozen).

TABLE 2.—*Eggs: Liquid, frozen, and dried production; percentage of shell egg production; and civilian per capita use, shell and processed, 1938–58*

Year	Liquid, frozen, and dried egg production		Civilian per capita use	
	Shell equivalent [1]	Percentage of shell egg production [2]	Shell	Processed [3]
	Million dozen	*Percent*	*Number*	*Number*
1938	119.0	3.5	293	17
1939	176.2	4.9	294	19
1940	183.4	5.0	300	19
1941	337.5	8.8	300	11
1942	808.9	18.2	306	12
1943	977.6	19.6	328	19
1944	1,243.2	23.2	327	27
1945	545.3	10.6	379	23
1946	630.6	12.3	359	20
1947	546.0	10.8	359	25
1948	401.7	8.0	361	28
1949	470.1	9.1	358	25
1950	557.5	10.2	364	25
1951	318.4	5.9	365	27
1952	297.9	5.5	362	28
1953	320.5	6.0	354	25
1954	363.1	6.7	351	25
1955	353.3	6.5	346	25
1956	362.2	6.6	343	25
1957	369.9	6.9	331	27
1958	365.2	6.8	323	26

[1] Converted on the basis of 37.5 pounds of liquid egg obtained per case of shell eggs broken prior to Jan. 1, 1951, and 38.5 pounds for subsequent breaking stock.

[2] Farm output plus 10 percent of such production to allow for nonfarm egg production, 1938–54; 9 percent, 1955; 8 percent, 1956; 7 percent, 1957; 6 percent, 1958.

[3] Liquid, frozen, and dried egg (egg solids) converted to a shell equivalent. A large part of liquid, frozen, and dried egg production in the war years was shipped abroad and is not reflected in per capita use of processed eggs.

Consumer disposable income is not influenced to any great degree by variations in the price, supply, or consumption of eggs. In the last 30 years, the value of retail expenditures for eggs has not been more than 2 percent of disposable personal income. Therefore, disposable personal income is treated as independent of fluctuations in the price, supply, or consumption of eggs. Koopmans (*30*, p. 131), however, has pointed out that the exogenous character of consumers' income is assumed merely for reasons of exposition. Price and quantity on any market affect income directly to some extent. Furthermore, the disturbances affecting the market under consideration may well be correlated with similar disturbances in several other markets. Together, they may have a considerably larger effect on consumers' income and, therefore, be correlated with the disturbances of the equation for the market under consideration. In general, however, when working with highly perishable items such as eggs, we can justify treating variables that relate to the general economy as predetermined.

It appears reasonable to assume that the current price of eggs does not greatly affect the supply or even the price of any competing product. Of course, as producers vary culling rates because of changes in profit level, more or less farm chickens are available for consumption. However, because the level of profits is a function not only of the price of eggs, but of feed and other variable and fixed costs, the effect of current egg prices on the supply of farm chickens for slaughter is small. Also, the degree to which poultry meat is substituted by consumers for eggs is probably negligible. It appears that these two commodities compete only in the sense that consumers' budgets are limited and, in allocating dollars for food expenditures, eggs and poultry meat both receive a share.

The major question to be resolved with respect to simultaneity, therefore, is whether the supply of eggs reacts to changes in the current egg price within the same year. If the current price of eggs does not have a significant effect on supply, then a single-equation estimating procedure can be used to determine the structural coefficients for the demand for eggs. Otherwise, a system of equations should be solved simultaneously to allow for the interaction of supply with current price.

As eggs are a perishable agricultural commodity produced continuously throughout the year, price must adjust so that current production continuously clears the market, after allowing for storage, hatchings, breaking, and exports. In the spring months of flush production, into-storage movement and breaking activity become important. For an analysis of annual data, however, it can be assumed that the price of eggs is determined as a function of the quantity of eggs available for consumption and factors affecting consumer demand.

Because only a small part of production is exported, annual production and domestic consumption are closely related. During the period 1925–41, 95 percent of the annual variation in the consumption of eggs was associated with changes in the production of eggs. In terms of year-to-year differences, the coefficient of determination is about 82 percent. For the postwar period 1946–54, the relation between production and consumption (civilian consumption and the quantities purchased by the military) is approximately unchanged in terms of original values. In that period, however, there was little relation between year-to-year changes in production and consumption due mainly to the effect of military purchases and Department of Agriculture transactions in 1946–50. Those events, however, were due to extraordinary circumstances and did not reflect a basic shift in economic relationships.

Fox (*15*, p. 59) suggests that an indication of the amount of simultaneity that may exist between production and current price can be obtained by correlating production with the predetermined and exogenous variables that are known to influence production. The residual variation is a measure of the endogenous or simultaneously determined aspects of production as well as a measure of the "disturbance bias" which might be involved. Endogenous variables are designated as those variables which are determined simultaneously within the model. Exogenous variables are defined as influencing the set of relationships constituting the model but are not considered as influenced by them. Exogenous variables are grouped with lagged values of endogenous variables under the term predetermined variables.

Among the factors influencing farm egg production, the number of hens and all pullets on farms on January 1, the average rate of lay during the current year, and the egg-feed ratio for the previous year meet the "predetermined" criterion. An analysis of the first differences of logarithmic values of the variables showed that for the period 1925–53, these predetermined variables explained 81 percent of the variation in egg production on farms. The value of the coefficient obtained for the lagged egg-feed ratio was not statistically significant and it could be dropped from the equation with only a slight reduction in the percentage of variation in farm egg production explained by predetermined variables. Consequently, although a large part of the variation in egg production can be explained by predetermined variables, a significant amount of variation due to the action of endogenous supply factors remains unexplained. On the strength of this finding, it appeared appropriate to design a structural analysis to test the extent to which production is in part endogenous. The following sections examine the factors that influence the supply and demand for eggs for simultaneous relationships, formulating the major factors into a model of the egg economy.

Factors That Influence the Supply of Eggs

Formulation of an answer to whether supply is affected by current price is complicated by the lack of empirical data for many of the variables involved. Conceptually, if the price received by farmers for eggs increases, and other things remain unchanged, producers would be willing to supply more eggs—if price decreases, fewer eggs—than at the original price. This is merely a description of the familiar Marshallian supply schedule or curve under conditions of pure competition. As a theoretical formulation, it serves admirably. In application to actual experience, modifications become necessary. Marshall was altogether aware of the limitations, particularly in reference to time, of an all-embracing supply curve and consequently distinguished three types: the market curve, the short-run normal curve, and the long-run normal curve (*33*, pp. 496–497).

We can consider the market curve as a completely inelastic short-run supply curve. The physical quantity of goods available for sale is fixed. "It is a holders' or dealers' curve, rather than a producers'" (*6*, p. 379). The short-run supply curve permits changes in production in response to demand changes as long as they take place within the existing limits of economic resources. This is the curve generally met in everyday experience. If sufficient time is allowed for the so-called fixed economic resources to change, then the long-run supply curve evolves.

Short-Run Supply Period

Our consideration of egg supplies centers on the short-run supply curve. Within the framework of a given-sized egg enterprise, farmers can vary production in response to temporary fluctuations in cost-price relationships other than expected seasonal variations by changing the number of birds removed from the laying flock. A reduction from the corresponding level of the previous year in the number sold or consumed expands short-run production, an increase contracts short-run production. Because of the opportunity to vary the number sold or consumed, the annual short-run supply curve for eggs cannot be considered as completely inelastic, as is the case for many agricultural commodities. Conceptually, within certain limits, supply can adjust almost instantaneously to price.

If we accept the principle that producers act to maximize returns (or minimize losses), changes in the number of birds sold and consumed on farms where produced occur as cost-price relationships fluctuate because the criteria which constitute a producer's appraisal of a profitable layer vary under different cost-price conditions. Obviously, periods could exist when producers' criteria of a profitable layer would point toward the elimination of all layers. This does not happen because, as individual producers reduce the size of laying flocks by increased sales and home consumption, an equilibrium point is reached. At that point, supply is sufficiently contracted in relation to effective demand so that the majority of producers remaining in the industry do not want to further reduce the size of their laying flocks under the existing cost-price relationships.

If we consider the short-run supply curve for the period January through December, producers can also vary egg production by starting more or less chicks for laying flock replacement than the number necessary to maintain the existing level of egg production. Of course, if actual egg production is to be reduced, reductions made in the size of the laying flock must be sufficient to more than offset the trend increase in rate of lay. Adjustments of supply to price conditions lag appreciably when this method is used because approximately 5 to 6 months are required before newly hatched chicks start laying eggs. As farmers predominantly start chicks for flock replacements in the spring, egg production measured over a calendar year has a hypothetical upper limit set upon it in the last 6 to 7 months by the number of layers on farms on July 1, plus the number of chicks started for laying flock replacement in the period January through June.

Entry or withdrawal of firms.—Our concept of the short-run supply curve is sufficiently broad to allow the entry or withdrawal of firms from the egg industry. Because changes in short-run supply can take place only within the framework of existing economic resources, entry into or withdrawal from the egg industry is determined by the relative attractiveness of profits earned by existing productive resources when utilized in alternative opportunities. The principle of equal advantage states that equilibrium of the economic system is attained "when the advantage derived from the employment of resources in all occupations is the same" (*3*, p. 183). Generally, we assume that resources are free to shift from one field of employment to another.

We formulate the hypothesis that if profits earned from egg production become more attractive because of an increase in demand, or a decrease in production costs, than earnings that can be derived from using the same combination of economic resources in the pro-

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duction of some other product, those resources will be shifted to the production of eggs up to the point where profits gained from the production of eggs are in line with profits earned from using the comparable resources in producing another commodity. The inverse procedure, of course, takes place for a decrease in demand or an increase in production costs.

In actual practice, producers probably lag in their reactions to changing conditions, with the degree of delay tending to be greater for contraction than expansion of production. Economic theory suggests that the long-run supply curve is reversible, but the short-run curve is not. The latter is generally considered as behaving differently for increases and decreases in supply. If demand increases, there will be a large expansion in production and a small rise in price. If demand decreases, production contracts relatively little, while prices drop sharply. Briefly, supply may be more inelastic in contraction than in expansion.

The concept of the irreversible short-run supply curve is presented in figure 2. At demand *DD*, equilibrium price P_o is obtained with Q_o the quantity supplied. *SS* represents the long-run supply curve. With an increase in demand to *D'D'*, short-run production expands

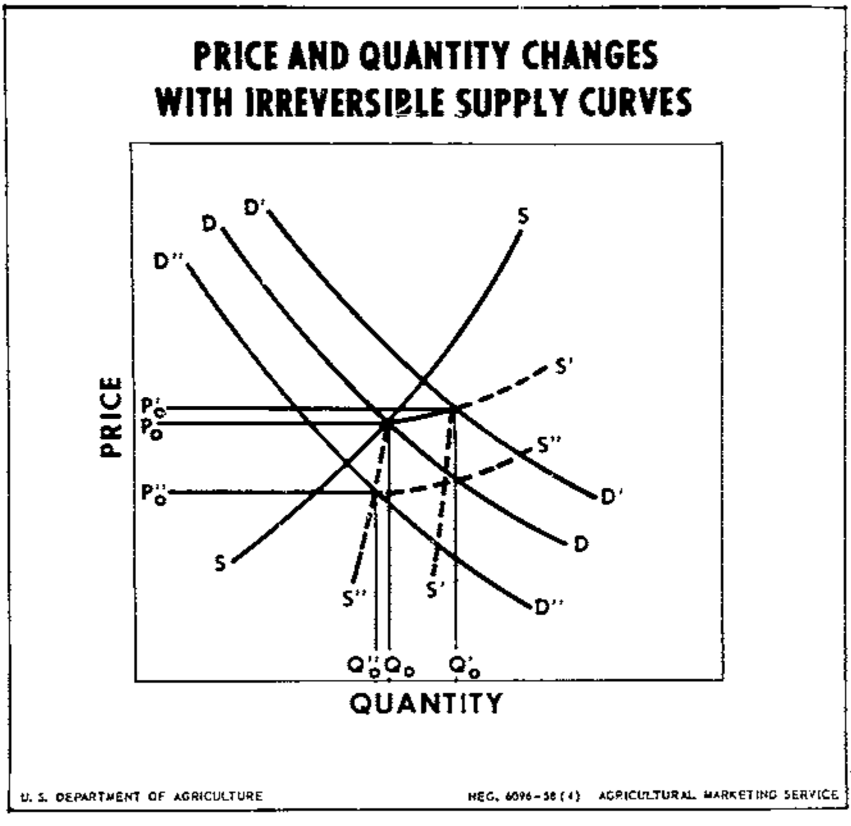

FIGURE 2.—Commodities that have irreversible supply curves expand more with an increase in demand than they contract with a corresponding reduction in demand.

rapidly to the new equilibrium price P_0' and quantity Q_0'. If demand decreases from DD to $D''D''$, the short-run contraction of production establishes the new equilibrium points P_0'' and Q_0''. At these different equilibriums, supply changes proceed along the curves $S'S'$ and $S''S''$.

One explanation for irreversibility in the short-run stems from the ease of entry into an industry relative to that of withdrawal. Once an initial investment in a plant is made, the tendency exists to conduct production at or as near capacity as possible and to continue operation (at least during the short-run) as long as variable costs are covered.[2] These actions stem from sound economic principles. Resources as such do not earn for their owners—they must be utilized.

Entry into the egg industry is readily available to those who have the necessary economic resources or the means to obtain them. Licenses, franchises, patents, distributorships and other restrictions on entry into the industrial and commercial world do not impede prospective egg producers. And the capital needed to build up a laying flock, shelter, feed, and care for it is small relative to the capital required in many other fields of enterprise. Because of these factors, and also because of the psychological appeal of a "return to the soil," the production of eggs is looked upon by many retired workers as a profitable occupation to supplement their income from savings, pensions, and other sources. In addition, laying flocks can readily be tended by farmers and other members of farm households in their spare moments and a part or all of the costs of production can be charged against the entire farm operation. For such egg producers, opportunity cost has little influence.

Using Census of Agriculture classifications for flock size, approximately 44 percent of the eggs sold from commercial farms in 1954 came from flocks of fewer than 400 birds. Because the Census data related to flock size are limited to eggs sold, and exclude subsistence and part-time farms, flocks of fewer than 400 birds undoubtedly account for more than 44 percent of the eggs produced in that year. Census data for 1930 show that more than four-fifths of the eggs produced on all farms in that year came from flocks of fewer than 400 birds. While there has been a decided trend to larger flocks, it appears reasonable to assume that close to 50 percent of egg production comes from flocks of fewer than 400 birds. In 1954, the average number of birds in flocks of fewer than 400 birds was 85 birds per flock.

The elements of small-scale production and nonsensitiveness to opportunity costs is a contributory factor to the irreversibility of the short-run supply curve for eggs. Because income from eggs is supplemental to many small producers, they tend to continue production unchanged or with only slight downward modifications when egg prices become unfavorable. Reaction to favorable prices, however, is generally, within the limits of available capital, along expansionary lines. Because the marginal cost curve of small-sized egg producers is not inclined steeply, the returns to be gained from raising additional layers, or retaining birds in the laying flock, more than offset the increased cost of producing the additional eggs.

[2] Some operation may even continue in the short-run without covering variable costs.

Normally, expansion continues to the point where the additional returns just equal the added cost.

Factors that determine the marginal cost curve.—The elastic nature of the marginal cost curve for eggs arises mainly from the cost composition of production. Christensen and Mighell (*8*, p. 25) summarize the results of several cost studies, as follows:

Cost item	Percentage distribution of total costs	Cost item	Percentage distribution of total costs
	Percent		*Percent*
Feed	50	Other [1]	15
Labor	20		
Flock depreciation	15	All items	100

[1] Includes building depreciation, interest on investment in the laying flock, litter, land, fuel, lights, and taxes.

The individual producer contemplating a production increase will consider the major component of cost, the price of feed, to be unaffected by his increased demands. The action of that individual will not influence feed prices. Consequently, in evaluating increased returns in relation to increased costs, the marginal cost of feed can be considered as almost perfectly elastic. On an industry-wide basis, however, an expansion in flock size increases feed requirements, which could lead to a rise in feed prices. The marginal cost curve for the industry, as a result, is less elastic than that for individual producers.

An assessment of the marginal cost of labor for producing eggs is complicated by the structural make-up of the egg industry. One might assume that labor's marginal cost is the going wage rate—the rate that an egg producer has to pay to hire an additional unit of labor. However, little hired labor is used in egg production. The majority, instead, is supplied by the individual producer and his family. The cost of their labor should be computed as its opportunity cost (the price they could earn in alternative endeavors). But for a large part of this labor, opportunity cost is negligible because there are few or no alternative sources of employment. Some authors have pointed out that no "price tag" is applied to family labor and no "out-of-pocket" cost is involved in its use. In fact, labor is frequently used on family farms to a point where its marginal return is less than its market price (*19*, p. 501). Consequently, labor's marginal cost is relatively elastic, particularly when modern husbandry management techniques make it possible for a producer and his family to care for 5,000 layers without hiring additional help.

Flock depreciation is usually considered as the cost of producing pullets or the value of the pullets when they are added to the laying flock minus the salvage value of the hens. The data on page 16 overestimate the charge for the depreciation of the flock because no allowance is made for the value of cull hens. A more realistic appraisal would indicate that the farmer probably recoups about one-third of his cost of producing or purchasing pullets. The flock depreciation charge declines from 15 percent to 9–10 percent of total egg production costs after this allowance for returns on culls. A breakdown of costs (*8*, p. 25) showed that almost two-thirds of flock depreciation charges consist of feed and labor costs for producing pullets, 20 percent for purchasing chicks, and the remaining 15 percent for other charges such as depreciation of buildings, land, fuel, and so forth. We have shown that marginal costs for feed and labor are relatively elastic for many individual producers and a similar line of reasoning also applies to costs of purchasing chicks and to several of the other smaller charges entering into the cost of producing eggs and pullets. As a result, the added charge incurred for flock depreciation when the flock is expanded increases at a slow rate, indicating that the marginal cost for flock depreciation is probably very elastic.

It appears from this discussion that the marginal supply curve which faces the individual egg producer is relatively elastic, thereby contributing to an expansionary tendency in times of expected favorable profit.

Price Expectations of Producers

In deciding what action to take under changing cost-profit situations, the individual producer is influenced not only by factors that contribute to the irreversibility of the short-run supply curve, but also by the effect of psychological motivation. For example, in a period of unfavorable returns, some individual producers may feel that they can best improve their position by maintaining their laying flock at its existing size while the industry, in the aggregate, reacts to unfavorable returns by heavier culling of layers. If total production is cut so much that prices subsequently rise, the producer who has maintained his laying flock will have a larger output to sell than if he had cut its size. The individual producer's disposition to maintain or reduce flock size, the timing of his reduction, and its extent, must necessarily depend on equating possible future income to be realized by maintaining laying flock size with the immediate loss to be avoided by a reduction.

Individual producers do not formulate scientific hypotheses of their expectations concerning the future price of eggs, but they do, nevertheless, weigh the factors which they believe influence the returns to be obtained from production. Boan (*2*, p. 90) points out: "When resources have to be committed before the outcome can be known, some assumptions about economic returns must be made. But the expected returns are uncertain, and how the farmer reacts to this uncertainty will determine, other things being equal, how productive he is." For crops which are produced on a discontinuous basis, expected price plays an important part in determining the planted acreage. For egg production, which is continuous, the influence of expected price probably reacts both upon the number of layers removed from the flock and upon the number of chicks purchased for future addition to laying flocks.

Schultz and Brownlee (*40*, p. 496) found in an attempt to formulate a price expectation model that, in a sample of Iowa farmers, producers of corn based their actions on past relationships. While recent increases in yields of corn were discounted about one-half, farmers appraised the other half as a real gain which they expected would continue. The relationship between past and expected yields was modified somewhat by location, age, tenure, and education of the operator. In the case of hog prices, however, which fluctuate more than corn yields, Iowa farmers showed a strong preference for using current prices in formulating their price expectations.

The egg-feed ratio.—Each factor considered by a producer in making his plans for short-run production should be included in the formulation of an expectation model for the egg industry. Whether a producer culls more or fewer layers than usual and the number of baby chicks purchased for future addition to laying flocks are a function of the producer's expectations of future returns. A yardstick of returns is the egg-feed ratio which shows the number of pounds of feed that can be purchased with the price received by farmers for one dozen eggs. With more than half of total production costs, and an even greater part of variable production costs, represented by the cost of feed, the egg-feed ratio reflects the ratio of returns to the most important short-run cost factor that faces the producer.

In using the egg-feed ratio as an indicator of returns to producers, consideration must be given to the effect of improvements in husbandry practices and flock management. These have permitted greater egg output per layer (see page 24) and, in efficient flocks, per pound of feed fed. As output per layer trends upward, the producer's concept of a profitable ratio of egg prices to feed prices tends to change. To eliminate this effect in the statistical verification of expectation models based on time series data, analyses should be conducted using the method of first differences, or else the trend increase in output per layer should be allowed for by introducing it as a variable.

If means were available to conduct a sample survey in which each respondent was asked what he expected the egg-feed ratio to be in some future period, an average of their expectations for the specified date could be found. These sample results could be contrasted with egg-feed ratios derived from alternative mathematical models to ascertain which expectation model yields an egg-feed ratio with the smallest deviation from the average expected by producers included in the sample. The model thus selected would be chosen as illustrative of how producers frame their expectations. Unfortunately, no such experiments have been conducted for the egg industry.

Decision functions with respect to flock replacement.—In formulating future production plans, producers must decide how many baby chicks to purchase for future flock replacement. Because those chicks will not begin producing until about 6 months after they are hatched, purchases are conditioned by what producers feel returns will be from the eggs produced in a time span 6 to 18 months later, as well as by the response of producers to previous returns. An indication of that decision function is given by farmers' "Intended Purchases of Baby Chicks" as of February 1, reported annually in the February issue of Crop Production (*45*). Although farmers may subsequently vary from their stated intentions because of changing conditions during the period February through May when they purchase the major part of their replacement chicks, changes in the actual number of chickens raised conform closely to early season plans, as shown in figure 3.

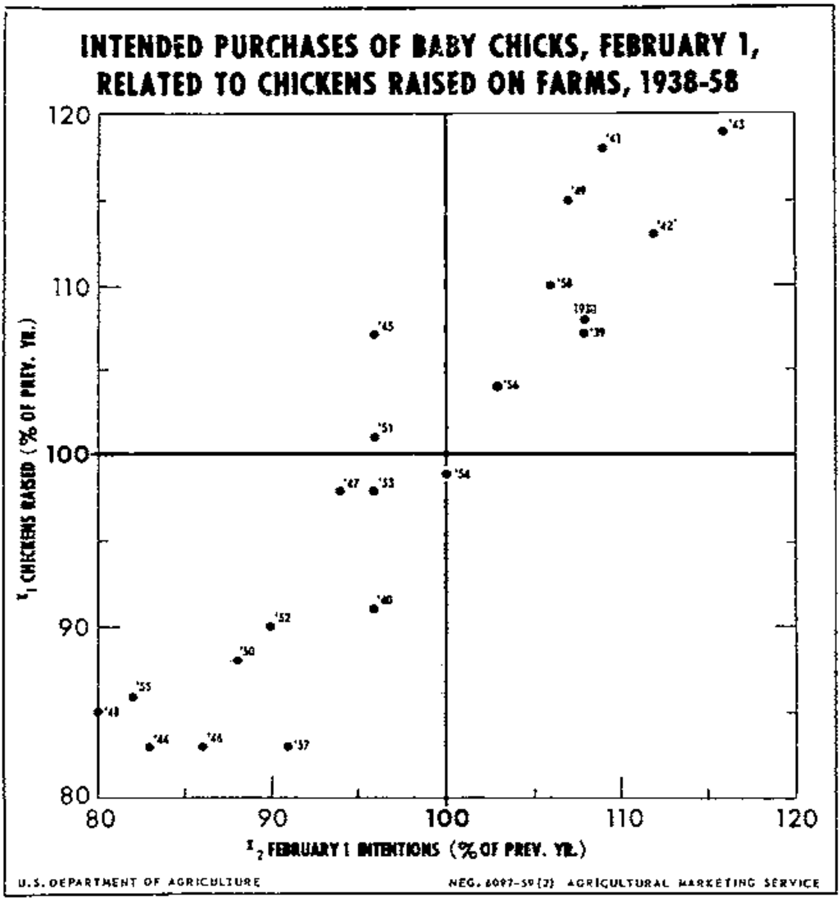

FIGURE 3.—Farmers closely follow their early season intentions to purchase baby chicks as indicated by the number of chickens raised during the year.

A producer's decision to purchase baby chicks undoubtedly is conditioned by his expectations of what egg production profits will be at the time of marketing his products. To aid in his decision making, he has available the past history of the egg-feed ratio and his knowledge of the current egg-feed ratio. In addition, the producer probably introduces a number of other factors which he believes are relevant. The number of hens, pullets of laying age, and pullets not yet laying that are on farms at the time of decision all influence egg production during the following 6–18 months. Egg production, in turn, affects the egg-feed ratio through its effect on price, as well as by influencing the demand for poultry feed.

The simplest expectation model that can be formulated is to assume that producers' intentions to purchase baby chicks are influenced by the prevailing level of the egg-feed ratio. This model[1] implies that farmers do not react to past experiences in framing their opinions of a future period, but consider instead that the present short-run market phenomena will continue. In a test of this hypothesis, year-to-year ratios of the January egg-feed ratio explained 54 percent of the variation during the period 1938–54 in the year-to-year ratios of farmers' intentions to purchase baby chicks.[3] On the average, a 10 percent increase over the previous year in the January egg-feed ratio was associated with a 3.4 percent increase over the previous year in February 1 intentions.

An additional factor that might be introduced into this model is the influence of trend in the rate of lay. If a producer expected price to remain unchanged from recent levels and, therefore, intended to purchase the number of baby chicks which, in six months, would produce the current quantity of eggs, he might reduce his purchases compared to the previous year's purchases in order to allow for an increased rate of lay from the replacement chicks. Adding year-to-year ratios of the rate of lay per layer to the simple expectation model formulated above increased the percentage of variation explained in the year-to-year ratios of farmers' intentions to purchase baby chicks to 65 percent.[4]

More sophisticated models can be formulated by assuming that past prices as well as current experience influence producers' expectations about future prices. In weighing the influence of past prices, it appears reasonable to give less importance to less recent prices. Table 3 gives the results of two analyses that were made which relate previous experience with the egg-feed ratio to farmers' intentions to purchase baby chicks. In the first analysis, farmers' February 1 intentions to purchase baby chicks (which are reported as a ratio of the previous year's intention) were expressed as a function of rate of lay and the egg-feed ratio lagged one year; the assumption being that producers are guided by their profit experience in the previous year. The second analysis used percentage changes from year-to-year in the 10-year moving average of the egg-feed ratio, with the last 4 years weighted 2, 3, 4, and 5, as an indicator of how producers' evaluations of past outcomes are formed. The coefficients obtained from these analyses, as well as the amount of variation in the dependent variable explained by the independent variables were not significant.

From the poor results obtained for these models, it appears that age, health of operator, size of household, availability of labor, size of capital assets and liquid assets, previous income experience and levels, and other factors at the micro-economic level that we have not measured have an important effect on producers' decision func-

[3] The equation obtained for 1938–41 and 1947–54 (omitting the years for World War II) was:

$$\log X_1' = 1.31 + \underset{(0.10)}{0.34} \log X_2 \qquad (1)$$

$$r_{12}^2 = 0.54 \qquad s_{1.2} = 0.03$$

The number in parentheses in this and subsequent equations is the standard error of the regression coefficient.

[4] The equation obtained for 1938–41 and 1947–54 was:

$$\log X_1' = 1.26 + \underset{(0.09)}{0.36} \log X_2 - \underset{(1.36)}{2.24} \log X_3 \qquad (2)$$

$$R_{1.23}^2 = 0.65 \qquad r_{12.3}^2 = 0.63$$

$$s_{1.23} = 0.03 \qquad r_{13.2}^2 = 0.23$$

tions. In a study of production responses, Johnson (*24*, p. 221) says, "In as much as individual production responses are tied so closely to risk, uncertainty, preferences for security, liquidity, and social status, industry supply responses are related to the same factors."

TABLE 3.—*Farmers' intended purchases of baby chicks: Results of correlations for alternative expectation models* [1]

Dependent variable	Coefficient of multiple determination	Effect on intended purchases of a 1-percent change in			
		Rate of lay		Egg-feed ratio	
		Net effect	Standard error	Net effect	Standard error
Farmers' intended purchases of baby chicks,		*Percent*	*Percent*	*Percent*	*Percent*
Feb. 1	0.05	−1.27	2.41	[2] 0.07	0.16
Do	.04	−1.35	2.76	[3] .17	1.25

[1] Computed by least-squares analysis of data for the period 1938–41 and 1946–56 expressed as ratios to the previous year's data. The coefficients of multiple determination and the regression coefficients obtained from these analyses do not differ significantly from zero at the 5 percent probability level.

[2] Egg-feed ratio, lagged 1 year.

[3] 10-year moving average of the egg-feed ratio, with the last 4 years weighted 2, 3, 4, and 5.

An additional factor that should be considered in appraising the results of expectation models is that from 1949 to 1956 the annual price of eggs received by farmers alternated from high to low. If a producer accepted this as a recurring event, then when prices for a particular year were favorable, the producer would expect low prices to follow and would reduce production. After a low price year, the inverse action would be followed. Such behavior could explain the negative relations obtained. Producers, in general, probably do not follow such pattern or else their actions would tend to negate the events they expected.

The previous discussion on expectations assumed that producers act to maximize their profits consistent with a given output and expected price. However, as an alternative, producers may follow a course of action which, instead, minimizes the effect of possible losses. One writer (*32*, p. 70) said, "No one would seriously hold that businessmen have no other goal than money profits. It takes no unusual powers of observation to realize that not all businessmen want to get stomach ulcers, that some of them prefer to take it easy, that most of them dislike sleepless nights worrying about risky deals, that some like to gamble, that many are patriots who will want to avoid doing things which the government says are bad for the country, that several like to be 'big shots' running big enterprises and being admired for their position, that many have a pride of workmanship and a feeling for sportsmanship."

The attitude of producers towards profit maximization can be illustrated by a device called the payoff matrix. We assume that a probability distribution is attached to a producer's expectation about a future price, that is we create imaginary situations, associate them with named future dates, and assign to each of the hypotheses thus formed a place on a scale measuring the degree of our belief that a specified course of action on our own part will make this hypothesis come true (*41*, p. 2). For example, a producer may feel that there are 4 chances out of 5 that the average price he will receive in the following year for eggs will be 35 cents. But he also feels that there is 1 chance out of 10 that the price could be 38 cents, 1 chance out of 20 that it could be 40 cents, 1 chance out of 30 that it could be only 30 cents, and so forth. The conservative producer tends to act on the probability of 80 percent; the more speculative producer on a smaller probability of certainty, but a greater probability of gain. Shackle (*41*, p. 4) feels that "the enterpriser does, in fact, concentrate his attenttion exclusively on the best and the worst hypotheses in this range." In a payoff matrix, these attitudes are illustrated as follows:

	Profit	Loss	Outlook
Size	Low	Low	Conservative.
Probability	High	Low	
Size	High	High	Speculative.
Probability	Low	High	

Obviously, both the concept of profit maximization and the minimum-maximum approach (payoff matrix) are premised on future expectations about price and other variables. Therefore, without resolving the question of the course of behavior of producers, we can, nevertheless, introduce expectations about future price as an important factor influencing farmers' intentions to purchase baby chicks. Because our regression analysis shows a historical relationship between intentions to purchase baby chicks, the current egg-feed ratio, and the rate of lay, it appears satisfactory to premise this relationship as an indication of producers' expectations about future levels of profit.

Physical Factors That Influence Supply

Reference to figure 1 shows that the physical factors that bring about changes in annual egg production are changes in annual output per layer and changes in the annual average size of the laying flock.[5]

[5] The Crop Reporting Board estimates monthly egg production by multiplying the average number of layers on farms during a month by the average number of eggs produced monthly per layer. Annual egg production is the sum of the 12 monthly estimates.

The average number of layers on hand during the month is the mean of the estimated number on the first of that month and the first day of the succeeding month. Estimates of the total number of layers on the first of each month are made on the basis of monthly reports on the number of layers on crop reporters' farms. The number of layers on farms January 1, as estimated annually, serves as the starting point for these monthly estimates. Benchmark data on chickens over 4 months old are available from the Census of Agriculture every 5 years.

To assess the relative influence of the average number of layers and of output per layer upon year-to-year changes in egg production, measures of the "direct effect" of each factor were obtained using the procedure outlined in *Reserve Levels for Storable Farm Products* (*58*, p. 26). Figure 4 shows these results for the period 1926–58.

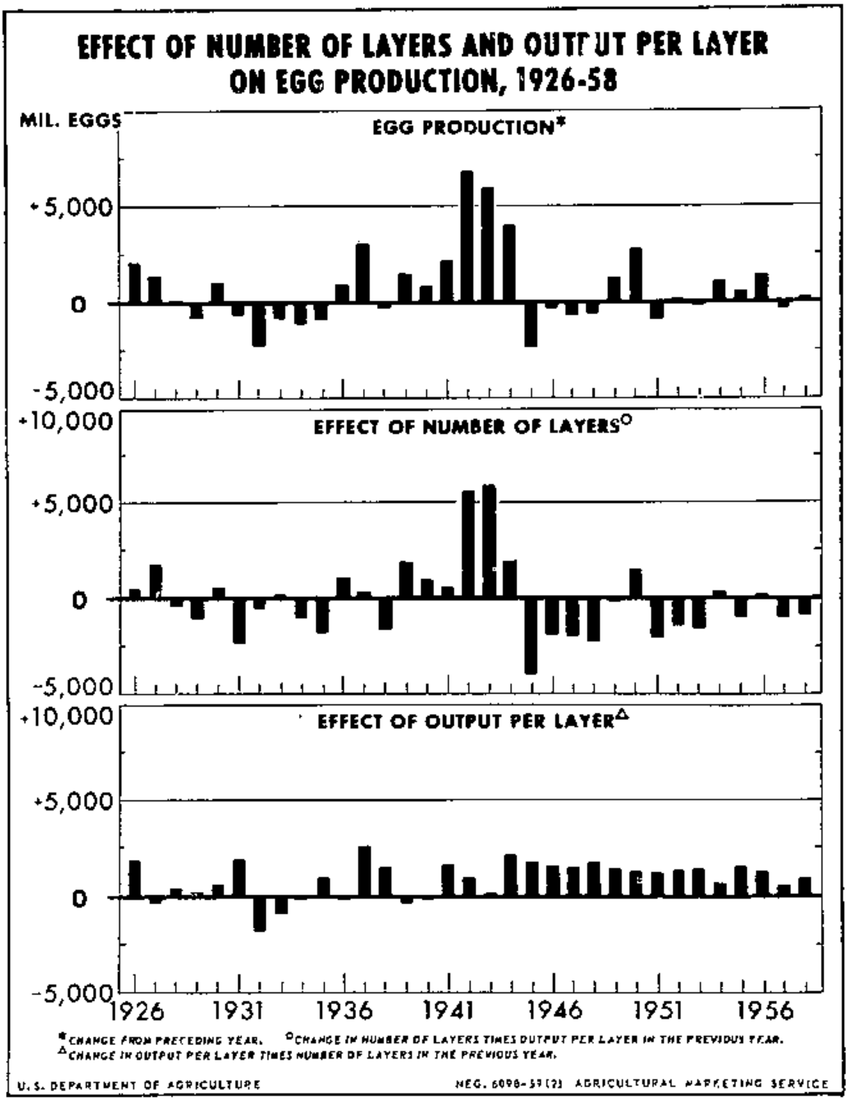

FIGURE 4.—Changes in egg production in the last 10 years have been less than previously, with a reduction in layers on farms almost off-setting the increased rate-of-lay.

In more than half the years during this period, changes in the average number of layers on farms were the major factor contributing to changes in farm egg production. Particularly during 1941–50, changes in number of layers had the greater effect as numbers expanded rapidly to an all-time peak in 1944 and then contracted. With output per layer trending upward at about a constant rate since 1941, the effect of changes in rate of lay has varied little during the past 15 years to 20 years. To surpass the trend factor in rate of lay as the major contributing effect to changes in egg production, a minimum change from 1 year to the next of about 5 million in number of layers on farms during the year is required.

Output per layer.—A host of factors which can be grouped into "trend" in genetics and management practices influence rate of lay. These mainly consist of the crossing and breeding of higher producing strains of layers, the control of infectious diseases, the adoption of better flock management practices, and the improvement of feed formulas. Each has contributed to an increase in rate of lay, but their effects are not individually measurable.

Producers can influence output per layer by adopting these salutory factors, but once an improved genetic quality or management practice is put into use it tends to remain in use until supplanted by another, more efficient, factor. As an improvement is adopted, the average cost curve of a producer shifts to the right to a new, more profitable equilibrium position which he attempts to maintain. This lessens or eliminates that factor as a control in the hands of the producer over output per layer.

Inspection of the top chart of figure 5 shows that the annual increase in eggs produced, per layer [6], was not very marked until the late 1930's. Beginning about 1940, however, the increase each year in rate-of-lay rose to about 3–4 eggs per layer.

Because rate of lay is such an important determinant of the quantity of eggs produced, and because an increased rate of lay has the effect of lowering the cost curve as long as the marginal cost of obtaining the increase is less than or equal to the marginal return from the higher rate of lay, producers are interested in whether the trend increase in the rate of lay will continue. Conceptually, the upper limit on egg output per layer is the length of the physiological sequence required between each ovulation. Sturkie (*44*, p. 254) found that the interval between successive eggs ranges from 24 to 28 hours for most hens, depending on the length of the sequence. On this basis the upper limit to the rate of lay would fall between 313 and 365 eggs. Whether such a high output per layer for a flock could be attained is conjectural. However, rates of lay of 350–360 eggs have been reported for individual layers. The charts in the lower half of figure 5 show that the rate of lay appears to have leveled off in the spring months of peak production and is increasing less rapidly in the remaining months. In addition, data by States, for recent years, on rate of lay show that annual output per layer has leveled off in many States (table 4). It appears more reasonable to assume, therefore, that rate of lay will continue to trend upward at an increasingly slower rate than to assume that the present increase of about 3–4 eggs per year will continue until the physiological maximum is reached. In the economic model of

[6] The number of eggs produced on farms during the year divided by the average number of hens and pullets of laying age on farms during the year.

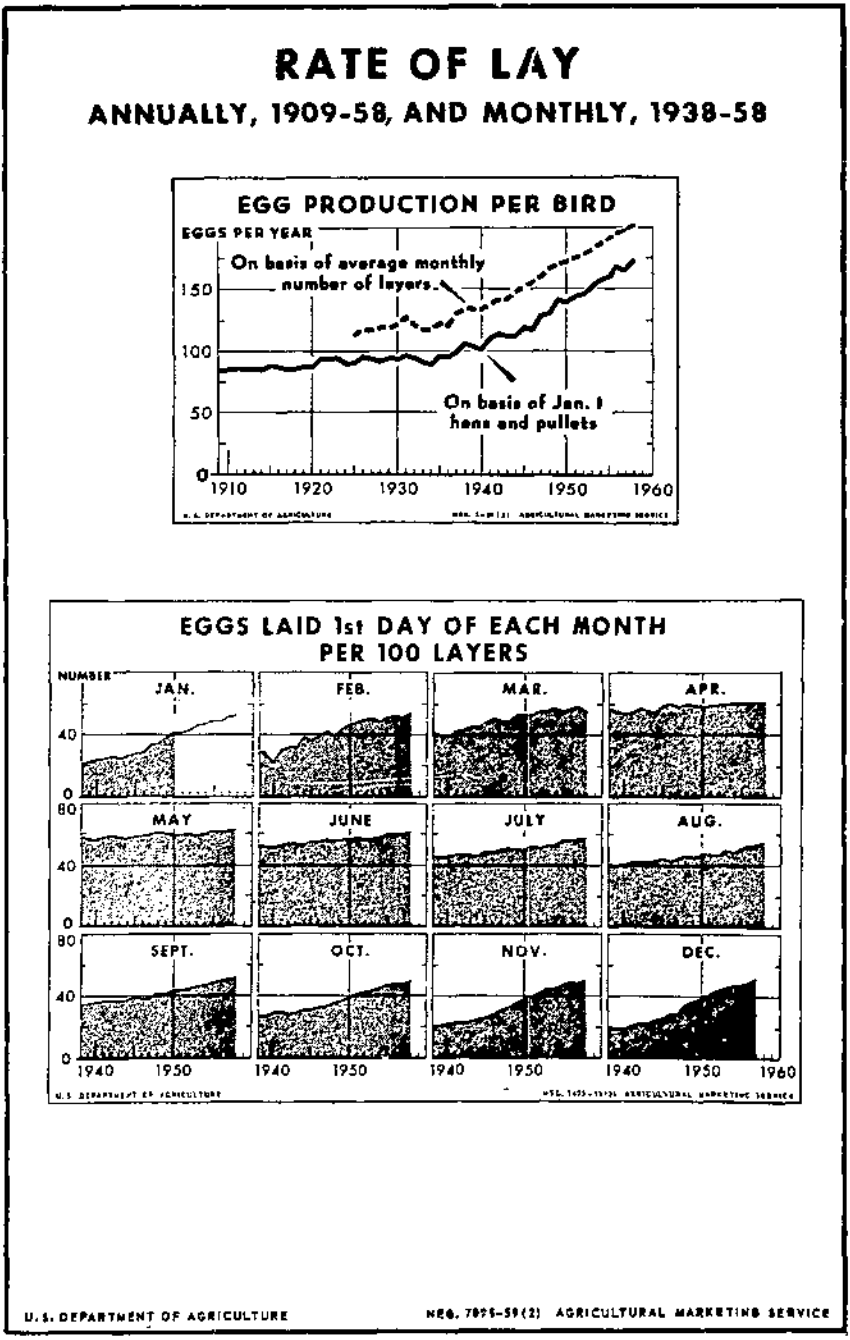

FIGURE 5.—Output per layer has increased almost 4 eggs each year since 1940 due to improved breeding and better management practices. Gains have chiefly come from increased laying in the winter months.

TABLE 4.—*Eggs: Rate of lay per layer, by States, annually, 1950–58*

State and division	Eggs laid annually per hen and pullet of laying age on farms during year [1]								
	1950	1951	1952	1953	1954	1955	1956	1957	1958
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Maine	195	200	198	200	204	211	212	210	208
New Hampshire	192	196	197	202	204	202	205	202	202
Vermont	202	200	206	207	216	210	215	212	207
Massachusetts	205	205	207	211	212	209	212	214	213
Rhode Island	201	203	206	207	210	208	218	207	213
Connecticut	202	201	204	198	202	206	212	207	215
New York	188	190	200	197	199	202	202	205	209
New Jersey	185	187	191	191	188	189	192	195	194
Pennsylvania	183	183	191	195	196	198	202	205	207
North Atlantic	189	190	196	197	197	199	202	204	205
Ohio	183	184	189	190	190	194	201	201	205
Indiana	179	184	189	189	193	196	201	204	208
Illinois	173	176	183	185	185	193	197	197	200
Michigan	183	185	187	189	192	194	195	197	202
Wisconsin	177	183	187	188	192	199	201	204	208
East North Central	179	182	187	188	190	195	199	201	205
Minnesota	183	191	192	197	195	201	205	207	212
Iowa	185	189	192	198	201	207	209	212	216
Missouri	171	174	175	176	176	183	183	183	187
North Dakota	158	163	172	174	177	177	177	180	182
South Dakota	165	174	177	182	181	184	191	198	202
Nebraska	176	180	180	185	188	194	198	200	203
Kansas	173	176	179	184	183	193	193	196	200
West North Central	177	182	184	189	190	196	199	201	206

Delaware	177	178	179	184	182	186	192	179	184
Maryland	171	177	174	183	182	180	185	183	185
Virginia	170	171	172	175	173	177	182	184	189
West Virginia	170	174	175	177	176	175	179	178	178
North Carolina	155	156	161	163	175	180	188	193	193
South Carolina	139	147	152	161	163	179	184	184	186
Georgia	139	149	158	173	178	192	196	197	199
Florida	166	172	174	183	202	204	208	207	208
South Atlantic	158	162	165	172	177	184	190	191	193
Kentucky	163	163	166	166	162	164	169	173	170
Tennessee	144	149	149	152	152	160	166	166	166
Alabama	135	145	148	158	164	173	179	180	186
Mississippi	130	134	138	148	151	156	166	161	163
Arkansas	139	144	146	151	154	160	171	170	175
Louisiana	129	133	138	143	152	155	162	161	164
Oklahoma	159	161	166	171	167	176	175	177	179
Texas	154	155	164	170	169	173	178	182	184
South Central	148	151	156	161	161	167	172	174	176
Montana	175	171	177	183	183	189	190	190	196
Idaho	187	187	192	192	200	201	207	210	212
Wyoming	175	178	179	187	188	191	186	191	193
Colorado	168	169	179	185	185	185	191	190	191
New Mexico	161	165	165	170	180	185	177	182	186
Arizona	174	172	183	188	194	186	204	197	208
Utah	184	189	191	193	203	202	199	198	208
Nevada	176	188	180	185	196	182	214	185	173
Washington	203	204	202	208	211	212	219	220	222
Oregon	195	199	204	204	204	210	216	218	221
California	192	192	197	203	209	211	218	222	225
Western	189	190	195	200	205	207	213	216	219
United States	174	177	181	185	188	192	196	198	201

[1] Number of eggs produced during the year divided by the average number of hens and pullets of laying age on hand during the year. Chickens and Eggs (*46*).

the egg economy, formulated on page 64, output per layer is classified as a predetermined variable because, within the time period of a year, trend factors predominate.

This assumption does not allow for the effect upon output of changes in feeding rates. For varying levels of profit, producers may change the quantity of feed provided for the laying flock. However, it has been shown that the most profitable feeding practice is to provide layers all the feed they will consume. The practice of full-feeding probably is not as applicable to small scale flocks as to large commercial flocks. Nevertheless, in the economic model of the egg economy developed in this bulletin, it was assumed that over the period of a year the effect on output per layer of varying feeding rates in response to changes in levels of profit is small and overshadowed by the predetermined trend factors discussed above.

Average size of laying flocks.—Figure 1 shows that, on a physical accounting basis, year-to-year changes (for January-December) in the average number of layers on farms reflect the net interrelationships of changes in: (1) the number of "potential layers" (hens, pullets of laying age, and pullets not of laying age) on farms on January 1; (2) the number of baby chicks started in January through June for subsequent addition to laying flocks; (3) mortality rates, and (4) the number of layers sold and consumed on farms where produced. Data are available which directly measure the number of "potential layers" on farms on January 1, the number of layers sold, and the mortality rate of layers. Approximations must be made of the number of baby chicks started for flock replacement, the number of layers consumed on farms where produced, and the mortality rate of pullets not yet of laying age.

The number of hens and pullets on January 1 (usually referred to as "potential layers") is a predetermined variable in a calendar year analysis. In the period 1931–54, a 10-percent change from the previous year in the January 1 number of potential layers reflected a change of about 1 percent in the January 1 number of hens, a change of about 7 percent in the number of pullets of laying age, and a change of about 2 percent in the number of pullets not yet of laying age.

As an indicator of the number of baby chicks started in the period January through June for subsequent addition to laying flocks, estimates were derived of the number of pullets raised. The estimated number of pullets raised in a calendar year equals the number of pullet chicks started in the period January through June for subsequent addition to laying flocks less the pullet chicks that died before laying their first egg. Table 5 shows how the estimated numbers of pullets raised in the years 1924–58 were derived from reported figures on the number of chickens raised, and the percentages of sexed cockerels and sexed pullets purchased by producers.

We would expect from our previous consideration on producers' expectations when formulating production plans that the number of pullets raised would be associated with the level of profits (indicated, in part, by the egg-feed ratio) prevailing in the months preceding those in which producers start baby chicks. If the egg-feed ratio in the first half of the year, when producers are starting chicks for future flock replacement, is lower than the ratio for the corresponding period in the previous year, producers generally start fewer replacements. If the egg-feed ratio is higher, they tend to increase the number of chicks started for flock replacements. The relationship of chick replacements (as measured by the number of

TABLE 5.—*Pullets raised: Methods of estimating from reported data on chickens raised, 1924–58*

Year	Chickens raised	Composition of farmers' chick purchases		Straight-run chickens [1] [2]	Pullets [1]		
		Cockerels	Pullets		Straight-run [3]	Sexed [4]	Total raised [5]
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Millions	*Percent*	*Percent*	*Millions*	*Millions*	*Millions*	*Millions*
1924	662. 2	--------	--------	662. 2	331. 1	--------	331. 1
1925	678. 7	--------	--------	678. 7	339. 4	--------	339. 4
1926	718. 3	--------	--------	718. 3	359. 1	--------	359. 1
1927	750. 4	--------	--------	750. 4	375. 2	--------	375. 2
1928	700. 0	--------	--------	700. 0	350. 0	--------	350. 0
1929	751. 1	--------	--------	751. 1	375. 5	--------	375. 5
1930	777. 0	--------	--------	777. 0	388. 5	--------	388. 5
1931	709. 4	--------	--------	709. 4	354. 7	--------	354. 7
1932	735. 5	--------	--------	735. 5	367. 8	--------	367. 8
1933	750. 1	--------	--------	750. 1	375. 0	--------	375. 0
1934	644. 4	--------	--------	644. 4	322. 2	--------	322. 2
1935	658. 3	--------	--------	658. 3	329. 2	--------	329. 2
1936	715. 0	--------	--------	715. 0	357. 5	--------	357. 5
1937	601. 1	--------	--------	601. 1	300. 6	--------	300. 6
1938	650. 7	--------	--------	650. 7	325. 3	--------	325. 3
1939	696. 7	--------	--------	696. 7	348. 3	--------	348. 3
1940	633. 7	--------	--------	633. 7	316. 9	--------	316. 9
1941	745. 0	--------	--------	745. 0	372. 5	--------	372. 5
1942	844. 3	--------	20. 9	667. 8	333. 9	176. 5	510. 4
1943	1, 001. 4	5. 4	17. 2	775. 1	387. 5	172. 2	559. 8
1944	832. 1	4. 9	20. 3	622. 4	311. 2	168. 9	480. 1
1945	890. 4	4. 8	18. 5	683. 0	341. 5	164. 7	506. 2
1946	737. 6	4. 4	22. 3	540. 7	270. 3	164. 5	434. 8
1947	719. 4	4. 5	26. 0	500. 0	250. 0	187. 0	437. 0
1948	615. 1	4. 5	30. 0	402. 9	201. 4	184. 5	386. 0
1949	705. 1	4. 0	31. 0	458. 3	229. 2	218. 6	447. 7
1950	619. 8	5. 0	32. 0	390. 5	195. 2	198. 3	393. 6
1951	622. 9	5. 0	33. 0	386. 2	193. 1	205. 6	398. 7
1952	561. 0	5. 0	37. 0	325. 4	162. 7	207. 6	370. 2
1953	547. 5	5. 0	42. 0	290. 2	145. 1	230. 0	375. 1
1954	539. 9	6. 0	49. 0	243. 0	121. 5	264. 6	386. 0
1955	461. 9	7. 0	50. 0	198. 6	99. 3	230. 9	330. 2
1956	478. 6	7. 0	53. 0	191. 4	95. 7	253. 6	349. 4
1957	394. 3	6. 0	61. 0	130. 1	65. 1	240. 5	305. 6
1958	435. 8	6. 0	61. 0	143. 8	71. 9	265. 8	337. 7

[1] Based on unrounded data.
[2] Column 1 multiplied by [100—column 2—column 3].
[3] Estimated as one-half of straight-run chickens.
[4] Column 1 multiplied by column 3.
[5] Straight-run pullets plus sexed pullets.

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pullets raised annually) to the weighted egg-feed ratio[7] in the January–June period, shown in figure 6, appears sufficiently strong to support the conclusion of a simultaneous relationship between the supply and price of eggs within the calendar year.

The conclusion of a simultaneous relationship between the supply and price of eggs is to a large extent determined by the choice of the year studied. For example, in a July-June year the number of

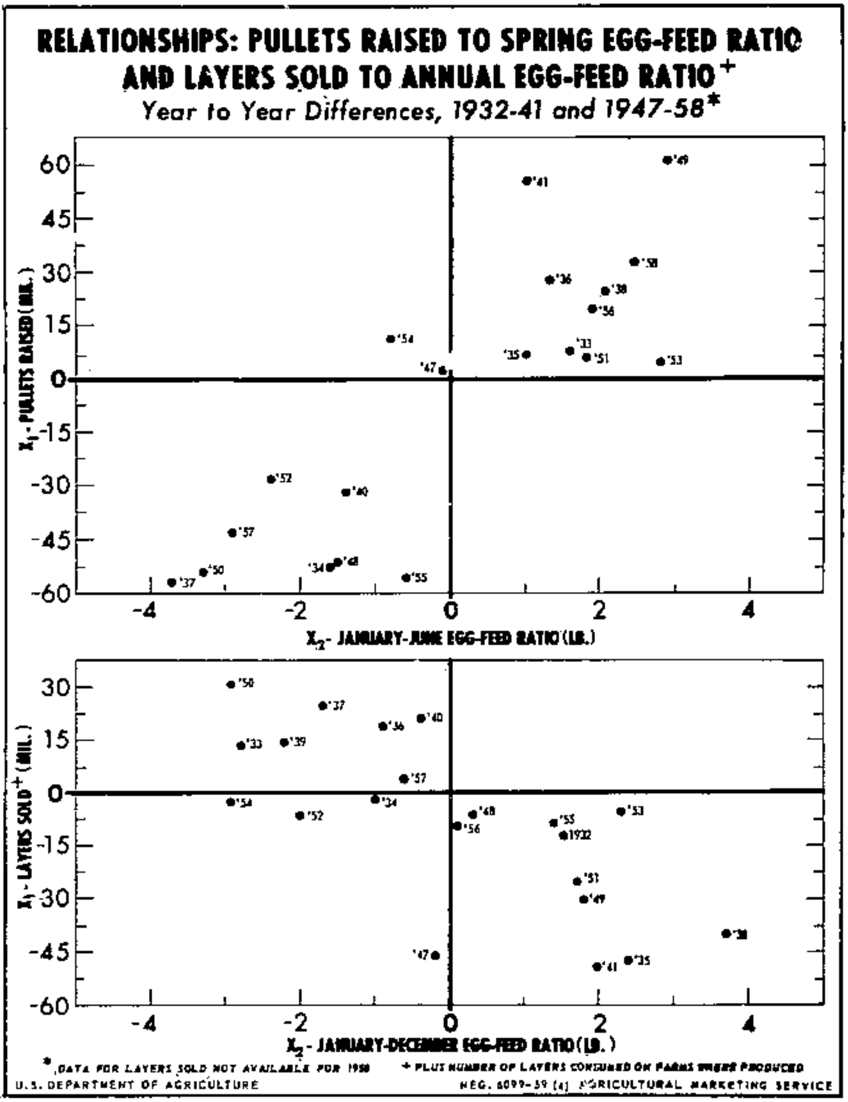

FIGURE 6.—The numbers of pullets raised and layers sold in a year react to prices within the same time period, establishing a simultaneous relationship between price and production.

[7] To allow for the effect of different numbers of chick placements in each month, the egg-feed ratio in the months January through June were weighted as follows: January, 3; February, 4; March, 5; April, 3; May, 1; and June, 1.

replacement chicks started in the first six months is small. Production during the July-June year, therefore, is little affected by pullets raised in that year. The degree of simultaneity between supply and price is thereby lessened. Analyses in this study were made for calendar year relationships because it was felt that more information could be obtained on the demand, supply, and price structure for eggs than if any other 12-month grouping was used.

The third physical factor that influences changes in the average size of the laying flock is changes in mortality rates. Data are available for the reported death loss of layers as well as death loss during the year of chickens on hand January 1. As hens and pullets comprise from 90–95 percent of chickens on hand January 1, this series gives an approximation of the death loss of layers and pullets not yet of laying age. Table 6 shows for the years 1924–58 death loss as a percentage of the number of hens and all pullets on farms on January 1. The increase during this period in death loss is surprising when so much has been done to control infectious diseases through the use of vaccines and antibiotics. The higher death loss rate probably has been due to increased stresses such as crowding, artificial lighting, and other pressures used to increase rate of lay. The result of these practices has been to remove the hen from a condition resembling its natural environment to one foreign to it.

It seems reasonable to assume that each producer acts to control death loss to what he considers an economic minimum. The effect of mortality rates, therefore, is probably not directly responsive to price, although it could be contended that the producer's concept of an economic minimum may vary with price and the rate of profitability of the enterprise.

The fourth factor that physically affects changes in the average number of layers on farms is the number of layers sold and consumed on farms where produced. Producers principally remove layers from their flocks in the latter part of each year, although, as pointed out above, producers probably vary removals more or less than normal as cost-price relationships fluctuate.

Direct measures are available for the number of layers sold from farms, but not for the number consumed on farms where produced. However, estimates for the years 1931–57 were made by: (1) obtaining the ratio that mature chickens sold by farmers is to total chickens sold; (2) applying these ratios for each year to the annual number of chickens consumed on farms where produced to estimate the farm home consumption of layers; and (3) adding the number of mature chickens sold to the estimated farm home consumption of layers. These estimates are presented in table 7.

Variation from year-to-year in the number of layers sold and consumed on farms where produced is influenced by the number of potential layers on farms at the beginning of the year and by the profitability of the egg enterprise. Other things being equal, the larger the number of potential layers at the beginning of the year, the greater the number of mature chickens likely to be removed from the laying flock, and vice versa when the initial number of potential layers is small. In addition, the number of birds removed from the flock is influenced by the current profitability of egg production. The two effects are interrelated.

TABLE 6.—*Farm chickens: Death loss as a percentage of number of potential layer*, *Jan. 1, 1924–58*

Year	Potential layers, Jan. 1 [2]	Death loss [1]	
		Number	Percentage of potential layers, Jan. 1
	Millions	*Millions*	*Percent* [3]
1924	389.6	56.9	14.6
1925	390.5	52.7	13.5
1926	393.8	53.7	13.6
1927	414.9	56.8	13.7
1928	427.1	60.1	14.1
1929	403.8	58.7	14.5
1930	420.5	62.6	14.9
1931	401.8	62.8	15.6
1932	385.8	62.9	16.3
1933	390.7	65.2	16.7
1934	385.3	66.1	17.2
1935	350.4	60.6	17.3
1936	362.6	64.4	17.8
1937	379.8	68.6	18.1
1938	353.0	67.5	19.1
1939	376.1	75.6	20.1
1940	392.7	78.1	19.9
1941	381.3	80.8	21.2
1942	427.9	92.4	21.6
1943	489.0	87.7	17.9
1944	523.6	107.2	20.5
1945	473.9	91.3	19.3
1946	472.8	91.1	19.3
1947	431.4	83.7	19.4
1948	417.6	79.0	18.9
1949	399.4	82.3	20.6
1950	423.8	84.5	19.9
1951	399.3	83.4	20.9
1952	397.2	87.6	22.1
1953	373.0	83.6	22.4
1954	371.0	85.1	22.9
1955	368.6	84.4	22.9
1956	360.3	86.0	23.9
1957	368.8	86.8	23.5
1958	352.5	80.8	22.9

[1] Death loss during the year of chickens on hand, Jan. 1.
[2] Hens and all pullets.
[3] Computed from data reported in thousands of units.

Chickens and Eggs (*46*).

For example, if the number of potential layers at the beginning of the year is above the year-ago level (and we assume no changes in the demand for eggs or in production costs), the increased supply of eggs will act to drive the egg-feed price ratio below the year-ago level. Faced with a less favorable current level of returns from production (as measured by the egg-feed ratio), farmers in the spring will start fewer chicks for flock replacement. The prospect of a reduction in flock size will subsequently bolster egg prices, raising the egg-feed ratio. With fewer replacement pullets and with an improved cost-returns situation, farmers in the latter part of the year will tend to retain more layers in order to build up flock size. Over the extent of a year, we assume that the net result of these forces and decisions will be reflected in more layers being removed from flocks in unfavorable years than in years of good returns. This indicates an interaction between demand and supply within the 12-month span of January through December.

The relationship of year-to-year differences in the number of layers sold and consumed on farms where produced to the annual egg-feed ratio is shown in the lower section of figure 6. A similar relationship also exists with respect to year-to-year changes in the number of potential layers on farms on January 1.

TABLE 7.—*Layers sold and home consumption of layers: Method of estimating from reported data on chickens sold, 1931–57*

Year	Chickens sold			Home consumption of layers [1]	Estimated layers sold and home consumption [2]
	Mature	Total	Mature as percentage of total		
	Millions	*Millions*	*Percent*	*Millions*	*Millions*
1931	183.5	428.5	42.8	98.9	282.3
1932	170.3	418.3	40.7	100.4	270.6
1933	180.4	441.1	40.9	104.0	284.4
1934	183.3	403.3	45.5	99.6	283.0
1935	147.6	365.5	40.4	88.4	236.0
1936	159.6	395.0	40.5	95.2	254.9
1937	173.8	351.8	49.4	106.2	280.0
1938	141.3	326.4	43.3	98.6	240.0
1939	159.4	376.6	42.3	95.1	254.4
1940	178.5	369.8	48.3	97.2	275.6
1941	152.5	412.3	37.0	73.1	225.7
1942	175.5	493.0	35.6	69.0	244.5
1943	242.1	682.9	35.4	67.5	309.6
1944	266.6	611.9	43.6	77.9	344.5
1945	237.6	609.3	39.0	71.4	309.0
1946	246.8	529.4	46.6	80.6	327.4
1947	211.6	491.5	43.1	69.8	281.3
1948	198.9	401.6	49.5	75.9	274.8
1949	180.6	440.9	41.0	64.0	244.7
1950	200.6	408.7	49.1	74.7	275.2
1951	182.8	397.9	45.9	67.0	249.8
1952	176.1	363.5	48.4	66.9	243.0
1953	172.0	336.6	51.1	65.7	237.8
1954	169.5	331.6	51.1	66.1	235.6
1955	155.6	264.2	58.8	71.5	226.9
1956	148.5	261.2	56.9	70.6	219.1
1957	144.5	212.4	68.0	78.5	223.0

[1] Reported data for chickens consumed on farms where produced prorated according to the percentage that mature chickens are to total chickens sold.

[2] Total of mature chickens sold and home consumption of layers based on unrounded data.

The relationship gives evidence that a change in structure may have occurred in the years subsequent to 1952. If the observations for 1952 and the subsequent years are examined, they show that with extreme year-to-year changes in the egg-feed ratio the number of layers sold changed only slightly. In 1952 and 1954, when the egg-feed ratio declined sharply, we would have expected from earlier relationships that the number of layers sold would increase by about 15 to 30 million layers. Instead, the number of layers sold declined about 2 and 8 million head, respectively.

The trend toward fewer, but larger size flocks, with a tendency to operate close to plant capacity, may have contributed to a change in the structure of the egg economy, which shows up in the retention-profit relationship. However, a sufficient number of other factors are present to make this questionable. For example, the egg-feed ratios for the spring of 1952 were the lowest on record, with the exception of 1937, since the series was first compiled in 1924. In the last six months of 1952, however, the egg-feed ratios were about average. As the major removal of layers from flocks takes place in summer and fall, the excessively low egg-feed ratios in the spring may have had little effect on the decision of producers to sell layers. Consequently, it appears reasonable to reject the hypothesis of a structural change in the relationship between layers sold and consumed on farms where produced and the egg-feed ratio unless further evidence becomes available.

An additional indication of the relationship between layers sold and consumed on farms where produced and the profitability of production (as indicated, in part, by the egg-feed ratio) is obtained by examining data on number of hens on farms on January 1 in relation to the number of pullets on farms the preceding January 1. Chicks are usually started in the spring of the year, become laying pullets in the fall, and by October of the following year are classified as hens. A part are retained for another laying year while some are sold or consumed in farm households where produced, and some are lost through deaths. Although the death rate of layers appears to have trended upwards, year-to-year changes are not too marked. Therefore, year-to-year changes in the difference between pullets on farms, January 1, and the number of hens on farms the following January 1 approximately reflect changes in the number of layers eliminated in that period.

Figure 7 shows the relationship during 1931–58 of year-to-year changes between layers sold and consumed on farms where produced and the January-December egg-feed ratio. The scatter chart shows that when the egg-feed ratio rises from the previous year there are fewer layers eliminated from flocks than the previous year and, conversely, more layers are eliminated with an egg-feed ratio lower than the previous year. The effect of the price of hens on layers sold is considered to be negligible. Layers are raised mainly for production of eggs. The significant variables that affect the number of layers sold are assumed to be prices of eggs and of poultry feed. Hence, figure 1 indicates no effect of hen prices upon the number of layers sold.

Although changes in the number of layers removed from flocks in a calendar year appear to be related to changes in the ratio of egg prices to feed prices, relationships of monthly removals to cur-

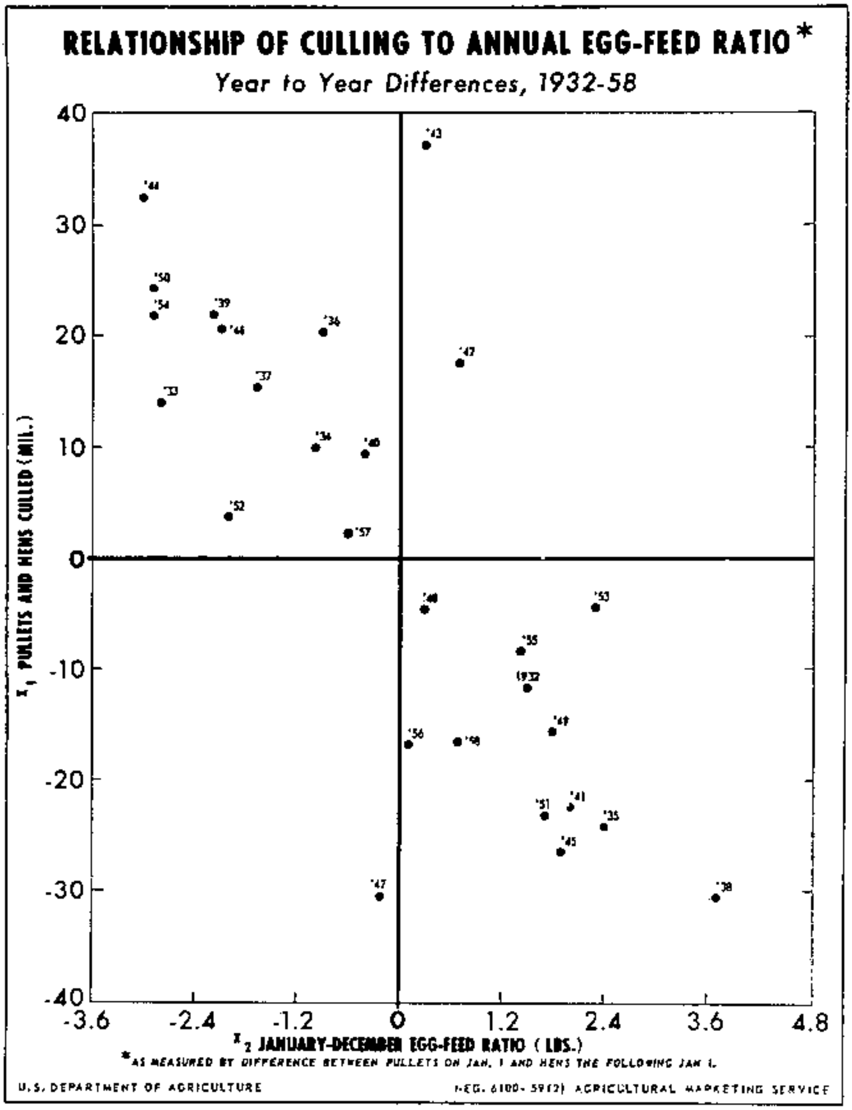

FIGURE 7.—When the egg-feed ratio rises from the previous year fewer layers are eliminated from flocks than the previous year and, conversely, more layers are eliminated when the egg-feed ratio is lower than the previous year.

rent egg-feed ratios do not show a definite relationship. Estimates of monthly removals were obtained by expressing monthly link relatives of layers on farms as ratios to previous five year averages of monthly link relatives for each month to obtain an index of "net disappearance" of birds from laying flocks (table 8). An index number below 100 suggests that the "net disappearance" of birds from laying flocks is relatively greater than it was, on the average, in the preceding 5-year period. An index number higher than 100 suggests that the "net disappearance" of birds from laying flocks is

TABLE 8.—*Layers on farms: Index numbers of "net disappearance" of birds from laying flocks, 1930–58* [1]

Year	Jan. 1	Feb. 1	Mar. 1	Apr. 1	May 1	June 1	July 1	Aug. 1	Sept. 1	Oct. 1	Nov. 1	Dec. 1
1930	--------	98.5	99.9	99.6	99.7	98.8	99.1	99.8	100.0	103.6	98.6	98.6
1931	98.5	98.7	98.0	99.2	99.6	99.9	98.9	99.5	100.5	102.3	99.7	99.4
1932	99.9	99.9	99.5	99.1	101.2	99.6	99.9	100.0	100.9	101.2	99.4	101.5
1933	100.7	100.0	99.9	100.7	99.3	100.3	97.6	99.5	101.0	99.7	101.6	100.8
1934	100.2	99.7	100.7	99.9	99.9	98.6	99.6	98.4	99.2	98.5	99.5	99.5
1935	97.3	100.7	100.9	100.2	100.0	100.0	100.5	100.5	99.9	103.0	101.3	100.2
1936	100.0	99.8	100.7	100.5	100.1	99.7	99.9	100.0	100.7	102.4	101.8	101.1
1937	100.9	99.0	99.9	99.9	99.8	99.5	99.1	100.6	98.7	98.8	98.9	98.4
1938	98.5	100.3	99.8	100.0	99.0	101.0	100.6	101.6	101.9	100.7	101.6	99.9
1939	101.1	100.3	100.0	99.6	99.8	100.6	100.2	99.8	101.6	100.2	101.5	100.3
1940	100.7	99.8	100.5	99.5	100.8	100.0	98.3	99.3	101.5	97.8	99.9	99.8
1941	98.7	99.6	100.0	100.2	100.1	100.5	101.5	100.7	100.9	103.6	101.1	101.5
1942	100.2	100.6	100.4	101.3	101.0	101.0	100.7	100.0	99.3	101.4	103.5	101.8
1943	100.9	100.6	101.1	100.8	99.5	101.2	100.2	96.4	98.7	101.2	100.3	100.8
1944	100.1	99.5	101.9	100.1	99.1	98.5	98.6	98.0	98.7	101.3	97.4	98.1
1945	95.8	98.8	100.1	98.4	99.9	100.4	100.4	98.1	99.7	100.9	99.6	98.7
1946	98.8	99.8	100.2	98.9	99.3	96.8	99.4	98.6	101.1	99.9	99.0	97.2
1947	98.9	98.9	99.5	99.7	99.9	101.0	101.5	100.9	100.3	101.2	98.4	97.0
1948	97.8	99.8	98.0	99.5	100.2	99.9	101.1	101.3	102.2	100.6	99.8	97.2
1949	98.7	100.2	99.7	98.9	100.7	100.7	101.8	102.1	102.6	102.0	101.4	100.4
1950	100.1	99.4	99.1	100.2	99.7	99.9	100.4	102.9	102.4	99.3	98.9	98.0
1951	98.4	100.0	100.1	99.3	100.8	100.4	100.8	101.2	102.5	100.4	99.9	99.1
1952	99.6	100.2	99.7	99.2	100.2	100.1	99.1	101.5	102.2	100.0	97.9	99.4
1953	98.5	99.2	99.6	100.8	101.1	100.5	101.1	102.0	100.5	99.7	98.7	99.8
1954	98.9	99.8	99.7	100.9	100.4	101.6	100.5	103.0	103.1	99.7	96.8	97.7
1955	98.5	98.8	100.8	100.0	101.2	100.8	101.6	101.3	99.3	98.0	97.0	98.6
1956	98.8	101.3	100.4	100.7	101.5	101.3	101.5	102.8	99.9	96.1	97.2	98.4
1957	100.3	99.7	100.4	100.5	101.0	100.7	100.5	101.6	99.3	95.5	97.2	99.3
1958	99.9	100.4	100.4	101.6	100.5	101.8	101.9	101.5	98.3	96.7	98.9	100.3

[1] Computed as ratios of monthly link relatives of layers on farms the first day of the month to previous 5-year averages of monthly link relatives for each month.

relatively smaller than it was, on the average, in the preceding 5-year period. In February-August, relatively few pullets are added to laying flocks. Therefore variations in the monthly index numbers from February to August are roughly indicative of the rate of removals. As pointed out previously, mortality rate does not vary markedly from year to year. In the fall and early winter months, however, the effects of adding pullets to laying flocks more than offsets mortality and removals of layers.

If producers vary the number of layers removed from flocks with changes in the rate of profitability of egg production, some degree of positive association would be expected between the "net disappearance" of birds from laying flocks and changes in the egg-feed ratio. From among the many models that could be formulated of relationships between the two variables, year-to-year ratios of the monthly "net disappearance" of birds from laying flocks were related to year-to-year ratios of the average relative monthly change in the egg-feed ratio prevailing in the two preceding months. It was assumed that the producer in formulating his decision on removing layers considers both the current level of profitability, as well as expected future levels. From the analysis relating to price expectation (p. 17), current experience seems to be the most important decision factor. Therefore, we would expect the "net disappearance" from January 1 to February 1 to be associated positively with recent changes in the egg-feed ratio. Because the egg-feed ratio is computed as of the 15th of each month, an average of the two immediately preceding months was used. By this method, allowance is made for some lag in adjustment and extreme monthly aberrations are smoothed. Examination of these relationships, however, offers little evidence of a positive relationship between the number of layers eliminated from flocks, as measured by the index of "net disappearance," and the prevailing egg-feed ratio. The small amount of variation from month to month in the number of layers on farms appears to preclude adequate measurement of any relationship with variation in the monthly egg-feed ratio.

However, based on the analyses of the relation over a calendar year of layers sold and consumed on farms where produced with the prevailing egg-feed ratio and assumptions about the actions of producers, it appears reasonable to assume that current prices received for eggs do influence the number of layers removed from flocks and, in turn, production. The number of layers sold and consumed or farms where produced, therefore, should be treated as an endogenous variable in the supply, demand, and price structure for eggs.

Summary

The previous sections on the response of producers to current price pointed out that egg production during the year is the product of the average number of layers on farms during the year and the average rate of lay. The latter was assumed to be predetermined in a particular year while the average number of layers on farms was seen to be the result of several factors which could be combined into an equation, such that:

$$X_1 = X_2 + X_3 - X_4 - X_5 \quad (3)$$

where:

X_1=average number of layers on farms during the year
X_2=January 1 number of hens and pullets on farms
X_3=replacement chicks started in January–June
X_4=mortality of layers and pullets not yet of laying age
X_5=number of layers sold and consumed on farms where produced.

In the foregoing discussion, reasons were given for classifying the variables X_2 and X_4 as predetermined and the variables X_1, X_3, and X_5 as endogenous. Reported data for X_1 and X_2 are available, but values for X_3, and part of X_4 and X_5 were estimated. The summation of X_2, X_3, X_4, and X_5, however, does not equal X_1, for the reasons discussed below.

The average number of layers on farms during the year, X_1, is obtained by averaging the 12 monthly reports by the Crop Reporting Board of the number of layers on farms during each month. The latter number is the mean of the estimated number on the first day of a particular month and the first day of the succeeding month. Estimates of the total number of layers on the first of each month are made on the basis of monthly reports on the number of layers on crop reporters' farms. The number of layers on farms January 1, as estimated annually, serves as the starting point for these monthly estimates. The difference between two months in the number of layers on hand reflects the net effect of pullets added to the flock, layers removed from the flock, and death loss. Because these monthly data are not available, it was necessary to derive the annual estimates discussed above.

The use of annual data for the number of pullets raised, the number of layers removed from flocks and the mortality of layers, when added to January 1 numbers of hens and all pullets on farms to form the accounting equation, overstates the average number of layers on farms during the year. The overstatement arises because the annual data are, in effect, distributed proportionally within the year, whereas changes from month to month in the variables X_3, X_4, and X_5, which affect the number of layers on farms during each month, are not proportional. For example, if monthly data were available, a pullet that reached laying age in October would only influence the average number of layers on farms during the year for the three months, October, November, and December, whereas the use of annual data influences numbers in each month of the year. In table 9, the variables used in the accounting equation are shown, with the residual amount listed separately. The residual amount represents the statistical and conceptual discrepancies in estimating the variables X_3, X_4 and X_5.

The analysis of factors that influence the calendar year supply of eggs indicates that the number of replacement chicks started in the first 6 months of each calendar year and the number of layers removed from flocks throughout the year are influenced by current changes in the egg-feed ratio. Therefore, a model to explain the structural relationships that exist in the egg economy should allow for the simultaneous relation of demand and supply within the 12-month period January through December. Before formulating such a model (see p. 62), the relevant variables which are believed to influence the demand for eggs are discussed.

TABLE 9.—*Layers on farms: Variables that enter into the accounting equation and the unexplained residual, 1931–57*

Year	Hens and all pullets, Jan. 1	Pullets raised	Mortality		Layers sold and consumed in farm households where produced [1]	Average number layers on farms [2]
			Layers	(Residual)		
	(1)	(2)	(3)	(4)	(5)	(6)
	Millions	*Millions*	*Millions*	*Millions*	*Millions*	*Millions*
1931	401. 8	354. 7	62. 8	108. 4	282. 3	303. 0
1932	385. 8	367. 8	62. 9	121. 0	270. 6	299. 1
1933	390. 7	375. 0	65. 2	116. 4	284. 4	299. 7
1934	385. 3	322. 2	66. 1	67. 7	283. 0	290. 7
1935	350. 4	329. 2	60. 6	106. 6	236. 0	276. 4
1936	362. 6	357. 5	64. 4	115. 9	254. 9	284. 9
1937	379. 8	300. 6	68. 6	43. 8	280. 0	288. 0
1938	353. 0	325. 3	67. 5	94. 9	240. 0	275. 9
1939	376. 1	348. 3	75. 6	104. 8	254. 4	289. 6
1940	392. 7	316. 9	78. 1	59. 3	275. 6	296. 6
1941	381. 3	372. 5	80. 8	146. 4	225. 7	300. 9
1942	427. 9	510. 4	92. 4	259. 8	244. 5	341. 6
1943	489. 0	559. 8	87. 7	268. 5	309. 6	383. 0
1944	523. 6	480. 1	107. 2	156. 2	344. 5	395. 8
1945	473. 9	506. 2	91. 3	210. 4	309. 0	369. 4
1946	472. 8	434. 8	91. 1	131. 5	327. 4	357. 6
1947	431. 4	437. 0	83. 7	158. 3	281. 3	345. 1
1948	417. 6	386. 0	79. 0	118. 2	274. 8	331. 6
1949	399. 4	447. 7	82. 3	189. 4	244. 7	330. 7
1950	423. 8	393. 6	84. 5	118. 2	275. 2	339. 5
1951	399. 3	398. 7	83. 4	137. 0	249. 8	327. 8
1952	397. 2	370. 2	87. 6	116. 3	243. 0	320. 5
1953	373. 0	375. 1	83. 6	114. 6	237. 8	312. 1
1954	371. 0	386. 0	85. 1	122. 1	235. 6	314. 2
1955	368. 6	330. 2	84. 2	78. 5	227. 0	309. 1
1956	360. 3	349. 4	86. 0	94. 7	219. 1	309. 9
1957	368. 8	305. 6	86. 8	59. 8	223. 0	304. 8

[1] Mature chickens sold plus part of home consumption (ratio of mature chickens to chickens sold).

[2] Col. (1) + col. (2) − col. (3) − col. (4) − col. (5).

Factors That Influence the Demand for Eggs

Analyses that relate to the theory of demand are more extensive and complete than are those that deal with factors that affect the supply of a commodity. The theory of consumer behavior postulates that consumers are generally willing to take more of a commodity at lower prices than at higher prices. Based on this fact, economists have formalized (1) the concept of a demand curve and (2) the measurement known as the "elasticity of demand"—the percentage change in consumption that accompanies a given percentage change in price.

The demand curve, which may be a straight line, shows quantities that consumers are willing to buy at various prices. The slope, or relative steepness of the curve, evaluated at some point on the curve indicates the degree of elasticity of demand with respect to price.[8] Demand is considered to be elastic if the consumer adjusts the quantity demanded more than proportionally to changes in price so that total value increases as price decreases or decreases as price increases. If the consumer responds so that total value decreases with a decline in price or increases with a rise in price, demand is said to be inelastic. Finally, if the consumer makes proportional adjustments so that total value remains unchanged regardless of the level of price, we say that demand is of unit elasticity.

Consumer responses have thresholds, however, so that stimuli may evoke no response up to a point and may then suddenly bring striking responses [see (*43*, p. 1078)]. A corollary to this is the usefulness of calling attention to the stimuli through advertising, for example, or of making the stimuli strong enough to call attention to themselves—as through substantial rather than small price changes. Such variations in consumer behavior, of course, make the task of economic analysis more difficult, but do not invalidate the concept of consumers adjusting to marginal changes in demand and supply factors.

The whole demand curve can shift up and down, or to the left or right. This is referred to as a "shift" in demand or a change in its level. The level of demand for eggs is mainly influenced by the size of the population, consumer income, supplies and prices of competing commodities, and consumer tastes and preferences.

Indicators that relate to the demand for eggs at retail can be obtained by examining: (1) movements over time in the variables that affect the demand for eggs and quantifying the relationships by statistical analysis (time series analysis); (2) results of consumer expenditure surveys (cross-section analysis); and (3) studies of consumer preferences and household practices.

Time Series Analysis

In the analysis of demand using time series data, the size of the population, consumer income, supplies and prices of competing commodities, consumer tastes and preferences, and other variables that

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[8] Elasticity$=\frac{\Delta q/q}{\Delta p/p}=\frac{\Delta q}{\Delta p}\cdot\frac{p}{q}$; where Δq is the change in quantity, Δp is the change in price, and p and q are the values for price and quantity, respectively, at the point on the demand curve where the elasticity is being evaluated.

affect demand are fluctuating within the period being studied. Therefore, when looking at the relationship between quantity and price, or between any other pair of variables, over a period of time, it is necessary to allow for the influence of the other factors that enter into the demand complex.

The demand equation formulated for eggs (p. 64) includes population, income, and the general price level as demand shifters that refer to the economy as a whole, and the prices of eggs, and several competing and complementary commodities as demand shifters that are more directly related to the egg industry. Two goods are competitive in demand when an increase in the consumption of one brings about a fall in the demand for the other. They are complementary in demand when an increase in the consumption of one brings about a rise in the demand for the other. It can be seen that the more nearly a good can be substituted for another, the more competitive it is in demand.

The influence of population on the demand for eggs is introduced into the model by putting egg consumption and disposable personal income on a per capita basis. As an alternative, population could have been included as a separate variable. However, because the relationships of consumption and income, respectively, with population are assumed to be homogeneous functions, the simple correlation of per capita consumption and per capita income probably tends to equal the multiple correlation of consumption with income and population. Consequently, because consumption and disposable income are customarily considered on a per person basis, they have been treated in that form in the egg model.

Based on everyday experiences, meats, fish, cheese, noodle products, and breakfast cereals are food items that should appear as commodities that compete most directly with eggs for a share in consumers' expenditures, while bacon is a complementary commodity to eggs. Because of religious observance and/or a desire to have variety in the diet, many families have a meatless menu at least once a week. If the menu planning offered by home economists in the daily newspapers has any influence on housewives' meal preparation, then an egg, cheese, fish, or noodle dish or some combination of these is served in place of meat as the main course of the meal. While meat and fish appear to be substitute goods for eggs, cheese and noodle products may have both a complementary and a substitute relationship. Many dishes require both eggs and cheese, or eggs and noodle products, or combinations of all three as ingredients (soufles, cheese omelets, noodle casseroles, and so forth).

Breakfast cereals appear to be a substitute commodity for eggs at breakfast time, because a choice is usually made between eggs, or some dish involving eggs (such as waffles), and breakfast cereals.

Everyday experiences suggest that the relationship between eggs and bacon should be defined as complementary in demand. If more eggs are eaten, more bacon will also be consumed. However, the degree of relationship may be complex. For example, if a person usually eats two strips of bacon with one egg, he probably will not increase his bacon consumption if he decided to have two eggs for breakfast some morning. However, if he generally does not eat eggs for breakfast and decides to have them tomorrow morning, then he may also decide that bacon will go well with them. In the former example there is no complementary demand relationship; in the latter there is a complementary relationship.

For the vast majority of people, custom, habit, and probably taste and convenience incline them to have bacon when they eat eggs. Fried and scrambled eggs, as well as omelets, generally require some grease or shortening for cooking purposes, and bacon conveniently supplies the needed item. Data from a survey in Birmingham and Indianapolis (*49*) showed that for eggs prepared for table use, 76 percent were either fried, scrambled, or used in omelets in the former city while 63 percent were prepared in one of the three ways in the latter city (table 10). In addition, based on the survey information, four-fifths or more of the eggs were served at the table as recognizable eggs. The remaining fifth, used in batters, doughs, and other food preparations, would be less complementary or possibly noncomplementary with bacon.

TABLE 10.—*Eggs: Method of preparing for table use in two cities, Spring, 1953*

Method	Percentage prepared each way—		Method	Percentage prepared each way—	
	Birmingham	Indianapolis		Birmingham	Indianapolis
	Percent	*Percent*		*Percent*	*Percent*
Cooked:					
Soft	5	14	Omelet	1	1
Hard	13	14	Other	2	2
Fried	43	49			
Poached	4	7	All	100	100
Scrambled	32	13			

(*49*, p. 22).

For these reasons, retail price index numbers of meats, poultry, and fish; cheese; ready-to-eat cereals; and bacon were included in the demand equation. Ideally, separate price indexes of meats and fish, a price index of noodle products, and one of all breakfast cereals, rather than one of ready-to-eat cereals, should be used, but data for the period used in fitting the model of the egg economy are not available.

Some analysts have used the relationship between the ratio of prices and the ratio of quantities as measures of the elasticity of substitution. However, this approach ignores the effect of different income elasticities between the commodities [see (*36*)], and is only valid when it can be assumed that the income elasticities are the same. From analyses of family food expenditure data (p. 44), it is seen that the assumption of equal income elasticities among eggs and the items included in the demand equation is not valid. Consequently, the differing effects of income would have to be allowed for by introducing income as a variable in the analyses of quantity and price ratios. Analyses of this type have not been made for eggs because the simultaneous relationship between the price and quantity of eggs requires a system of equations to be solved. It is more expeditious, in such a case, to obtain the cross elasticities of egg consumption with the prices of the several substitute and complementary commodities directly from a demand equation included in a multiple equation model.

In the multiple equation model of the egg economy, formulated on page 64, prices of the substitute and complementary commodities are treated as predetermined variables, that is, as variables that are believed to have influenced the quantity or price of eggs during the years included in the study, but not to have been influenced by them to a significant degree during any given calendar year. Treating the prices of substitute and complementary commodities as predetermined involves several restrictive assumptions. However, treating each price of the substitute and complementary commodities as an endogenous variable would require the addition of a minimum of 4 equations,[9] thereby complicating the statistical fitting of the model. The statistical bias introduced into the model by treating the substitute and complementary items as predetermined, however, is believed to be small.

Based on a nationwide survey of 6,000 households in the spring of 1955, the money value of foods purchased in a week was $22.61. Of this amount, 3.6 percent was spent for eggs; 31.4 percent for meats, poultry, and fish (including 2.0 percent for bacon); 2.3 percent for cheese; and 1.1 percent for ready-to-eat and hot breakfast cereals. Because expenditures for those items, with the exception of the meat category, are small, changes in consumer expenditures for any one item releases little income to be shifted to expenditures for the other items. In addition, the price of cheese is chiefly set by conditions in the dairy economy, while prices for breakfast cereals are isolated in an institutional framework of advertising, premiums, and so forth. It seems reasonable to assume, therefore, that prices of cheese and breakfast cereals are not influenced by the price of eggs and can be considered as predetermined in a model of the egg economy. A similar argument appears applicable to bacon and the meat, poultry, and fish composite, whose prices are established by forces within the feed-livestock economy for meats, and to a large extent by weather and the size of canned and frozen stocks of fish.

The demand equation for eggs also includes a variable, the Consumers' Price Index, representing the general price level. All

[9] Assuming that consumption of all substitute and complementary items is predetermined, the following equations would need to be added to the egg model if prices of meats, poultry and fish; cheese; bacon; and ready-to-eat cereals were treated as endogenous variables:

$$P_M = (Q_E, Q_M, Q_C, Q_B, Q_T, Z_1, u_1)$$
$$P_C = (Q_E, Q_M, Q_C, Q_B, Q_T, Z_2, u_2)$$
$$P_B = (Q_E, Q_M, Q_C, Q_B, Q_T, Z_3, u_3)$$
$$P_T = (Q_E, Q_M, Q_C, Q_B, Q_T, Z_4, u_4)$$

where:

P's = prices
Q's = consumption
Z's = other predetermined variables
u's = random error terms

If consumption of any of the items is not assumed to be predetermined, additional equations would be required in the model.

goods and services purchased by consumers are to some degree competitive or complementary to eggs. Such diverse expenditures as vacation trips, medical treatment, housing, and education can have some substitution effect with eggs, because a consumer might be forced to curtail his food budget in order to meet payment on the nonfood expenditures. In addition, inclusion of a variable representing the general price level allows for the effect on demand of the value of money. While several statistical considerations favor introducing the general price level as a deflator (that is, by dividing each price and income variable by the Consumers' Price Index), that has not been done in the demand equation for eggs, because interest is generally centered on price relationships that prevail among undeflated variables.

Cross-Section Analysis

The use of data from consumer expenditure surveys to examine aspects of demand, generally called cross-section analysis, is similar to cutting into a moving panorama of the factors that influence demand and studying them at one instant of time. Income, population, price, taste preferences, and other demand factors are considered to be fixed in cross-section analysis. It is not necessary, therefore, to explain their movements as it is for time series analysis. In addition, information on other factors that affect food consumption, such as size of family, occupation, race, nationality, and regional location often are obtained. Cross-section analysis, therefore, serves to provide a measure of the reaction of consumption and expenditures to changes in family income without the complications of changes in the distribution of income, family size, age of population, and related economic and demographic factors which are present when demand relationships in reference to income variation are studied over time. Because of shifts over time within the income distribution scale and changes in other economic and demographic factors, economists have reservations about using quantity-income and price-income coefficients derived from time series analysis as measures of the elasticity of demand with respect to income. Rather, coefficients derived from data from consumer expenditure surveys are thought to give a more appropriate indication of the structural elasticity measurement.

In addition, survey data can be used to compare the estimates of such relationships with similar estimates for competitive commodities. These comparisons can be used to assess the effect of given changes in income levels upon changes in relations among commodities. Comparisons can also be made among cross-section data from different periods to test for changes in structure. An additional use of cross-section data is to pool the results of surveys made at different points in time, after allowing for dynamic changes, and to compare the pooled-analysis with estimates from time-series data, or to substitute in time-series analysis coefficients derived from pooled cross-section data in order to estimate price elasticities.

The most recent data available on consumption and expenditures for food items by households in the United States are from a survey conducted by the U.S. Department of Agriculture in the spring of 1955 (*59*). In addition, nationwide surveys of food consumption of both urban and nonurban families were made in 1936 (*55*, *61*, and *62*) and 1942 (*60*). Surveys of food consumption of urban families only were made in 1948 (*9*) and 1951 (*53*), the latter survey conducted by the U. S. Department of Labor.

1955 Consumer expenditure survey.—Table 11 lists the consumption and money value[10] of shell eggs consumed, per household and per person, in a week, by income groups, and urbanization, in spring, 1955. Data for households are on a per person basis to adjust for differences in family size associated with level of income. Because households with higher incomes tend to include a greater number of people per household than do lower income households, relationships between consumption, or money value, and income should properly be examined on a per person basis to adjust for differences in household size. For example, in the 1955 survey, all households of 2 or more persons with family incomes of $10,000 and over used 23 percent more eggs per household than households of 2 or more persons with family incomes under $1,000, but only 10 percent more on a per person basis. For urban households comparable percentages are 78 and 24 percent, respectively; for rural nonfarm households, 37 and 13 percent; and for rural farm households, 12 and 3 percent.

TABLE 11.—*Eggs: Average consumption and money value, per household and per person, in a week, by income groups and urbanization, spring, 1955* [1]

Income class (dollars)	Average size		Income per—		Consumption per—		Money value per—	
	Family [2]	Household [3]	Family [4]	Person [5]	Household	Person [6]	Household	Person [6]
	Urban							
	Persons	*Persons*	*Dollars*	*Dollars*	*Dozens*	*Dozens*	*Dollars*	*Dollars*
1-person households	1.00	1.05	1,833	1,833	0.75	0.71	0.41	0.39
Households of 2 or more:								
Under 1,000	2.59	2.51	478	185	1.37	.55	.65	.26
1,000–1,999	2.98	2.88	1,520	510	1.53	.53	.77	.27
2,000–2,999	3.28	3.21	2,511	766	1.78	.55	.94	.29
3,000–3,999	3.60	3.53	3,517	977	1.99	.56	1.05	.30
4,000–4,999	3.65	3.50	4,500	1,233	1.94	.55	1.04	.30
5,000–5,999	3.62	3.48	5,444	1,504	2.11	.61	1.13	.32
6,000–7,999	3.62	3.40	6,766	1,869	2.05	.60	1.11	.33
8,000–9,999	3.77	3.45	8,860	2,350	2.19	.63	1.21	.35
10,000 and over	3.80	3.61	16,050	4,224	2.44	.68	1.44	.40
All households	3.26	3.13	4,826	1,480	1.83	.58	.98	.31

See footnotes at end of table.

[10] Home produced food and food obtained without direct expense were valued at average prices paid by households of the same urbanization-region group for similar items.

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TABLE 11.—*Eggs: Average consumption and money value, per household and per person, in a week, by income groups and urbanization, spring, 1955* [1]—Continued

Income class (dollars)	Average size: Family [2]	Average size: Household [3]	Income per—: Family [4]	Income per—: Person [5]	Consumption per—: Household	Consumption per—: Person [6]	Money value per—: Household	Money value per—: Person [6]
	Rural nonfarm							
	Persons	*Persons*	*Dollars*	*Dollars*	*Dozens*	*Dozens*	*Dollars*	*Dollars*
1-person households	1. 00	1. 14	1, 266	1, 266	0. 96	0. 84	0. 41	0. 36
Households of 2 or more:								
Under 1,000	2. 95	2. 99	475	161	1. 56	. 52	. 70	. 23
1,000–1,999	3. 42	3. 46	1, 479	432	2. 07	. 60	. 90	. 26
2,000–2,999	3. 88	3. 78	2, 529	652	2. 32	. 61	1. 05	. 28
3,000–3,999	3. 98	3. 81	3, 501	880	2. 39	. 63	1. 10	. 29
4,000–4,999	3. 88	3. 77	4, 487	1, 156	2. 39	. 63	1. 13	. 30
5,000–5,999	4. 22	4. 03	5, 468	1, 296	2. 46	. 61	1. 19	. 30
6,000–7,999	3. 83	3. 77	6, 712	1, 752	2. 34	. 62	1. 17	. 31
8,000–9,999	4. 00	3. 83	8, 605	2, 151	2. 23	. 58	1. 20	. 31
10,000 and over	4. 00	3. 61	13, 256	3, 314	2. 13	. 59	1. 03	. 29
All households	3. 56	3. 47	3, 635	1, 021	2. 12	. 61	. 99	. 29
	Total nonfarm							
1-person households	1. 00	1. 07	1, 680	1, 680	0. 81	0. 76	0. 41	0. 38
Households of 2 or more:								
Under 1,000	2. 81	2. 80	476	169	1. 49	. 53	. 68	. 24
1,000–1,999	3. 17	3. 14	1, 502	474	1. 77	. 56	. 83	. 26
2,000–2,999	3. 50	3. 42	2, 517	719	1. 98	. 58	. 98	. 29
3,000–3,999	3. 73	3. 63	3, 512	942	2. 12	. 58	1. 07	. 29
4,000–4,999	3. 71	3. 57	4, 497	1, 212	2. 07	. 58	1. 06	. 30
5,000–5,999	3. 78	3. 63	5, 451	1, 442	2. 20	. 61	1. 15	. 32
6,000–7,999	3. 67	3. 48	6, 754	1, 840	2. 11	. 61	1. 12	. 32
8,000–9,999	3. 81	3. 51	8, 815	2, 314	2. 20	. 63	1. 21	. 34
10,000 and over	3. 83	3. 61	15, 661	4, 089	2. 40	. 66	1. 38	. 38
All households	3. 35	3. 23	4, 461	1, 332	1. 92	. 59	. 98	. 30
	Rural farm							
1-person households	1. 00	1. 48	1, 229	1, 229	2. 01	1. 36	0. 79	0. 53
Households of 2 or more:								
Under 1,000	3. 90	3. 99	205	53	2. 73	. 68	1. 07	. 27
1,000–1,999	3. 77	3. 87	1, 454	386	2. 77	. 72	1. 07	. 28
2,000–2,999	4. 03	4. 11	2, 467	612	3. 07	. 75	1. 16	. 28
3,000–3,999	4. 12	4. 19	3, 443	836	3. 39	. 81	1. 28	. 31
4,000–4,999	4. 38	4. 33	4, 480	1, 023	3. 47	. 80	1. 31	. 30
5,000–5,999	4. 68	4. 56	5, 400	1, 154	3. 23	. 71	1. 25	. 27
6,000–7,999	4. 82	4. 82	6, 768	1, 404	3. 63	. 75	1. 42	. 29
8,000–9,999	5. 03	4. 89	8, 845	1, 758	3. 22	. 66	1. 21	. 25
10,000 and over	4. 00	4. 38	15, 417	3, 854	3. 06	. 70	1. 26	. 29
All households	4. 01	4. 08	2, 799	698	3. 01	. 74	1. 16	. 28

See footnotes at end of table.

TABLE 11.—*Eggs: Average consumption and money value, per household and per person, in a week, by income groups and urbanization, spring, 1955* [1]—Continued

Income class (dollars)	Average size		Income per—		Consumption per—		Money value per—	
	Family [2]	Household [3]	Family [4]	Person [5]	Household	Person [6]	Household	Person [6]
	All							
	Persons	*Persons*	*Dollars*	*Dollars*	*Dozens*	*Dozens*	*Dollars*	*Dollars*
1-person households	1.00	1.09	1,663	1,663	0.85	0.78	0.42	0.39
Households of 2 or more:								
Under 1,000	3.23	3.26	371	115	1.97	.60	.83	.25
1,000–1,999	3.31	3.30	1,491	450	1.99	.60	.88	.27
2,000–2,999	3.57	3.52	2,510	703	2.13	.61	1.00	.28
3,000–3,999	3.76	3.67	3,506	932	2.23	.61	1.08	.29
4,000–4,999	3.76	3.62	4,496	1,196	2.16	.60	1.08	.30
5,000–5,999	3.83	3.69	5,448	1,422	2.26	.61	1.16	.31
6,000–7,999	3.73	3.56	6,755	1,811	2.19	.62	1.14	.32
8,000–9,999	3.89	3.60	8,817	2,267	2.26	.63	1.21	.34
10,000 and over	3.84	3.64	15,652	4,076	2.42	.66	1.38	.38
All households	3.43	3.33	4,286	1,250	2.04	.61	1.00	.30

[1] Food purchased, home-produced, and received as gift or pay by housekeeping families in the United States.
[2] Members in the primary economic family during the survey week. Members temporarily away from home were included.
[3] Total meals served at home adjusted to 21-meal equivalent.
[4] Money income, after deduction of State and Federal income taxes, of all persons who were members of the primary economic family during all or any part of 1954. Farm income was the total of all farm receipts during the year (after payment of share rent to others) minus farm operating expenses.
[5] Adjusted by average family size.
[6] Household data adjusted by average household size.

Derived from (*59*).

In making such adjustments, a decision must be reached as to whether average family size or average household size should be used as the basic divisor. In the 1955 survey, average family size included persons living alone or a group of persons who lived together and drew from a common fund for their major items of expense. Family members temporarily away from home—at school, at work, or on vacation—were considered members of the economic family, although not residing in the dwelling unit at the time of the interview. Average household size was obtained by taking the total number of meals[11] from family food supplies served to all persons in the household (that is, the group of persons who shared family food supplies, including family members at home, guests, boarders, and hired help) and dividing by 21 to obtain the household size

[11] See (*59*, p. 194) for meal weights. For example, lunches carried from home and supplemented by purchased food were considered a half meal and those supplemented by beverages only were counted as a full meal.

in equivalent persons. For these analyses, income was adjusted to a per person basis by dividing by the average family size, while consumption and money value were put on a household size (21 meal equivalent) basis.

For the survey week in 1955, shell egg consumption per person was highest in rural farm areas and lowest in urban areas. For the United States as a whole, average shell egg consumption per person in a week was 0.61 dozens (7.3 eggs). The high consumption (8.9 eggs) of persons in rural farm areas can be attributed to the ready availability of eggs from farm or commercial flocks at a cost that includes no marketing charges. Of the 7.3 eggs consumed per person, in a week, for all urbanizatons, 5.7 eggs were purchased while 1.6 eggs were home-produced. For rural farm areas, only 1.8 of the 8.9 eggs consumed per person, in a week, were purchased. In addition, people on farms are generally more active physically than nonfarm residents, consequently requiring a greater intake of calories. Traditionally, farm breakfasts are meal-size while many urban dwellers favor a quick, light breakfast.

While there is a tendency for egg consumption per person for urban households to increase with income through all income classes, farm and rural nonfarm households exhibit a different tendency (figure 8). The declining consumption of shell eggs as income increases for farm families probably reflects the degree of specialization on the farm enterprise. On subsistence level and the smaller, low income farms, laying hens are kept primarily as a source of food for those on the farm while on higher income, specialized

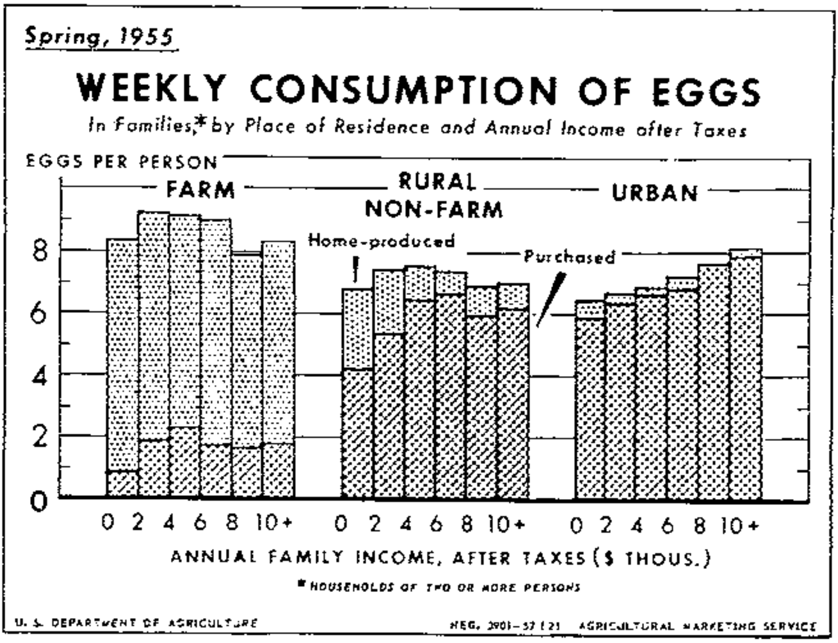

FIGURE 8.—Egg consumption per person for urban households tends to increase with income. Farm and rural nonfarm households exhibit a different tendency, reflecting chiefly a large use of home-produced eggs by the lower income groups.

farms, laying hens would be kept primarily to supply the off-farm market. A similar explanation probably accounts for the rural nonfarm behavior, with lower income families having backyard flocks and higher income families purchasing the greater share of their eggs. The 1955 survey showed that both farm and rural nonfarm higher income families purchase a larger share of the shell eggs they consume than do lower income families.

Measurements of the relationship of consumption and money value to income level, for households of 2 or more, for each urbanization group, are presented in table 12. Based on consumption per person for all urbanizations, a 10 percent rise in per capita disposable income is associated with a 0.2 percent increase in per capita shell egg consumption, chiefly because of the consumption response to income in the urban household sector. For the rural nonfarm and farm sectors, there is no statistically measurable income-consumption relationship. The data for money value of eggs consumed per person, however, show a more pronounced response to changes in income per capita. For all urbanizations, a 10 percent rise in per capita disposable income was associated with a 1.2 percent increase in the money value of eggs consumed, and both the urban and rural nonfarm household sectors showed a statistically significant (although small) response to income change.

TABLE 12.—*Eggs: Percentage change in consumption and money value per person associated with a 1-percent change in income and related statistical coefficients, by urbanization class, 1955* [1]

Urbanization	Based on consumption			Based on money value		
	Coefficient of determination	Effect of a 1-percent change in income		Coefficient of determination	Effect of a 1-percent change in income	
		Net effect	Standard error		Net effect	Standard error
		Percent	*Percent*		*Percent*	*Percent*
Urban	0.68	0.07	0.02	0.90	0.14	0.02
Rural:						
Nonfarm	.28	[2] .03	.02	.79	.09	.02
Farm	.02	[2] .01	.02	.02	[2] .01	.02
All	.57	.02	.01	.90	.12	.01

[1] Computed by least-squares analysis from data in table 11 converted to logarithmic values.

[2] Does not differ significantly from zero at the 5 percent probability level.

Differences between consumption-income and money value-income relationships are due to variations in the price paid for a commodity by different income classes. If all income classes paid the same price for eggs purchased, the coefficients for consumption-income and expenditure-income relationships would be equal, because price would be constant. However, as seen by dividing the money value of eggs by the consumption of eggs (table 13), families in the upper income classes pay a higher price for eggs than do lower income families, although the variation in prices paid by income classes for the rural farm sector is small. The greater part of the variation in prices paid by consumers appears to be associated with the size of egg purchased; the higher the average price paid for eggs by a specified income class, the greater the money value of large, extra large, and jumbo eggs consumed. Only the rural farm group does not follow this pattern closely. However, the rural farm sector mainly uses assorted size eggs while for the other sectors, assorted size eggs constitute a small portion of the eggs used.

TABLE 13.—*Eggs: Average price paid per dozen, and percentage of money value spent for large, extra large, and jumbo sizes, by income and urbanization class, 1955* [1]

Income class (dollars)	Urbanization class							
	Urban		Rural				All	
			Nonfarm		Farm			
	Average price	Money value	Average price	Money value	Average price	Money value	Average price	Money value
Households of 2 or more:	*Cents*	*Percent*	*Cents*	*Percent*	*Cents*	*Percent*	*Cents*	*Percent*
Under 1,000	47	48	45	29	39	24	42	30
1,000–1,999	50	46	45	27	39	30	44	35
2,000–2,999	53	53	45	36	38	24	47	43
3,000–3,999	53	57	46	46	38	26	48	51
4,000–4,999	54	62	47	47	38	31	50	56
5,000–5,999	54	64	48	57	39	30	51	60
6,000–7,999	54	68	50	62	39	35	52	64
8,000–9,999	55	73	54	82	38	19	54	70
10,000 and over	59	85	48	80	42	44	57	83
	Percent		*Percent*		*Percent*		*Percent*	
Coefficient of variation [2]	6.2	------	6.8	------	3.3	------	9.6	------

[1] Average price derived by dividing money value of eggs used by consumption (table 11).
[2] The standard deviation expressed as a percentage of the mean.

Because the money value of eggs used is the product of the price paid and the quantity consumed, the elasticity of money value equals the sum of the elasticity of consumption and the elasticity of price. In cross-section data, however, all consumers are assumed to face essentially the same average level of prices (except for regional variation). Therefore, variation in the price paid is due to variation in the quality of the commodity used. For eggs, the consumer usually has a choice of several grades and sizes, with differing prices. By classifying the attributes of grade and size into the term quality, variation in prices paid by consumers can be considered as variation due to quality and an elasticity measurement can be derived. It can be shown (see Appendix, p. 149) that the elasticity of quality with respect to income is equal to the difference between the elasticity of expenditures with respect to income and the elasticity of consumption with respect to income. For the 1955 data, the elasticities of quality obtained are:

Urban	0.06
Rural:	
Nonfarm	.06
Farm	(1)
All	.09

[1] Less than 0.005.

The absence of a quality response for the rural farm sector appears reasonable when it is remembered that a large part of consumption by this group is of eggs produced on the farms where consumed and, therefore, may have no quality identification.

Households of one person are excluded from the regression analyses because they are atypical, consumption per person exceeding that of other size households at all income levels. The large consumption of shell eggs by 1-person households may be due to the relative ease in preparing eggs compared with other foods as well as to economies of scale. On the latter point, Bylund (4, p. 54) concluded from an investigation of egg consumption in a Pennsylvania city that, "It appears that the number of children in the household is the important factor associated with level of egg consumption rather than simply the number of persons in the household. The data indicate that children eat fewer eggs than adults[12] and that the number of children is related in such a way that the effect is more than additive. In other words it appears that four children in one household would eat fewer eggs than four children in four one-child households." Ideally, the relationships of consumption and money value to income level should be adjusted for number of children in the household. However, data are not published to make this adjustment.

An indication of the effect of children on the consumption-income pattern is obtained from the 1948 survey of food expenditures of urban households. Table 14 shows that although egg consumption per person in households with children is below consumption per person for comparable family income classes in households with no children, consumption per person increases with income about twice as fast for households with children as for households with no children. In households with children, a 10 percent increase in per person income was associated with a 2 percent increase in consumption per person, while for households with no children a 10 percent increase in per person income was associated with less than a 1 percent increase in consumption.[13]

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[12] This agrees with the findings of Hopper (22).

[13] The relationship of consumption per person (X_1) with income per person (X_2) was:

(1) Households with children:

$$\log X_1' = -0.91 + 0.20 \log X_2 \quad (4)$$
$$(0.03)$$
$$r_{12}^2 = 0.92 \qquad s_{1.2} = 0.02$$

(2) Households with no children:

$$\log X_1' = -0.52 + 0.09 \log X_2 \quad (5)$$
$$(0.09)$$
$$r_{12}^2 = 0.41 \qquad s_{1.2} = 0.04$$

TABLE 14.—*Eggs consumed at home: Average consumption per person and expenditures per household in a week, by income group and child status, April–June 1948* [1]

Income class (dollars)	Consumption per person in household with—		Expenditures per household with—	
	Children	No children	Children	No children
	Dozens	*Dozens*	*Dollars*	*Dollars*
Under 2,000	0.38	0.52	0.90	0.74
2,000–2,999	.46	.56	1.10	.77
3,000–3,999	.51	.60	1.25	.94
4,000–4,999	.51	.68	1.23	.94
5,000–7,499	.55	.58	1.28	.89
7,500 and over	.58	.66	1.68	1.09

[1] Urban housekeeping families of 2 or more persons in the United States. Derived from (*9*).

Comparisons with other commodities.—Comparison of the relationship of consumption and money value to income level for eggs and the commodities that are close substitutes and complements reveals that meats, poultry, and fish and cheese have greater consumption-income and expenditure-income responses than eggs, and that breakfast cereals and bacon have about the same response (tables 15 and 16).

Large variation between income groups in the average price paid for meats, poultry, and fish and for bacon account for money value-income relationships significantly higher than quantity-income relationships for these items. As income rises, consumers tend to buy higher grade meat and the more choice cuts. For example, for all urbanizations combined, 53 percent of households of 2 or more persons used some form of beef steak in the survey week, with 24 percent of the households in the less than $1,000 income class and 74 percent of the households in the $10,000 and over income class reporting some use. On the other hand, 29 percent of the households with incomes less than $1,000 used salt pork, while only 6 percent of the households with incomes of $10,000 and over used that item. Much of the fish in the lower income brackets was obtained without a money expenditure, while purchases by the higher income brackets include a greater proportion of more expensive shellfish. For cheese, average price per pound, by income class, is about the same in all income classes, except for the $10,000 and over class, and for breakfast cereals, average price per pound differs only for the less than $1,000 income group. Therefore, the elasticity of money value with relation to income for cheese and for breakfast cereals is not significantly different from the consumption-income relationships of these items.

TABLE 15.—*Selected foods consumed at home: Average consumption per household and per person, in a week, by income groups, all urbanizations combined, April–June 1955* [1]

Income class (dollars)	Consumption				Money value			
	Meats, poultry and fish	Cheese	Breakfast cereals	Bacon	Meats, poultry and fish	Cheese	Breakfast cereals	Bacon
	Per household							
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
1-person households	5.14	0.59	0.31	0.38	3.07	0.28	0.08	0.21
Households of 2 or more:								
Under 1,000	9.67	.57	.66	.78	4.55	.28	.16	.39
1,000–1,999	11.67	.77	.76	.79	5.78	.38	.23	.41
2,000–2,999	13.86	.98	.90	.93	7.23	.46	.24	.49
3,000–3,999	14.31	1.05	.91	.90	7.92	.51	.27	.48
4,000–4,999	15.14	1.14	.95	.87	8.84	.56	.28	.50
5,000–5,999	16.21	1.26	1.01	.94	9.83	.60	.30	.55
6,000–7,999	16.49	1.32	.88	.96	10.25	.64	.26	.59
8,000–9,999	15.70	1.48	.81	.81	10.26	.73	.25	.50
10,000 and over	17.63	1.56	.82	.88	12.64	.82	.25	.57
All	13.77	1.06	.82	.84	7.99	.51	.24	.47
	Per person							
1-person households	4.72	0.54	0.28	0.35	2.82	0.26	0.07	0.19
Households of 2 or more:								
Under 1,000	2.97	.17	.20	.24	1.40	.09	.05	.12
1,000–1,999	3.54	.23	.23	.24	1.75	.12	.07	.12
2,000–2,999	3.94	.28	.26	.26	2.05	.13	.07	.14
3,000–3,999	3.90	.29	.25	.25	2.16	.14	.07	.13
4,000–4,999	4.18	.31	.26	.24	2.44	.15	.08	.14
5,000–5,999	4.39	.34	.27	.25	2.66	.16	.08	.15
6,000–7,999	4.63	.37	.25	.27	2.88	.18	.07	.17
8,000–9,999	4.36	.41	.22	.22	2.85	.20	.07	.14
10,000 and over	4.84	.43	.22	.24	3.47	.23	.07	.16
All	4.14	.32	.25	.25	2.40	.15	.07	.14

[1] Food purchased, home-produced, and received as gift or pay by housekeeping families in the United States.

Derived from (*59*).

The elasticity measurements obtained from the 1955 survey data suggest that expenditures for eggs associated with rising consumer incomes per person are less than the corresponding increased expenditures for meats, poultry, and fish and for cheese. We would expect, therefore, that eggs will receive a smaller share of each additional dollar in future years, so long as consumer incomes continue to rise, than meats, poultry, and fish and cheese, and about the same as breakfast cereals and bacon, provided price relationships,

TABLE 16.—*Selected foods consumed at home: Percentage change in consumption and money value per person associated with a 1-percent change in income and related statistical coefficients, all urbanizations, 1955* [1]

Item	Based on consumption			Based on money value		
	Coefficient of determination	Effect of a 1-percent change in income		Coefficient of determination	Effect of a 1-percent change in income	
		Net effect	Standard error		Net effect	Standard error
		Percent	*Percent*		*Percent*	*Percent*
Meats, poultry and fish	0.96	0.14	0.01	0.97	0.27	0.02
Cheese	.98	.28	.02	.98	.27	.02
Breakfast cereals	.12	.03	[2] .03	.50	.09	.04
Bacon	(3)	(3)	(3)	.64	.09	.03

[1] Computed by least-squares analysis from data in table 15 converted to logarithmic values.
[2] Does not differ significantly from zero at the 5 percent probability level.
[3] Less than 0.01.

consumer tastes and preferences, and other economic and demographic variables that may influence the relationships between these items do not alter over time.

Comparisons over time.—While the 1955 survey data indicate that consumption and expenditures for eggs have a small income response, more confidence would attach to inferences drawn from that result if the estimate could be confirmed with the aid of cross-section studies at other points in time. Comparisons among surveys at different points in time are difficult because of differing conceptual and methodological aspects employed. However, on a broad basis, and keeping in mind the inherent shortcomings of such comparisons, data for eggs from surveys in 1942, 1948, and 1951 are compared in table 17 and figure 9. These data are for urban income groups; consequently, they should be compared with data for the urban group only in the 1955 survey. In the lower income groups there are marked differences between the consumption of urban and rural farm families, with rural nonfarm families occupying an intermediate position. In addition, both the 1942 and 1951 data include single-member households, which have higher per person consumption and expenditure rates for eggs for their per-person income level than do multi-member households in the same per-person income levels. However, if single-member households are not concentrated in any one income class (which appears a reasonable assumption), comparing data from surveys which include single-member households with data from surveys which exclude single-member households should not alter the basic consumption-income and money value-income relationships.

Regression coefficients for the consumption-income and money value-income relationships for eggs for urban groups in the 1942, 1948, and 1951 surveys (table 18) did not differ significantly from

TABLE 17.—*Eggs: Average consumption and money value per household and per person, in a week, by urban income groups, spring, 1942, 1948, and 1951*

Income class (dollars)	Income per—[1]		Average size		Consumption per—		Money value per—	
	Family	Person	Family	Household [2]	Household	Person [3]	Household	Person [3]
1942 [4]	*Dollars*	*Dollars*	*Persons*	*Persons*	*Dozens*	*Dozens*	*Dollars*	*Dollars*
Under 500	310	183	1.69	1.77	0.90	0.51	0.31	0.18
500–999	735	322	2.28	2.45	1.43	.58	.49	.20
1,000–1,499	1,244	482	2.58	2.95	1.86	.63	.67	.23
1,500–1,999	1,750	614	2.85	3.00	2.12	.71	.76	.25
2,000–2,499	2,232	725	3.08	3.24	2.23	.69	.77	.24
2,500–2,999	2,736	827	3.31	3.30	2.30	.70	.86	.26
3,000–4,999	3,714	1,004	3.70	3.60	2.41	.67	.87	.24
5,000–9,999	6,138	1,395	4.40	4.15	2.50	.60	.98	.24
1948 [5]								
Under 1,000	610	243	2.51	2.84	1.43	.50	.78	.27
1,000–1,999	1,555	536	2.90	3.23	1.67	.52	.96	.30
2,000–2,999	2,505	764	3.28	3.49	1.90	.54	1.08	.31
3,000–3,999	3,485	990	3.52	3.65	2.08	.57	1.20	.33
4,000–4,999	4,421	1,267	3.49	3.50	2.20	.63	1.24	.35
5,000–7,499	5,861	1,724	3.40	3.31	1.94	.59	1.11	.34
7,500 and over	11,766	3,080	3.82	3.84	2.36	.61	1.46	.38
1951 [4]								
Under 1,000	614	409	1.5	1.5	(6)	(6)	.49	.33
1,000–2,000	1,532	730	2.1	2.3	(6)	(6)	.64	.28
2,000–3,000	2,534	939	2.7	2.9	(6)	(6)	.87	.30
3,000–4,000	3,487	1,090	3.2	3.2	(6)	(6)	.98	.31
4,000–5,000	4,462	1,312	3.4	3.4	(6)	(6)	1.07	.31
5,000–6,000	5,449	1,514	3.6	3.4	(6)	(6)	1.11	.33
6,000–7,500	6,618	1,789	3.7	3.3	(6)	(6)	1.15	.35
7,500–10,000	8,434	2,109	4.0	3.7	(6)	(6)	1.26	.34
10,000 and over	15,914	4,301	3.7	3.4	(6)	(6)	1.27	.37

[1] Income after Federal taxes in 1941 and 1947. For 1951 data, 1950 income after Federal, State, and local taxes.
[2] Total meals served at home adjusted to 21-meal equivalent.
[3] Household data adjusted by average household size.
[4] Includes single-member households.
[5] Households of 2 or more persons.
[6] Not reported in preliminary releases.

Derived from: 1942 (*60* and *54*), 1948 (*9*), and 1951 (*53*).

the regression coefficients for the 1955 survey,[14] indicating a stable income response for eggs. The only constant term that differed significantly from zero at the 10-percent level of probability[15] was the value for the consumption-income relationship in the 1948 survey. However, the differences among the constant terms for each of the periods, although not significantly different from zero at the 10-percent level of probability, do appear to reflect some effect of changes in the general price level as well as changes in price relationships between eggs and other goods, shifts in income distributions, changes in preferences and tastes, and many other additional unspecified factors. Because it is generally assumed that tastes, preferences, income distributions, and other factors that are primarily determined by institutional forces change slowly over time, changes in the general price level appear to be the major factor contributing to differences in the height of the regression lines for the four surveys being considered.

Allowance can be made for changes in the general price level by deflating the money value and income variables in each regression problem by the Consumers' Price Index for all items (published by the United States Bureau of Labor Statistics). Because the Consumers' Price Index is the same for all observations in each period, adjusting for the CPI is equivalent to dividing by a fixed value, and, therefore, the regression coefficients remain unchanged; only

[14] The "t" values obtained for the differences between regression coefficients in each pair of periods were:

Survey	Value of "t"		Degrees of freedom
	Consumption-income	Money value-income	
1955 and—			
1942	*0.8	*0.6	13
1948	*.6	*.2	12
1951	No data	*1.3	14

*Does not differ from zero by a statistically significant amount at the 10-percent probability level.

[15] The "t" values obtained for the differences between the constant terms in each pair of periods were:

Survey	Value of "t"		Degrees of freedom
	Consumption-income	Money value-income	
1955 and—			
1942	*0.4	*1.4	13
1948	6.5	*.6	12
1951	No data	*1.4	14

*Does not differ from zero by a statistically significant amount at the 10-percent probability level.

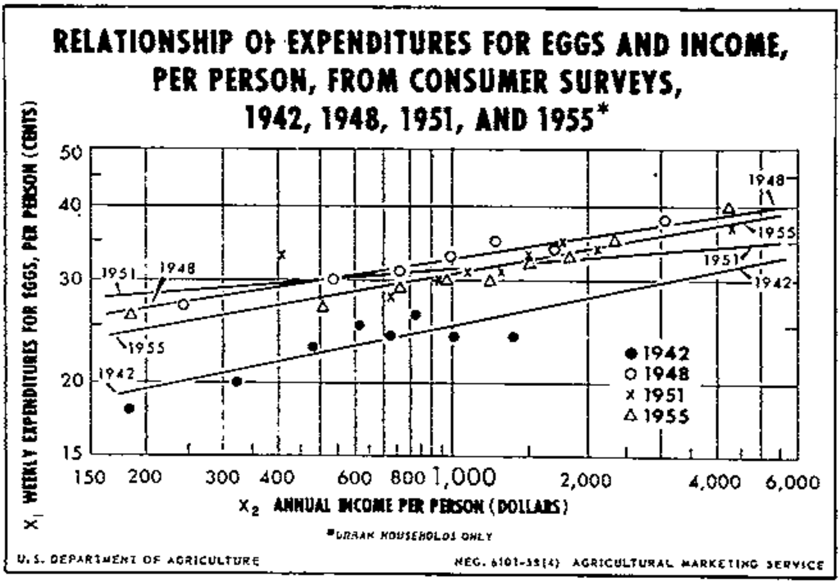

FIGURE 9.—In the last 15 years the relationship of a dollar increase in income to weekly per person expenditures for eggs has remained relatively stable.

the constant terms in the equations change. The "t" values[16] obtained for the differences between the constant terms adjusted for the price level in each period were not significant, with the exception of the 1955-1948 consumption-income relationship. Therefore, data for the consumption of eggs from the 1955 and 1942 surveys and data for the money value of eggs from the 1955, 1951, 1948, and 1942 surveys were pooled in regression analyses to compare with regression analyses from time series data.

In pooling data from the different surveys, the Consumers' Price Index was added as a separate variable rather than as a deflator so that comparisons could be made more easily with coefficients obtained from the 11-equation time series model of the egg economy (p. 64). In addition, the derived average price paid for eggs in the survey week by each income class was added to the consumption-income analysis to allow for shifts in the consumption-income

[16] The "t" values obtained for the differences between the constant terms in each pair of periods, after adjustment for price level, were:

Survey	Value of "t"		Degrees of freedom
	Consumption-income	Money value-income	
1955 and—			
1942	*1.1	*0.4	13
1948	7.2	*1.4	12
1951	No data	*1.5	14

* Does not differ from zero by a statistically significant amount at the 10-percent probability level.

TABLE 18.—*Eggs: Percentage change in consumption and money value per person associated with a 1-percent change in income and related statistical coefficients, urban groups, for specified periods*[1]

Year and source	Based on consumption			Based on money value		
	Coefficient of determination	Effect of a 1-percent change in income		Coefficient of determination	Effect of a 1 percent change in income	
		Net effect	Standard error		Net effect	Standard error
		Percent	*Percent*		*Percent*	*Percent*
1942 (*60*)	0.45	0.12	0.05	0.74	0.16	0.04
1948 (*9*)	.78	.09	.02	.96	.13	.01
1951 (*53*)	(2)	(2)	(2)	.45	.08	.04
1955 (*59*)	.68	.07	.02	.90	.14	.02

[1] Computed by least-squares analysis from data in tables 11 and 17 converted to logarithmic values.
[2] Data not available.

relationship attributable to changes in the price schedule facing consumers at different time periods. For the pooled 1955 and 1942 consumption-income data for urban households, a 1-percent change in per capita income was associated positively with about a 0.2 percent change in the per capita consumption of eggs, after adjusting for the influence of the price of eggs and the general price level.[17] An elasticity of demand with respect to income of 0.2 for urban households is higher than the values obtained for any of the individual periods studied (table 18) as well as higher than elasticities obtained for all households in the 1955 cross-section study (table 12) and any of the time series analyses (table 23). As previously pointed out, we would expect an income elasticity for eggs for urban households higher than for all households combined. In addition, we would expect results from the cross-section studies for eggs to be more significant statistically than the time series studies because time series analyses for eggs that incorporate data from 1931–54 are complicated by intercorrelation between income and the general price level.

The elasticity of demand with respect to own price of −1.48, obtained from the pooled 1955 and 1942 survey data for urban households, is a great deal higher than the results obtained from time series data (table 23). We would expect a higher elasticity, however, because the variation in the price of eggs among income classes, especially for urban households, is due mainly to variations in the

[17] The logarithmic relationship obtained for the pooled 1955 and 1942 survey data was:

$$\log X_1' = -0.86 + \underset{(0.04)}{0.18} \log X_2 + \underset{(0.38)}{0.76} \log X_3 - \underset{(0.54)}{1.48} \log X_4 \qquad (6)$$

$$R^2_{1.234} = 0.74 \qquad s_{1.234} = 0.03$$

where:
X_1 = Consumption of eggs in dozens, per capita, urban households.
X_2 = Disposable personal income in dollars, per capita.
X_3 = Consumers' price index (1947–49=100).
X_4 = Derived average price of eggs, per dozen.

grade and size (see p. 50) of eggs used. The price effect on consumption in a pooled cross-section study, therefore, mainly reflects this influence.

The elasticity of demand with respect to the general price level, derived from the pooled 1955 and 1942 cross-section study, appears reasonable when compared with the estimates from the time series analyses (table 23).

Results from the pooled 1955, 1951, 1948, and 1942 money value data indicate that a 1-percent change in income per capita is associated positively with about a 0.13 percent change in the money value of eggs, per person, after adjusting for the general price level.[18] This value falls within the range of values obtained for the money value-income relationships for each of the surveys (table 18).

From the analyses discussed above, it appears that the influence of income on egg consumption for urban households is extremely small, although statistically significant. The consumption-income relationship for all urbanizations is probably even smaller than that obtained for urban households, based on the 1955 survey data for both groups. The almost negligible influence of income on consumption is not surprising, since the data indicate that the average per capita consumption in each income group is about one egg a day and almost all families in each income group used eggs at some time in the survey period (table 19).

While it is evident that the consumption-income relationship for eggs is small, the precision of the relationship derived empirically is limited by errors in the survey data and by the statistical methods used in deriving a measure of the relationship. The analyst gen-

TABLE 19.—*Eggs: Percentage of households using, by income terciles, in a week, spring 1942, 1948, and 1955* [1]

Income tercile	Percentage of households using		
	1942	1948	1955 [2]
	Percent	*Percent*	*Percent*
Lower	94	97	98
Middle	100	98	99
Upper	99	100	99
All	98	98	99

[1] Includes quantities purchased, produced at home, or received as a gift or in payment for services rendered.

[2] Income terciles are only approximate, being based on grouped data.

From (*51*, p. 9) and (*59*, p. 93).

[18] The logarithmic relationship obtained for the pooled 1955, 1951, 1948, and 1942 survey data was:

$$\log X_1' = 0.07 + \underset{(0.02)}{0.13} \log X_2 + \underset{(0.07)}{0.51} \log X_3 \tag{7}$$

$$R^2_{1.23} = 0.86 \qquad s_{1.23} = 0.03$$

where:

X_1 = Money value of eggs in cents, per person, urban households.
X_2 = Disposable personal income in dollars, per capita.
X_3 = Consumers' price index (1947–49 = 100).

erally has no control over the reliability of the data used, but he must select the statistical form of the equation to be used, often with little basis for making a selection. The cross-section analyses for eggs used a log-log relationship (that is, the relationship was considered to be linear in logarithmic values). The major limitation to using a log-log relationship in fitting a regression line to consumption-income and money value-income relationships is that little is known about the behavior of households at the extremes of the income scale. A curvilinear relationship might be appropriate even when the data are converted to logarithms because, at low income levels, an increase in income probably is spent almost entirely for food while at high income levels the inverse is probably true. However, the pooled consumption-income relationship (equation (6)) was tested for nonlinearity (see Appendix, p. 149) and the log-log relationship used was found not to depart significantly from linearity within the range of the reported observations.

Consumer Preference Studies and Household Practices

Perhaps tastes and preferences have as important an influence on the demand for eggs as prices and income. But changes in tastes and preferences generally occur more slowly than do fluctuations in prices and income, and their effects on demand are difficult to measure. Studies of consumer preferences and household practices, nevertheless, aid in understanding the market that exists for eggs, and such studies may suggest ways for influencing demand.

The factors which housewives consider of primary importance when purchasing eggs appear to be quality, grade, and freshness, although, as table 20 shows, price and size also are important. The relatively minor importance of price indicated by the data may reflect situations in which the quantity purchased is largely influenced by price and income, but, once a purchase has been decided upon, quality and other associated factors become more important.

Because the evaluation of quality by housewives is a subjective concept, it is important to know how housewives make this evaluation in order to supply them with the product demanded. A summary of studies on consumer preferences indicates some general notions in consumers' minds of what constitutes quality. Principally, external appearance, source of supply, and appearance, taste, and odor after breaking out, as well as shaking the egg and other vague notions were reported by housewives as quality considerations. Results of several surveys show that consumers generally select AA or A grade eggs as the type they prefer, and that they can give a good reason for this preference.

Information on household practices also offers additional insights into demand. Results from one such survey covering two cities are listed in table 21. Almost all households used eggs for table use in the two cities but a much smaller percentage of households used eggs in batters and doughs and in other food preparations. As the quantity of a product used by a consumer increases, its demand tends to become inelastic. If production in such cases continues to increase, severe price and income decreases to producers can be avoided only by finding additional uses for that output. Batters, doughs, and other food preparations may offer opportunities for increased use of eggs.

TABLE 20.—*Eggs: Percentage of housewives who consider specified factors of primary importance when purchasing, selected cities*

City	Year study was conducted	Factor considered					
		Quality, grade, and freshness	Price	Size	Brand name, color, or cleanliness	Nothing specific, or relied on retailer's reputation	Miscellaneous and unclassified
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Baltimore	1938	22.0	23.4	------	[1] 5.8	47.7	1.1
Wichita	1949	83.1	16.9				
Peoria	1950	53.7	13.1	21.6	[2] 4.5	3.6	3.5
Des Moines	1949	18.5	4.6	42.8	[3] 10.8	13.0	10.3
Columbus	1950	66.4	23.0	9.0		1.3	.3
Ithaca	1952	71.0	11.0	12.0	[2] 2.0	--------	4.0

[1] Brand name.
[2] Color.
[3] Color, 3.8 percent; cleanliness, 7.0 percent.
From: Jasper (*23*, p. 8).

TABLE 21.—*Eggs: Percentage of households using and percentage used, by use and income class, Birmingham and Indianapolis, spring 1953*

Use	Birmingham				Indianapolis			
	All households	Household income			All households	Household income		
		Low	Middle	High		Low	Middle	High
	Percentage of households using							
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
For table	97	96	95	99	98	99	97	98
In batters and doughs	65	61	69	63	45	58	49	31
For other food preparation	47	32	53	56	43	32	48	48
Any	98	97	99	99	99	100	100	98
	Percentage used							
For table	81	81	79	82	87	87	87	87
In batters and doughs	12	14	13	10	6	8	6	5
For other food preparation	7	5	8	8	7	5	7	8
Total	100	100	100	100	100	100	100	100

(*49*, July 1954, p. 21).

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An 11-Equation Model of the Egg Economy

The section on factors that influence the supply of eggs indicates that the supply of eggs in a calendar year is influenced by price movements within the same period through two methods of adjustment under the control of producers—chick replacements and layers sold and consumed on farms where produced. (1) If the egg-feed ratio in the first half of the year, when producers are starting chicks for future flock replacement, is lower than the ratio for the corresponding period in the previous year, producers generally start fewer replacements. If the egg-feed ratio is higher than a year earlier, they tend to increase the number of chicks started for flock replacement. (2) The number of layers sold and consumed on farms where produced throughout the year is related to the egg-feed ratio prevailing in that year. When the egg-feed ratio is above the previous year, the number of layers sold and consumed on farms where produced is less than when the egg-feed ratio in the current year is below the ratio in the previous year. Consequently, there is an interaction between demand and supply within the 12-month time span of January through December.

Under this condition of a simultaneous relationship between supply and price, it has been shown [see, for example, (*18*) and (*29*)] that estimation of such coefficients as elasticity of demand with respect to price by the traditional method of a single regression equation fitted by least squares may result in a statistical bias. To avoid this bias, a "system" of equations should be solved simultaneously if the underlying economic relationships between demand, price, and supply factors are to be ascertained. We are concerned therefore, with obtaining a structural estimation of the relationships among the many variables that have been shown to affect the demand, price, and supply for eggs. Klein (*27*, p. 21) has stated that "in general, the goal is to estimate a set of relations that will remain valid or change in known ways under a wide variety of circumstances."

Variables

The variables that enter into the structural model of the egg economy are listed below, identified symbolically. In order to work with the limited information approach, the total variables in the system are divided into two categories—endogenous variables and predetermined variables. The former are those variables whose relationships among themselves and with other variables are to be determined from knowledge of variables whose values are assumed to be known. The latter variables are designated as predetermined.[10]

All variables in the system of equations relate to the calendar year except those having a prime ('), which designates values of the variables for January-June.

The following variables are assumed to be endogenous for this analysis:

Q_E=Civilian domestic disappearance of eggs, billions.
P_R and P'_R=Retail price of eggs, per dozen, cents.

[10] Technically, an endogenous variable is one that is correlated with the unexplained residual in the structural relation in which it appears, while a predetermined variable is uncorrelated with the unexplained residual.

Q_F=Farm production of eggs, billions.
L_F=Average number of layers on farms during the year, millions.
C_F=Number of pullets raised, millions.
L_C=Number of layers sold and consumed on farms where produced, millions.
P_F and P'_F=Farm price of eggs, per dozen, cents.
Q'_E=Farm production of eggs minus the January–June net into-storage movement of shell, frozen, and dried eggs (shell equivalent), excluding Government stocks, billions.
S'=January through June net into-storage movement of shell, frozen, and dried eggs (shell equivalent), excluding Government stocks, billions.

The following variables are assumed to be predetermined in this analysis:

I=Consumer disposable income, billion dollars.
P_M and P'_M=Retail price of meats, poultry and fish, index numbers (1947–49=100).
P_C and P'_C=Retail price of cheese, index numbers (1947–49=100).
P_B and P'_B=Retail price of bacon, index numbers (1947–49=100).
P_T and P'_T=Retail price of ready-to-eat cereals, index numbers (1947–49=100).
P_O and P'_O=Consumers' price index of all items (1947–49=100).
Q_A=Average number of eggs produced per layer during the year.
L_J=Number of hens and pullets of laying age and pullets not yet laying on farms, January 1, millions.
A=Difference between civilian domestic disappearance of eggs and farm production of eggs, billions.
M=Mortality of layers plus a balancing residual, millions.
P_G and P'_G=Average price of poultry ration, per 100 pounds, dollars.
H=Population eating out of civilian supplies, July 1, millions.
Q'_F=Number of eggs produced on farms, billions.
W=Unit labor cost of marketing food products, index numbers (1947–49=100).
F=Gain or loss on futures contract, previous year, speculative long position, per dozen, cents.

In the previous sections on factors that affect the supply and demand for eggs, reasons for choosing these variables are discussed, except for the net into-storage movement of shell, frozen, and dried eggs, S', the unit labor cost of marketing food products, W, and the gain or loss experienced by those who took a speculative long position on the previous year's futures contract, F. Reasons for including the variables S', W, and F in the structural model of the egg economy are explained below.

Years Included

The simultaneous equation analysis is based on first difference values for the years 1931–41 and 1946–54. Conditions during these years are assumed to have been sufficiently homogeneous to permit their inclusion in a single analysis. Years subsequent to 1954 are excluded so as to leave several observations against which to test the fitted equations. Individual equations presented in previous sections were, in some instances, fitted for years prior to 1931; however, data for all the variables used in the model of the egg economy are available only from 1931. The war years 1942-45 are excluded because of the abnormal circumstances that influenced supply and demand in that period. First differences are used because of the several trend factors that have affected the relationships.

Price supports for eggs, in order to bring about expansion of production to achieve certain announced goals, were mandatory from 1942 through 1946. In part of this period, maximum price controls were imposed on prices paid by retailers for shell eggs, and ceiling prices were imposed at wholesale levels for liquid, frozen, and dried egg products. In addition, the Government became a heavy purchaser of eggs for our military use as well as for the use of our allies. Levin (*31*, p. 888) states that the following percentages of the eggs produced on farms were procured for Lend-Lease purposes: "5 percent in 1941, 15 percent in 1942, 13 percent in 1943, 17 percent in 1944, and 2 percent in 1945." (See also table 48, p. 134.) Nearly all of these eggs were dehydrated. With the termination of the Lend-Lease program in the latter part of 1945, dehydrated eggs were taken for UNRRA and other overseas relief programs. However, it seems reasonable to assume that the effect of the wartime programs on eggs, as well as wartime influences that affected other variables in the model of the egg economy, were considerably lessened by 1946 so that the postwar years can be included in the analysis.[20]

Equations in the Model

The following structural equations are involved in a system that represents the supply and demand for eggs. The 11 equations shown correspond to the 11 endogenous variables in the system. Therefore, this is a complete system.

$$\frac{Q_E}{H}=a_1+b_{12}P_R+c_{11}\frac{I}{H}+c_{12}P_M-c_{13}P_C+c_{14}P_B+c_{15}P_T+c_{16}P_O+u_1 \quad (8)$$

$$Q_F=Q_A \cdot L_F \quad (9)$$

$$Q_E=Q_F+A \quad (10)$$

$$L_F=L_J+C_F-M-L_C \quad (11)$$

$$C_F=a_5+b_{52}\frac{P'_F}{P'_G}+u_5 \quad (12)$$

$$L_C=a_6+b_{62}\frac{P_F}{P_G}+u_6 \quad (13)$$

$$P_F=a_7+b_{72}P_R+b_{73}\frac{Q_E}{H}+c_{71}W+u_7 \quad (14)$$

$$P'_F=a_8+b_{82}P'_R+b_{83}\frac{Q'_E}{H}+c_{81}W+u_8 \quad (15)$$

[20] For a complete account of the effect of World War II programs on eggs, see Levin (*31*).

$$P'_R=a_9+b_{92}\frac{Q'_E}{H}+b_{93}\frac{S'}{H}+c_{91}\frac{I}{H}+c_{92}P'_M+c_{93}P'_C$$
$$+c_{94}P'_B+c_{95}P'_T+c_{96}P'_O+u_9 \quad (16)$$

$$\frac{S'}{H}=a_{10}+b_{102}\frac{Q'_F}{Q_F}+c_{101}F+u_{10} \quad (17)$$

$$Q'_E=Q'_F-S' \quad (18)$$

In this notation, the a's represent the constant term in each equation, the b's and c's represent structural coefficients that apply to the endogenous and predetermined variables, respectively, and the u's represent random error terms. No coefficients or random error terms are involved in equations (9), (10), (11), and (18) because they are identities; they need not be fitted by statistical means. The remaining seven equations each contain two or more endogenous variables and, therefore, were fitted by the method of limited information.[21]

Several modifications were made in fitting parameters to the model. The predetermined variable M was dropped from the system because representative data were not available. However, it was felt that the loss of information resulting from the exclusion of the predetermined variable M is minor, although each valid predetermined variable added to a system tends to increase the statistical efficiency of the model. When using the model for forecasting purposes, it is necessary to substitute an estimate of the variable M into equation (11) because it is an identity equation. Another modification in fitting the model involved the substitution of linear approximations for the nonlinear variables and relations, like Q_E/H and $Q_A \cdot L_F$. These modifications and certain other aspects of fitting are discussed in the Appendix.

Considerations in the formulation of the above equations are given in the sections that relate to supply and demand and the following remarks.

Equation (8).—The civilian disappearance of eggs is influenced by the price of eggs, population, income, the prices of substitute and complementary goods, as well as the general price level.

Equation (10).—Because annual egg production is the product of the rate of lay and the average number of layers on farms during the year, the variable A is added to equation (10) as a balancing item between civilian disappearance and farm production of eggs. The variable A is considered predetermined because annual changes in stocks, exports and imports, and eggs used for hatching are only a small percentage of annual egg production while military and USDA takings for export, which account for a large percentage of production in some years, are essentially exogenous factors.

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[21] Foote (*34*, p. 86) points out that the limited information method "is given that name because it makes use of only part of the information that is shown by the complete model. It yields estimates for a selected subset of equations when we neglect information about the variables that appear in particular equations in the remainder of the system." In deriving the coefficients in this model, the subset in each case consists of a single equation.

Equations (12) and (13).—These include the egg-feed ratios for January-June and January-December, respectively. Because these ratios have as one of their components the price received by farmers for eggs, they are classified as endogenous variables, thereby necessitating the addition of several equations to the system.

Equations (14) and (15).—Equation (14) relates P_F to the average retail price of eggs in each year (P_R), while equation (15) relates P'_F to the average retail price of eggs in the first six months of each year (P'_R). Essentially, equations (14) and (15) represent the function of the marketing system which transmits consumer demand to the farm price level. Farm and retail prices are related by (1) fixed charges such as costs of processing, transportation, and containers, and (2) percentage markups in wholesale and retail distribution.

Year	Farm-retail spread
	Cents
1920–29	15.9
1930–39	10.8
1940–49	15.0
1950	19.1
1951	20.3
1952	20.4
1953	17.8
1954	18.7
1955	18.0
1956	17.9
1957	18.3
1958	19.4

(*48*).

The farm-retail price spread for eggs rose rapidly in the years after World War II. Since 1953, however, it has changed little as higher costs have been offset by cost-reducing changes in marketing channels and practices. These include: (1) Reduction in numbers of egg handlers and frequency of handling individual eggs, through the bypassing of city wholesalers and associated distributors by large country assemblers and other integrated assembler-grader-distributors and retailers; (2) adoption of improved methods of grading and handling eggs in plants; (3) increases in number of specialized egg farms; (4) increases in buying of eggs from farms on the basis of U.S. consumer grades; and (5) increasing movement of grading and cartoning operations from city to country plants.

In a study conducted in July and October 1955 and January and April 1956 (*10*, p. 13) the average paying price for all eggs at the farm during the 4-month period was 34.5 cents per dozen. The average selling price to retailers and others for all eggs, including cartoned and loose of all sizes and grades, was 45.8 cents per dozen. Retailers added another 10 cents per dozen, bringing the retail price per dozen to almost 56 cents. The following tabulation shows the breakdown of the 21.5 cents per dozen in handling and transportation costs between the farm and the final retail outlet distributed among gross margins for country assembly points, city receiving plants, and retail outlets:

Cost item	Cost per dozen
	Cents
Country assembly plant:	
Procurement (pickup at farm)	0.68
Candling	.74
Cartoning	.94
Loading out	.16
Supervision	.33
Supplies	3.50
Commission	.31
Miscellaneous	.54
Total	7.20
Transportation	1.05
City receiving plant:	
Warehouse	.50
Trucks and sales	1.75
Miscellaneous	1.00
Total	3.25
Combined cost of assembly, transportation, and receiving	11.50
Retail gross margin	10.00
Farm-to-retail price spread	21.50

(*10*, p. 13).

The retail margin for eggs is not broken down because of the difficulty of allocating costs such as rent, labor, and electricity among the thousands of items sold in a retail outlet.

In the previous year, 1954, a different study (*11*, p. 23) showed that the typical marketing costs for country assemblers of midwestern eggs sold in eastern markets was 9.5 cents per dozen (table 22). The following tabulation indicates that marketing costs for wholesalers candling eggs in Washington, D.C. were about 8 cents per dozen:

Item	Typical marketing cost per dozen
	Cents
Labor (candling and other)	2.50
Cartons	2.23
Inspection	.20
Cases, flats, and fillers (replacements)	.25
Miscellaneous	.33
Throw out loss [1]	1.25
Overhead and profit	1.27
Total	8.03

[1] Loss incurred in replacing lower grade eggs with Grade A eggs when candling into consumer grades.

(*11*, p. 24).

TABLE 22.—*Eggs: Typical marketing costs for country assemblers of midwestern eggs sold in eastern markets, 1954*

Item	Cost per dozen	Items included
	Cents	
Freight on sales	2.70	Plant to consuming area.
Labor	.68	Processing, loading in and loading out.
Supplies	2.02	Cases, flats, fillers, nails, wire strapping.
Buying commission	2.38	Paid to station buyers and independent dealers for pickup at farm, grading, and handling.
Plant trucking costs	.59	Delivery costs, and expense of moving eggs from buying station to receiving plant.
General	1.13	Overhead, profit, etc.
Total	9.50	

(*11*, p. 23).

A measure of the influence of fixed marketing charges is represented in equations (14) and (15) by the variable W, an index of the unit labor cost of marketing food products. The influence of percentage markups is allowed for by including the variable Q_E/H in equation (14) and Q'_E/H in equation (15). This assumes that percentage markups vary with the quantity of eggs moving through the marketing channel. At each stage in the marketing channel differences between the cost of goods purchased and the subsequent selling price of those goods, after allowing for fixed transportation, packaging, and processing, is determined by the equilibrium price between the demand curve of a marketer and the supply curve of a marketer in the immediately lower distribution channel. At times of heavy marketings of a perishable commodity, such as eggs, prices at the retail level adjust so that supply clears the market. Because, in the short-run, distributors are willing to perform the marketing function if they cover only out-of-pocket costs, percentage markups would decrease with large supplies and increase with small supplies. However, if both fixed and variable costs are to be met, then percentage markups would increase with large supplies and decrease with small supplies. Consequently, the quantity of eggs moving through marketing channels, on a per capita basis, is included in the two price-level equations.

Equation (16).—Both P_R and P'_R are endogenous variables. The formulation of equation (8), which contains values for P_R, was explained above. Equation (16), which contains values for P'_R, is similar to equation (8); that is, it includes the factors which influence the demand for eggs, although only in the months January through June. However, the combination variable S'/H is included in equation (16), but not in equation (8). The variable represents the net into storage movement during the period January through June of shell, frozen, and dried eggs (on an equivalent shell basis) stated in per capita terms to adjust for the effect on demand of the growth in population. It is introduced into the January–June demand analysis for several reasons. As pointed out on page 6, the absolute level of January 1 stocks of eggs and changes in the level of stocks normally are of minor importance as a price making factor in the annual supply and distribution of eggs. However, because of the seasonal nature of egg production, the supply of fresh eggs available in the spring months of March through May is greater, and the supply in the fall months of August through October is less, than the average monthly supply over the entire year. This seasonal variation in supply, which is treated more thoroughly beginning on page 97, gives rise to the role of storage.

The excess shell eggs (in relation to the prevailing price) available in spring are placed in storage, or broken commercially for conversion into dried or frozen eggs. Part of the shell eggs put into storage in the spring are withdrawn in the fall, when supplies of fresh shell eggs are less than the quantity that would be demanded at the prevailing price. If it were not for storage, which serves to level the peaks and troughs in egg supplies, shell egg prices would tend to decline in the spring and rise in the fall to an extent greater than usually prevails. Because of the simultaneous relationship between the price of shell eggs in the January–June period and the quantity of eggs stored, the variable S' is treated as an endogenous variable, necessitating the addition of equation (17), to the system of simultaneous equations. In addition, because Q'_E/H is treated as an endogenous variable, equation (18) is added to make the system of simultaneous equations complete.

Equation (17).—This states that the net into-storage movement of eggs, per person, for January–June is a function of the ratio of January–June farm egg production to the January–December farm egg production, Q'_F/Q_F, the net gain, or loss, on the speculative position of the previous year's futures contract, F, and a random error term. (See pp. 119 to 131.)

The ratio of production in the two time periods is introduced to represent the trend in the seasonality of egg production. Through the use of artificial lighting, changes in the hatching date of chicks, improvements in breeding, and other factors, the seasonal peaks and troughs of production have tended to become less acute. Obviously, as production becomes less seasonal, the price incentive for storing eggs diminishes. The combined variable Q'_F/Q_F allows for this effect in our model.

Farm production of eggs in January–June (Q'_F) is included in the model as a predetermined variable, while production over the 12-month span January–December (Q_F) is treated as an endogenous variable in the system. Q'_F is considered to be predetermined because, as pointed out in the section on supply, producers principally start chicks for flock replacement in the first six months of the calendar year. Few chicks are started for flock replacement in July–December, although there has been an increasing tendency on the part of some producers to start chicks in this period. Producers generally cull in summer and fall. Classifying Q'_F as a predetermined variable, therefore, assumes that culling activity in response to changes in the egg-feed ratio in January–June is negligible, although culling activity over the entire calendar year is treated as responsive to the egg-feed ratio.

The variable F was obtained by: (1) Determining the monthly average of the daily closing prices of the September, October, and November egg futures contracts in their respective months of maturity and then obtaining the average of the three monthly averages; (2) determining the monthly average of the daily closing prices in March, April, and May of the September, October, and November futures contracts, and obtaining the average of the three monthly averages; and (3) subtracting the average obtained in (2) from the average obtained in (1). If the sum obtained is positive, long traders or unhedged storers had a greater likelihood of making a profit than if the sum was negative. A more satisfactory equation explaining the storage operation probably would include the "basis" (the spread between the current spot price and the nearest futures contract price). However, if the price of the nearest futures contract was included in our model (which in the January-June period would be the September contract for eggs), an equation explaining traders' expectations about demand, supply, and price in a future period would need to be constructed. Consequently, in order to restrict the model to a manageable size, the simplified form of equation (17) was used. As is shown on page 127, this simplified equation can be justified on a logical basis.

Equation (18).—This defines the civilian consumption of eggs in January–June, Q'_E, as the sum of the quantity of eggs produced on farms in the first six months of the year, Q'_F, less the net into-storage movement of shell, frozen, and dried eggs in the first half of the year, S'. The variable Q'_E is not strictly comparable with Q_E because changes from year to year in foreign trade, eggs used for hatching, military purchases, and other factors, which were included in the variable A, are not allowed for. However, because these factors constitute only a small part of production, the variable Q'_E, obtained as the sum of Q'_F minus S', adequately represents the supply of eggs available for consumption in January–June.

Results

The following results were obtained when the structural equations involved in the system representing the supply and demand for eggs were fitted by both the method of limited information and the method of least squares for the years 1932–41 plus 1947–54. Although it was pointed out that the method of least squares gives estimates of such coefficients as the elasticity of demand with respect to price that are statistically biased when simultaneous relationships exist (p. 5), least squares fits of the structural equations in the model of the egg economy are presented for the following reasons: (1) In forecasting values of the endogenous variables in the model, least squares results may be as good as, or better than, results obtained by forecasting from the limited information fit; (2) the amount of bias in the least squares coefficients appears to be small for some structural relationships; and (3) coefficients for least squares fits computationally are more easily obtained than for limited information fits.

Numbers in parentheses under the coefficients show their respective standard errors.[22] Variables with asterisks were used in the analysis in linearized forms (see Appendix, p. 142). The variables are described on pages 62 and 63.

[22] The standard error indicates the range which for two samples out of three includes the true-universe value, provided certain statistical conditions are met by the initial data.

Model I—Limited Information Results

$$\Delta\frac{Q_E^*}{H}=0.84-\underset{(44.94)}{14.68}\Delta P_R-\underset{(1.61)}{0.51}\Delta\frac{I}{H}-\underset{(6.42)}{1.01}\Delta P_M$$
$$+\underset{(46.72)}{14.77}\Delta P_C+\underset{(4.85)}{0.77}\Delta P_B-\underset{(15.93)}{6.17}\Delta P_T+\underset{(21.08)}{8.96}\Delta P_O \qquad (19)$$

$$\Delta Q_F=\Delta(Q_A\cdot L_F)^* \qquad (20)$$

$$\Delta Q_E=\Delta Q_F+\Delta A \qquad (21)$$

$$\Delta L_F=\Delta L_J+\Delta C_F-\Delta M-\Delta L_C \qquad (22)$$

$$\Delta C_F=-2.64+\underset{(2.77)}{14.22}\Delta\frac{P_F'^*}{P_G'} \qquad (23)$$

$$\Delta L_C=-9.32-\underset{(4.35)}{15.56}\Delta\frac{P_F^*}{P_G} \qquad (24)$$

$$\Delta P_F=-0.15+\underset{(0.08)}{0.82}\Delta P_R-\underset{(0.04)}{0.05}\Delta\frac{Q_E^*}{H}+\underset{(0.09)}{0.04}\Delta W \qquad (25)$$

$$\Delta P_F'=-3.07-\underset{(19.90)}{2.03}\Delta P_R'+\underset{(9.43)}{1.36}\Delta\frac{Q_E'^*}{H}+\underset{(18.25)}{2.55}\Delta W \qquad (26)$$

$$\Delta P_R'=-7.81-\underset{(1.45)}{2.17}\Delta\frac{Q_E'^*}{H}-\underset{(1.75)}{2.30}\Delta\frac{S'^*}{H}+\underset{(0.15)}{0.16}\Delta\frac{I}{H}$$
$$+\underset{(1.03)}{0.28}\Delta P_M'+\underset{(0.94)}{0.44}\Delta P_C'-\underset{(0.61)}{0.60}\Delta P_B'-\underset{(1.33)}{1.53}\Delta P_T'+\underset{(3.21)}{0.38}\Delta P_O' \qquad (27)$$

$$\Delta\frac{S'^*}{H}=-146.63-\underset{(591.26)}{199.55}\Delta\frac{Q_F'^*}{Q_F}+\underset{(12.42)}{3.97}\Delta F \qquad (28)$$

$$\Delta Q_E'=\Delta Q_F'-\Delta S' \qquad (29)$$

Equations (23) and (24), representing supply relationships, equation (25), representing a price level relationship, and equation (27), representing demand at the retail level in the months January through June have standard errors smaller than the regression coefficients for most of the variables included in each equation. The signs of the regression coefficients between price and per capita consumption in equations (19) and (27), representing demand relationships, agree with the postulate of economic theory that price and consumption are inversely related. However, because of the size of their standard errors little confidence can be placed in the price-consumption coefficients. The remaining variables in equations (19) and (27), and the variables in equation (26) and (28), also have such large standard errors relative to their regression coefficients, that little confidence can be placed in them. However, the high degree of statistical significance obtained in the supply relationships tends to confirm the presence of a simultaneous relationship between price and production within the same year through the response of chick placements and layers sold and consumed on farms where produced to the egg-feed ratio.

The results obtained by fitting each of the equations in model I by the method of least squares were:

Model I—Least Squares Results

$$\Delta Q_E/H = -3.05 - \underset{(0.47)}{0.84}\Delta P_R - \underset{(0.05)}{0.03}\Delta I/H + \underset{(0.54)}{0.07}\Delta P_M + \underset{(0.82)}{0.52}\Delta P_C - \underset{(0.22)}{0.61}\Delta P_B - \underset{(0.59)}{1.77}\Delta P_T + \underset{(1.66)}{5.11}\Delta P_O \quad R^2=0.72 \qquad (19a)$$

$$\Delta C_F = -3.05 + \underset{(2.40)}{15.36}\Delta P'_F/P'_G \quad r^2=0.72 \qquad (23a)$$

$$\Delta L_G = -8.91 - \underset{(2.10)}{9.22}\Delta P_F/P_G \quad r^2=0.55 \qquad (24a)$$

$$\Delta P_F = 0.02 + \underset{(0.05)}{0.96}\Delta P_R - \underset{(0.03)}{0.05}\Delta Q_E/H - \underset{(0.07)}{0.05}\Delta W \quad R^2=0.99 \qquad (25a)$$

$$\Delta P'_F = 0.31 + \underset{(0.04)}{0.95}\Delta P'_R - \underset{(0.03)}{0.04}\Delta Q'_E/H - \underset{(0.05)}{0.17}\Delta W \quad R^2=0.99 \qquad (26a)$$

$$\Delta P'_R = -2.03 - \underset{(0.32)}{0.66}\Delta Q'_E/H - \underset{(0.29)}{0.41}\Delta S'/H + \underset{(0.04)}{0.02}\Delta I/H - \underset{(0.45)}{0.15}\Delta P'_M + \underset{(0.42)}{0.28}\Delta P'_C - \underset{(0.20)}{0.10}\Delta P'_B - \underset{(0.51)}{0.73}\Delta P'_T + \underset{(1.38)}{1.54}\Delta P'_O \quad R^2=0.64 \qquad (27a)$$

$$\Delta S'/H = 0.95 + \underset{(1.23)}{1.41}\Delta Q'_F/Q_F + \underset{(0.23)}{1.23}\Delta F \quad R^2=0.69 \qquad (28a)$$

The coefficients obtained by limited-information methods and by least-squares methods for equation (23) and (23a) agree very closely while the coefficient on the egg-feed ratio (P_F/P_G) in equation (24) is about two-thirds larger than the coefficient in equation (24a). The standard error of the regression coefficient in equation (24), however, is more than twice as large as the standard error for the coefficient in (24a), so that the equations do not indicate any significant differences in measuring the supply relationships.[23] If the coefficients obtained from the limited information fit are expressed in terms independent of the units used, the supply elasticities obtained for the period 1931–41 plus 1946–54 indicate that a 10-percent change in the January–June egg-feed ratio is associated with about a 4-percent change in the same direction in the number of chickens raised for laying flock replacement while a 10-percent change in the annual egg-feed ratio is associated with about a 7-percent change in the inverse direction in the number of layers sold and consumed on farms where produced. The supply elasticity for pullets raised with respect to the spring

[23] $t(b_{12}-b'_{12})=1.31$, which is not significant at the 5-percent probability level.

egg-feed ratio seems quite reasonable, but the elasticity for layers sold with respect to the annual egg-feed ratio seems too large. However, the corresponding regression coefficient obtained from equation (24a), which did not differ significantly from the coefficient obtained in equation (24) at the 5-percent probability level, gives an elasticity of about -0.4. This estimate appears more reasonable than the estimate of -0.7 derived from equation (24).

The limited information fit of equation (25) agrees closely with the least-squares fit (25a). Correct signs were obtained for the coefficients associated with P_R and Q_E/H, although the latter coefficient is not significant at a high probability level. In neither equation was the coefficient of W statistically significant, although on a priori grounds we would expect a negative relationship in the equation formulated. However, the lack of significance for the coefficient of W could be due to the inclusion of Q_E/H in the equation. In formulating the marketing equations, we could have assumed that the marketing margin is simply a function of unit costs in marketing as reflected by unit labor costs in marketing (W). However, in any given year, because of a relatively fixed supply of marketing services, marketing charges may also vary with the volume of marketings. From a cost side, the higher charges might reflect overtime payments to labor, increased costs due to use of obsolete equipment, and similar items. Consequently, by including in equation (25) the variable Q_E/H as an indicator of the amount of eggs moving through the marketing sector we are removing that effect from the unit labor cost of marketing. This action makes it more difficult to get a significant coefficient on the variables Q_E/H and W.

In contrast, equation (26a) yielded a coefficient for W that was statistically significant. However, the simple coefficients of determination for the least-squares fits of (25a) and (26a) show that the r^2 value of Q_E/H and W in (25a) is 0.23 while the value of Q_E/H and W in (26a) is 0.02. Therefore, with no measurable statistical relationship between the quantity variable and the unit labor cost in marketing, we are able to get a significant result for the regression coefficient in equation (26a). Further evidence that the relationship between Q_E/H and W was the reason nonsignificant results were obtained in (25a) for W is obtained by refitting (25a) with Q_E/H eliminated. In this formulation, (25c), the regression coefficient for W equals -0.11 with a standard error of (± 0.06). (See p. 75.)

Although the limited information fit of (25) agrees closely with the least squares fit of (25a), equations (26) and (26a), which express the marketing relationships in the first half of the year, differ sharply. None of the coefficients in equation (26) were larger than their standard errors, a surprising result when judged against the significance obtained in equation (26a). One explanation for the seeming inconsistency stems from the different way in which the covariances between P'_R and Q'_E/H and between Q'_E/H and W affect the least squares and limited information estimates. The values of the simple correlation coefficients for these pairs of variables are negative, but extremely small, so that they do not change the gross positive relationship between P'_F and P'_R in the least square fit of equation (26a) to a negative net relationship. However, in the limited information fit of equation (26) the negative covariances for P'_R and Q'_E/H and for

Q'_E/H and W are coupled with the effects of the predetermined variables in the system. These combined effects have sufficient influence to produce a negative sign on the net coefficient between P'_F and P'_R.

As mentioned above, little confidence can be placed in the coefficients obtained from the limited information fits of equations (19) and (27), representing demand relationships, because of the large standard errors obtained. Least square fits of the demand relationships, equations (19a) and (27a), were better. The net regression coefficient between Q_E/H and P_R in equation (19a) is significant at the 10–20 percent probability level while the net regression coefficient between P'_R and Q'_E/H in equation (27a) differed significantly from zero at the 5–10 percent probability level. Significant coefficients also were obtained in equation (19a) for the variables representing the price of bacon, P_B, the price of breakfast cereals, P_T, and the general price level, P_O. The signs associated with the coefficients for P_B and P_O agreed with the signs expected on a priori grounds. However, the sign for the coefficient of P_T is contrary to the expected sign if breakfast cereals are a substitute for eggs in consumers' food expenditures.

Judged in their entirety, the least square fits of the demand equations, (19a) and (27a), are not much more satisfactory than the limited information fits of (19) and (27). The major reason for the unsatisfactory results appears to be the high degree of intercorrelation among the variables in the demand equations.[24] In many cases, as the degree of intercorrelation in a regression analysis increases beyond a certain level, the sign of some of the partial regression coefficients changes. In this region of the sign change the value of the regression coefficient does not differ significantly from zero for samples of modest size. It can be assumed that high intercorrelation also affects coefficients in a limited information fit in a similar manner, although no systematic study has been made of the method of limited information to determine at what level of intercorrelation the sign of a partial regression coefficient is affected.

Because of the high degree of intercorrelation among several of the predetermined variables in the demand equations, the model of the egg economy was reformulated with the predetermined variables P_M, P_C, P_B, P_T, P'_G, and W[25] dropped from the matrix of predetermined variables. Specifically, the demand equations were modified to exclude prices of substitute items. In fitting the individual equations, however, P'_G was used in equation (23b) and W was used in equation (25b) and (26b). In contrast to the earlier model, effect of volume of marketings on the retail-farm price margin was not included in (25b) and (26b). No other modifications of the equations on page 64 were made. The results obtained from the reformulated model were:

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[24] Simple correlation coefficients of 0.80 or more were obtained in equation (19a) for the relationships of: P_M, P_C (0.88); P_M, P_O (0.92); P_C, P_O (0.91); and P_T, P_O (0.87). In equation (27a) simple correlation coefficients of 0.80 or more were obtained for the relationships of: P'_M, P'_C (0.91); P'_M, P_O (0.93); P'_C, P_O (0.90); and P'_T, P_O (0.83).

[25] The simple correlation coefficient for the relationship of P'_G with P_G was 0.86, and for the relationship of W with P_O, 0.93. Simple correlation coefficients among the other predetermined variables are given in footnote 24, and on page 79.

Model II—Limited Information Results

$$\Delta Q_E^*/H = -6.83 - \underset{(1.31)}{2.97}\Delta P_R + \underset{(0.08)}{0.02}\Delta I/H + \underset{(1.73)}{3.80}\Delta P_O \qquad (19b)$$

$$\Delta Q_F = \Delta(Q_A \cdot L_F)^* \qquad (20b)$$

$$\Delta Q_E = \Delta Q_F + \Delta A \qquad (21b)$$

$$\Delta L_F = \Delta L_J + \Delta C_F - \Delta M - \Delta L_C \qquad (22b)$$

$$\Delta C_F = -2.64 + \underset{(3.49)}{15.76}\Delta P_F'^*/P_C' \qquad (23b)$$

$$\Delta L_C = -9.20 - \underset{(3.70)}{13.92}\Delta P_F^*/P_C \qquad (24b)$$

$$\Delta P_F = 0.01 + \underset{(0.09)}{0.83}\Delta P_R - \underset{(0.09)}{0.01}\Delta W \qquad (25b)$$

$$\Delta P_F' = -0.21 + \underset{(0.26)}{0.59}\Delta P_R' + \underset{(0.23)}{0.12}\Delta W \qquad (26b)$$

$$\Delta P_R' = -2.27 - \underset{(0.25)}{0.39}\Delta Q_E'^*/H - \underset{(0.31)}{0.36}\Delta S'^*/H + \underset{(0.04)}{0.02}\Delta I/H + \underset{(0.52)}{0.51}\Delta P_O' \qquad (27b)$$

$$\Delta S'^*/H = -0.52 + \underset{(1.55)}{1.89}\Delta Q_F'^*/Q_F + \underset{(0.25)}{1.21}\Delta F \qquad (28b)$$

$$\Delta Q_E' = \Delta Q_F' + \Delta S' \qquad (29b)$$

The least squares results obtained for the equations in model II are listed below. Least squares results for equations (23b), (24b), and (28b) are the same as equations (23a), (24a), and (28a).

Model II—Least Squares Results

$$\Delta Q_E/H = -4.69 - \underset{(0.44)}{0.73}\Delta P_R + \underset{(0.05)}{0.04}\Delta I/H + \underset{(0.81)}{1.43}\Delta P_O \qquad R^2 = 0.38 \qquad (19c)$$

$$\Delta P_F = 0.24 + \underset{(0.05)}{0.98}\Delta P_R - \underset{(0.06)}{0.11}\Delta W \qquad R^2 = 0.97 \qquad (25c)$$

$$\Delta P_F' = 0.36 + \underset{(0.04)}{0.95}\Delta P_R' - \underset{(0.06)}{0.16}\Delta W \qquad R^2 = 0.98 \qquad (26c)$$

$$\Delta P_R' = -2.36 - \underset{(0.22)}{0.36}\Delta Q_E'/H - \underset{(0.26)}{0.40}\Delta S'/H + \underset{(0.04)}{0.03}\Delta I/H + \underset{(0.47)}{0.46}\Delta P_O'$$

$$R^2 = 0.52 \qquad (27c)$$

The elimination from the matrix of predetermined variables of model II of the predetermined variables that were highly intercorrelated substantially improved the standard errors obtained for the regression coefficients. Of the 15 regression coefficients in model II, 7 differed significantly from zero at the 5 percent level of probability, 3 at the 10-30 percent level of probability, and 5 coefficients were smaller than their standard errors.

The coefficients obtained for the supply relationships, equations (23b) and (24b), were almost unchanged from the coefficients obtained for equations (23) and (24). This was expected because no variables were dropped from these two equations in refitting model I.

Equations (25b) and (26b), from which were dropped Q_E/H and Q'_E/H, respectively, had correct signs on the farm-retail price coefficients, and the coefficients differed significantly from zero at the 5 percent probability level. The exclusion of the variable representing the quantity of eggs per person moving through the marketing system did not alter the farm-retail price coefficient in equation (25) for which the correct sign and a statistically significant coefficient were obtained. However, excluding Q'_E/H in fitting equation (26b) gave a farm-retail price coefficient, with the proper sign, that differed significantly from zero at the 5 percent probability level whereas nonsignificant results were obtained for equation (26). The coefficient for W in both equations (25b) and (26b) in model II were not improved from the results obtained in model I even though W was excluded from the matrix of predetermined variables. In the least squares equations (25c) and (26c), however, the coefficients for W are significant at the 10 percent and 5 percent probability levels, respectively.

Substantial improvement in the significance of the coefficients for the demand equations fitted by the limited information method was obtained by dropping the highly intercorrelated variables in the model. In equation (19b) the regression coefficients for the retail egg price variable (P_R) and the general price level variable (P_O) are significant at the 5-percent probability level, but no significance can be attached to the coefficient for the income variable. In equation (27b), the significance of the regression coefficient for the consumption variable (Q'_E/H) increased from that obtained in model I, but the coefficient differed significantly from zero only at the 10–20 percent probability level. The regression coefficient for the storage variable (S'/H) also was significant at the 10–20 percent probability level. No statistical significance can be attached to the coefficients for per capita income (I/H) and the general price level (P'_O). Results from the least squares fit for equation (19c) were less satisfactory than the results from the limited information fit (19b); results from (27b) and (27c) were similar.

The coefficients obtained from the limited information fit of the storage equation (28b) were very much improved in model II, and were almost similar to the least squares results in equation (28a). The coefficient for the variable representing the availability of hedging opportunities (F) was highly significant while the coefficient reflecting the changing seasonality of production had the expected sign, although it differed significantly from zero only at the 20-30 percent level of probability.

Elasticities of Demand and Supply

The coefficients in the equations describing the demand, supply, and price structure of eggs express the changes from year-to-year in the variable to the left of the equality sign that are associated with year-to-year changes in the variables to the right of the equality sign when both are expressed in the units used in the analysis. For example, equation (19b) states that a 1-cent change from the previous year in the retail price of eggs is associated with an inverse change in per capita egg consumption of 2.97 eggs. However, associated with the 2.97 is a standard error of 1.31. When allowance is made for the standard error, we can state that a 1-cent per dozen change in the retail price of eggs is associated with an inverse change in per capita egg consumption that falls in the range of 1.66 to 4.28 eggs. The probability of this being a true statement is two-thirds. Statements that are correct 95 percent of the time can be made by using twice the standard error in computing the range.

A more convenient method of referring to related changes is a measure known as an "elasticity"—the percentage change in one variable that accompanies the percentage change in another variable. In equation (19b), for example, a 1 cent increase in the retail price of eggs is accompanied by almost a 3 egg decrease in egg consumption per person. The elasticity between these two variables, referred to as "the elasticity of demand with respect to price" is −0.4—a one percent increase in the retail price of eggs is accompanied, on the average, by a 0.4 percent decrease in egg consumption per person.[26] Table 23 presents measures of the elasticity of demand with respect to price and income, and other elasticities derived from the analyses discussed above.

TABLE 23.—*Eggs: Estimates of price, income, and other elasticities by type of analysis, based on data for 1931–41 plus 1946–54* [1]

Analysis and elasticity	Value	Standard error
Demand elasticity with respect to—		
Own price:		
Simultaneous approach:	*Percent*	*Percent*
Model I [2]	[3]−1.96	6.01
Model II [4]	−.40	.18
Least squares method:		
Model I [5]	[3]−.11	.06
Model II [6]	[3]−.10	.06
Equation (19d) [7]	[3]−.09	.07
Equation (19e) [8]	[3]−.11	.08
Income:		
Simultaneous approach:		
Model I [2]	[3]−1.33	4.20
Model II [4]	[3].04	.20
Least squares method:		
Model I [5]	[3]−.08	.12
Model II [6]	[3].09	.12
Equation (19d) [7]	[3].11	.11
Equation (19e) [8]	[3].14	.10
General price level:		
Simultaneous approach:		
Model I [2]	[3]2.10	4.94
Model II [4]	.89	.41
Least squares method:		
Model I [5]	1.20	.39
Model II [6]	[9].33	.19

See footnotes at end of table.

[26] Obtained by multiplying the coefficient (−2.97) in equation (19b) by the ratio of the average retail egg price for 1931–41 plus 1946–54 (45.6 cents) to the average per capita consumption of eggs (341 eggs) in the same period.

TABLE 23.—*Eggs: Estimates of price, income, and other elasticities by type of analysis, based on data for 1931–41 plus 1946–54*[1]—Con.

Analysis and elasticity	Value	Standard error
Supply elasticity with respect to—		
Price of poultry ration:		
Simultaneous approach:	*Percent*	*Percent*
Model I [10]	(11)	(12)
Model II [10]	−.31	(12)
Supply elasticity of pullets raised with respect to—		
Egg-feed ratio, January–June:		
Simultaneous approach:		
Model I [13]	.40	.08
Model II [14]	.44	.10
Least squares method:		
Model I, Model II [15]	.43	.07
Supply elasticity of layers sold with respect to—		
Egg-feed ratio, annual average:		
Simultaneous approach:		
Model I [16]	−.67	.19
Model II [17]	−.60	.16
Least squares method:		
Model I, Model II [18]	−.40	.09

[1] Elasticities computed at the mean value for the years, 1931–41 plus 1946–54. Values for variables used in these analyses are given in table 49, p. 152.
[2] Based on coefficients in equation (19), p. 71.
[3] Coefficient does not differ significantly from zero when tested at the 10-percent level.
[4] Based on coefficients in equation (19b), p. 75.
[5] Based on coefficients in equation (19a), p. 72.
[6] Based on coefficients in equation (19c), p. 75. The constant value in this equation differs significantly from zero at the 5-percent probability level. The effect of time per year obtained by dividing the constant value by the average per capita consumption of eggs during the period is 0.014 percent per year.
[7] Based on coefficients in equation (19d), p. 79.
[8] Based on coefficients in equation (19e), p. 79.
[9] Coefficient differs significantly from zero when tested at the 10-percent level but not at the 5-percent level.
[10] Derived from reduced form equations. (See text, p. 80.)
[11] Less than 0.05 percent.
[12] Not computed. (See text, p. 80.)
[13] Based on coefficient in equation (23), p. 71.
[14] Based on coefficient in equation (23b), p. 75.
[15] Based on coefficient in equation (23a), p. 72.
[16] Based on coefficient in equation (24), p. 71.
[17] Based on coefficient in equation (24b), p. 75.
[18] Based on coefficient in equation (24a), p. 72. The constant value in this equation differs significantly from zero at the 10-percent probability level but not at the 5-percent level. The effect of time per year obtained by dividing the constant value by the average number of layers sold and consumed on farms where produced during the period is 0.034 percent per year.

Measures of the elasticity of demand for eggs with respect to the retail price of eggs obtained from the simultaneous approach and the least squares method ranged from −0.09 to −1.96. However, only the elasticity from the simultaneous fit of Model II, −0.4, differed significantly from zero when tested at the 10-percent probability level. An elasticity of demand of −0.4 is relatively inelastic. To increase per capita consumption by one percent requires a price concession of about 2.5 percent,[27] with an accompanying decline in consumers' expenditures for eggs.

In none of the demand equations was a significant coefficient obtained for the variable representing per capita disposable income. One possible explanation for the failure to obtain a significant income coefficient—a priori we would expect a positive relationship—arises when the lower-order least squares relationships among the variables in equation (19c) are examined. These relationships for the years 1932–41 plus 1947–54 are:

Variables	Correlation coefficient	Variables	Correlation coefficient
$\Delta Q_E/H$, ΔP_R	0.01	ΔP_R, $\Delta I/H$	0.43
$\Delta Q_E/H$, $\Delta I/H$	.46	ΔP_R, ΔP_O	.66
$\Delta Q_E/H$, ΔP_O	.47	$\Delta I/H$, ΔP_O	.70

Although there is evidence of a significant positive relationship between year-to-year changes in per capita consumption and per capita income, the simple correlation coefficient is only a gross measure of the relationship, uncorrected for the price effect of the commodity itself (P_R) and of other commodities (P_O). In correcting for these effects, intercorrelation among the three variables I/H, P_R, and P_O affects the relationship of consumption and income.

For example the relationship between $\Delta Q_E/H$ and $\Delta I/H$ increases from the simple correlation coefficient of 0.46 to the partial correlation coefficient of 0.49 when the effect of year-to-year changes in the retail price of eggs is removed. The relationship between $\Delta Q_E/H$ and $\Delta I/H$ is reduced, however, from 0.46 to 0.20 when the effect of year-to-year changes in the general price level is removed. In the latter example, the high degree of relationship between per capita income (I/H) and the general price level (P_O) reduces the relationship of Q_E/H and I/H greatly. When the effects of changes in both the price of eggs and the general price level are removed from the gross measure of the consumption-income relationship, the partial correlation coefficient between $\Delta Q_E/H$ and $\Delta I/H$ is only 0.20.

In an attempt to lessen the effect of the intercorrelation between income and the general price level, the least squares equations (19d) and (19e)[28] were fit using the variable representing the general price

[27] This is the elasticity of price flexibility, obtained as the reciprocal of the elasticity of demand.

[28] The equations obtained were:

$$\Delta Q_E/H = -2.24 - \underset{(0.44)}{0.52}\Delta P_R/P_O + \underset{(0.03)}{0.03}\Delta I/HP_O \qquad (19d)$$

$$R^2_{1.23} = 0.12$$

$$\Delta \log Q_E/H = -0.003 - \underset{(0.08)}{0.11}\Delta \log P_R/P_O + \underset{(0.10)}{0.14}\Delta \log I/HP_O \qquad (19e)$$

$$R^2_{1.23} = 0.18$$

level as a deflator rather than as an independent variable. As shown in table 23, this treatment yields income elasticities that are slightly larger than their standard errors but still do not differ significantly from zero at the 10-percent probability level. The elasticities plus or minus their standard errors fall within a range of zero to 0.2. The reader may recall that on page 49, an elasticity of demand with respect to income of 0.02, which differed significantly from zero at the 5-percent probability level, was obtained from cross-section data for all urbanizations in the spring of 1955. In addition, an elasticity of demand with respect to income of 0.18, statistically significant at the 5-percent level of probability, was obtained from pooled cross-section data for urban households in 1955 and 1942 (p. 58). Although measures of income elasticities obtained from cross-section data tend to be smaller than measures from time series data, it appears reasonable to assume from these analyses that the elasticity of demand with respect to income for eggs for the period 1931–41 plus 1946–54 is very low, perhaps in the neighborhood of 0.1.

Measures of the elasticity of demand with respect to the general price level differed markedly between model I and model II and between the simultaneous approach and least squares. Model I probably more nearly represents the effect of the general price level on demand than model II because model I has attempted to remove from the effect of the general price level the effect of commodities that are believed to be substitutes for eggs in consumers' diets.

Measures of the elasticity of supply with respect to own price cannot be derived from either the structural equations or the reduced form equations of the models of the egg economy.[29] However, estimates of the elasticity of supply with respect to the price of poultry ration, derived by algebraically manipulating the simultaneous approach-reduced form equations for models I and II[30] indicate a relationship between changes in the price of poultry ration and the quantity of eggs produced of zero to −0.3. Although these estimates have error ranges attached to them, standard errors were not computed because of the involved computational procedures

[29] In both models, production responses are formulated with respect to the ratio of the farm price of eggs to the price of poultry ration. Therefore, it is not possible by algebraic manipulations of the structural equations to obtain the partial derivative of production (Q_P) with respect to either the annual average price received by farmers for eggs (P_F) or the January–June average price of eggs (P_F'). In addition, because both production (Q_P) and farm price (P_F and P_F') are endogenous variables, there is no unique solution for the relationship of production and farm price that can be derived from the reduced form equations of model I or model II.

[30] As an example from model II, fitted by the simultaneous approach, the elasticity of supply (Q_P) with respect to the price of poultry ration (P_G) is obtained by multiplying the coefficient of ΔP_G in equation (46), 58.445201, by the coefficient of ΔA_8 in equation (66), −0.092988, to obtain $-5.434702\ \Delta P_G$. The reader will recognize from the Appendix (p. 146) that ΔA_8 contains the term ΔP_G, and that the product of the two coefficients equals the partial derivative of ΔQ_P with respect to ΔP_G. The elasticity of supply with respect to the price of poultry ration, therefore, is:

$$E(Q_P)_{P_G}=\frac{\partial \Delta Q_P}{\partial \Delta P_G}\cdot\frac{P_G}{Q_P}=[(-0.092988)(58.445201)]\frac{2.66}{46.1}=-0.31 \qquad (30)$$

where the values of P_G and Q_P are the arithmetic means for the years 1931–41 + 1946–54.

necessary to obtain the standard errors of reduced form equations derived from a system of equations fitted by the method of limited information.

Because none of the equations in the model directly relate egg production to either the price received by farmers for eggs or the price of poultry ration, least squares estimates of the elasticity of supply with respect to the farm price of eggs or with respect to the price of poultry ration were not obtained.

The elasticities of supply of pullets raised with respect to the January-June egg-feed price ratio and of layers sold with respect to the annual egg-feed price ratio appear to be reasonable estimates of the relationships involved. The simultaneous equation results and the least squares results for these measures did not differ significantly.

Demand and Supply Elasticities From Other Studies

Elasticities of demand and supply from several different studies for eggs are presented in tables 24 and 25.

Estimates for the elasticity of demand with respect to own price ranged from −0.3 to −1.3, with an average for all the studies being about −0.5 to −0.6. The range of values obtained from the alternative models of the egg economy fitted in this study is greater than obtained for the studies presented in table 24. The elasticity from model II of this study, however, agrees closely with the average of the results obtained in the studies cited.

Estimates for the elasticity of demand with respect to income ranged from 0.3 to 1.1, values substantially larger than those obtained in the analyses presented in this study. Part of the differences in income elasticities obtained in other analyses and the income elasticities obtained in this study arises from the different time periods used. Only two of the analyses in table 24 included observations more recent than 1941; those two covered the period 1921–50. From the analyses of family budget data presented on page 58, however, we observe that the consumption-income relationship for urban households in the 1942, 1948, and 1955 survey periods was extremely small. As our analyses also showed that the consumption-income relationship for all households in the 1955 survey was less than that for urban households, we can conclude that income response in the post-World War II years is very small. We would expect, however, that it would be greater in the period of the 1930's when income levels were much lower, although we do not have empirical measures. Consequently, as the analyses in this bulletin included both pre- and post-World War II periods, we would expect a lower income elasticity than those obtained for pre-World War II analyses.

TABLE 24.—*Eggs: Elasticities of demand with respect to price and income, by type of analysis, for specified periods* [1]

Study	Period included in analysis	Method of analysis	Demand elasticity with respect to—			
			Own price		Income	
			Value	Standard error	Value	Standard error
			Percent	*Percent*	*Percent*	*Percent*
Fisher (*14*):						
Model I [2]	1915–40	Simultaneous approach	[3]−1.28	0.69	1.14	0.55
Model II [4]	1915–40	do	−.70	.20	.82	.19
Model III [5]	1915–40	do	−0.81 to −1.02	([6])	0.48 to .76	([6])
Model I [2]	1915–40	Least squares	−.29	.13	.44	.14
Model II [4]	1915–40	do	−.32	.08	.56	.09
Model III [5]	1915–40	do	−.31	.10	.31	.15
Fox (*16*)	1922–41	do	−.43	.08	.57	.07
	1922–41	do	−.34	.06	.49	.08
Judge (*25*)	1921–41	do	−.53	.09	.31	.08
	1921–41	Simultaneous approach	−.58	([6])	.44	([6])
	1921–50	Least squares	−.32	.13	.43	.12
	1921–50	Simultaneous approach	−.60	([6])	.27	([6])
Nordin, Judge, and Wahby (*37*).	1921–41	Least squares	−.55	([7])	.41	([7])

[1] Elasticities from the study by Fisher were computed at the mean value. The remaining studies used logarithmic values and, therefore, elasticities were equal to the regression coefficients reported in each study.

[2] Uses values deflated by a measure of the general price level.

[3] Coefficient differs significantly from zero at the 10-percent probability level but not at the 5-percent level.

[4] Uses actual values rather than deflated values.

[5] Uses first differences of deflated values. Estimates of elasticities vary depending on the way author handled income and supply in the simultaneous model.

[6] Could not be computed as standard errors of regression coefficients not given in original study.

[7] Stated as statistically significant at the 5-percent level.

The studies by Fisher and Judge also presented elasticities of supply with respect to the price of eggs and the price of feed. As seen from table 25, none of the supply elasticities, where standard errors were computed, differed significantly from zero at the 10-percent level of probability. However, based on the elasticities from the least-squares equations in table 25 whose values were larger than their respective standard errors, it appears that in about two-thirds of the time we could expect between a zero to 0.4 percent increase in production following a 1-percent increase in the average price received by farmers for eggs. No conclusions can be made about the magnitude of the elasticity of supply with respect to the price of feed because either data to establish error ranges were not given or else the standard errors were larger than their regression coefficients.

No direct comparison of the elasticities of supply with respect to the price of eggs can be made with the equations fitted in this study because the price of eggs and the price of feed were used in a ratio form in this study (see p. 80). The reader will recall, however, that the elasticity of egg supply with respect to the price of poultry ration derived in this study was in the range of no change to −0.3 (p. 80).

Fisher in his study also derived measures of long-run supply elasticities by using lagged variables. The long-run elasticities are 10 times greater than the comparable short-run estimates. The long-run elasticity derived by this procedure does not allow for factor costs to change. Production adjustments are required to take place within the framework of existing resources. Therefore, the concept of long-run used by Fisher differs from the definition of long-run on page 12. As adjustments take place within the framework of existing resources, Fisher's long-run elasticity differs from the annual short-run elasticity defined on page 12 only because it allows for production to adjust in response to a given price over a period longer than a year. While there is no a priori basis upon which to expect the magnitude of the relationship between short-run and long-run elasticities, in general the latter would be expected to be larger because of the opportunity to adjust over time which is entailed in the concept of long-run estimates. Some caution is warranted, however, in considering short-run versus long-run relationships in the egg industry. The two measures differ depending upon the period of time needed for an industry to adjust from a given level of production to some desired long-run equilibrium level. If a complete adjustment is made in one time period, the short-run and long-run elasticities would be equal. The long-run elasticity exceeds the short-run elasticity when more than one time period is required to adjust to the long-run equilibrium level. As producers can adjust so rapidly in the egg industry, it seems unlikely that the long-run elasticity would be so different from the adjustment producers can make in one year to a price change, except in response to a price increase that might encourage expansion beyond the existing capacity of the industry.

TABLE 25.—*Eggs: Estimates of short-run and long-run supply elasticities, by type of analysis, for specified periods* [1]

Study	Period included in analysis	Method of analysis	Elasticity of supply with respect to— Own price: Value	Own price: Standard error	Feed price: Value	Feed price: Standard error
			Short-run elasticities			
			Percent	*Percent*	*Percent*	*Percent*
Fisher (*14*):						
Model I [2]	1915–40	Simultaneous approach	[3] 0.20	0.53	[3] −0.16	0.18
Model I [2]	1915–40	do	−.11	([5])	−.03	([5])
Model II [4]	1925–40	Least squares	[3] .22	.13	−.11	([5])
Model III [6]	1921–50	do	[3] .19	.17	[3] .01	.15
Judge (*25*)	1921–50	Simultaneous approach	1.17	([5])	−.97	([5])
			Long-run elasticities [7]			
Fisher (*14*):						
Model III [6]	1925–40	Least squares	2.2	([5])	−1.1	([5])

[1] Elasticities from the study by Fisher were computed at the mean value. The remaining studies used logarithmic values and, therefore, elasticities were equal to the regression coefficients reported in each study.
[2] Uses values deflated by a measure of the general price level.
[3] Coefficient does not differ significantly from zero when tested at the 10-percent level.
[4] Uses actual values rather than deflated values.
[5] Could not be computed as standard errors of regression coefficients not given in original study.
[6] Uses first differences of actual values.
[7] Derived algebraically from a lagged equation given in (*14*, p. 58).

Use for Forecasting

The analyses presented in the preceding pages of this bulletin were designed to show the relationships among the major variables that make up the egg economy. The elasticities presented in table 23 conveniently summarized the more important measures of the basic economic relationships.

In addition to determining such relationships, we are often concerned with estimating the values of specified variables in a sector of the economy. For example, we might be interested in obtaining estimates of the consumption of eggs, per person, in some designated year, or of the farm price of eggs, per dozen, etc. The structural equations for the limited information and least squares fits of models I and II (p. 71, 72, 75, and 79) can be used for such purposes. Also, we can use for forecasting algebraic transformations of the limited information equations (called reduced form equations) as well as applying a least squares fit to the variables that appear in the reduced form equations derived from the limited information fit of the equations in the model. The former equations take into account the relationships among each of the endogenous and predetermined variables in the system. The reduced form equations for models I and II of the egg economy, and their derivation, are given in the Appendix (pp. 146 to 149).

The reader will notice that by making the transformation from the coefficients in the structural equations of the economic model to the coefficients in the reduced form equations, each of the endogenous variables in the model is expressed as a linear function of all of the predetermined variables in the model. In this form, the effect of a change in any one, or all, of the predetermined variables can be easily measured on any one, or all, of the endogenous variables in the model. For example, using model II, if we wished to measure the estimated change in the annual farm price for eggs that would be associated with an increase of $1 per 100 pounds in the annual average price of poultry rations, we would multiply $1 by 58.445201 (the coefficient of ΔP_G in the structural equation (46), p. 146), and, in turn, multiply the product by 0.185367 (the coefficient of ΔA_6 in equation (72), p. 148) to obtain an estimated change in the average farm price of eggs of +10.8 cents per dozen. The effect of the change in the annual average feed price is directly measured in relation to the change in farm price through its direct effect in the structural equation on the number of layers sold, after allowing for the indirect effect of all the predetermined variables, and modified by the interactions among all the endogenous variables in the system.

In the above example the annual average feed price was changed, but the January-June average feed price was not changed, thereby leaving as unchanged the relationship of the January-June feed price to pullets raised. However, if, at the same time that we allow the annual average feed price to increase $1, we allow the January–June average feed price to increase $0.20, then the average annual price received by farmers for eggs increases from the previous year by 13.1 cents per dozen.[31] In the latter case, we have taken the direct

[31] Obtained as [1.00 (58.445201) (0.185367) + 0.20 (−61.479308) (−0.185367)] where 58.445201 is the coefficient of ΔP_G in equation (46), p. —; 0.185367 is the coefficient of ΔA_6 in equation (72), p. 148; −61.479308 is the coefficient of ΔP_G in equation (45); and −0.185367 is the coefficient of ΔA_6 in equation (72), p. 148.

effect of the annual average feed price on the number of layers sold and consumed in farm households where produced and added to it the direct effect of the January-June average feed price on the number of replacement pullets raised, after allowing for the indirect effect of all the predetermined variables and modified by the interactions among all the endogenous variables in the system. The direct effect of the higher feed costs is to decrease the number of replacement pullets raised and to increase the number of layers sold. As a result, the size of the laying flock is decreased. In addition, as the rate of lay is also held unchanged, production falls, and prices rise as consumers have fewer eggs available to purchase with the same amount of income and an unchanged general price level.

Table 26 compares the actual values of the endogenous variables for the years 1948-57 with values estimated from the simultaneous approach and least squares fits of model I and model II of the egg industry. The values for the simultaneous approach were estimated by the process described above while the values for the least squares results were estimated from the structural equations on pages 72 and 75. Other comparisons that can be made are discussed on page 95 and some indication of the results of those comparisons are presented. As the estimating equations were based on data for the period 1931–41 plus 1946–54, estimated values for the years 1955–57 represent extrapolations of relationships beyond the range of observations used.

As an aid in assessing the relative merits of the alternative models and methods used in estimating values in the egg economy, table 27 shows the variation between actual and estimated values of the relevant economic variables within the egg industry for the years 1948–54, as well as for the years 1955–57. As the years 1948–54 include only part of the period for which the statistical coefficients of the models were fitted, and as the years 1955–57 were not included in the statistical fitting of the models, the ratio of the variation in a variable not explained by the model to the total variation in a variable can exceed 1.0.[32] For the period 1948–54, as well as for the years 1955–57, better estimates of the quantity variables appear to be obtained from the simultaneous fit of model I, while better estimates of the price variables appear to be obtained from the least squares fit of model I.

[32] Unexplained variation computed as the sum of the squared differences in each year between the year-to-year changes for a variable and its value estimated by specified model and method of fit. Total variation computed as the sum of the squared differences in each year of the year-to-year changes for a variable.

TABLE 26.—*Economic factors in the egg economy: Actual and estimated values of endogenous variables, 1948–57* [1]

Year	Domestic egg consumption, Q_E [2]					Farm egg production, Q_F [3]					Layers on farms, L_F				
	Actual	Estimated				Actual	Estimated				Actual	Estimated			
		Simultaneous approach		Least squares			Simultaneous approach		Least squares			Simultaneous approach		Least squares	
		Model I	Model II	Model I	Model II		Model I	Model II	Model I	Model II		Model I	Model II	Model I	Model II
	Bil.	*Bil.*	*Bil.*	*Bil.*	*Bil.*	*Bil.*	*Bil.*	*Bil.*	*Bil.*	*Bil.*	*Mil.*	*Mil.*	*Mil.*	*Mil.*	*Mil.*
1948	56. 5	57. 2	60. 9	56. 4	57. 5	54. 9	55. 9	59. 6	54. 9	56. 0	331. 6	332. 6	332. 6	(5)	(5)
1949	56. 6	56. 0	59. 6	57. 7	57. 4	56. 2	55. 6	59. 1	57. 3	57. 1	330. 7	323. 2	339. 0	(5)	(5)
1950	58. 5	56. 3	65. 6	59. 2	59. 3	59. 0	56. 9	66. 2	59. 8	59. 9	339. 5	322. 4	347. 8	(5)	(5)
1951	59. 3	60. 8	57. 5	61. 0	59. 8	58. 1	59. 4	56. 1	59. 7	58. 5	327. 8	333. 2	334. 1	(5)	(5)
1952	59. 8	60. 3	61. 2	61. 9	61. 7	58. 1	58. 6	59. 5	60. 1	59. 9	320. 5	319. 4	328. 8	(5)	(5)
1953	59. 1	59. 6	65. 0	59. 1	61. 1	57. 9	58. 6	64. 0	58. 0	60. 0	312. 1	310. 1	322. 5	(5)	(5)
1954	59. 8	59. 4	61. 1	60. 6	61. 7	58. 9	58. 6	60. 3	59. 9	61. 0	314. 2	307. 9	318. 4	(5)	(5)
1955	60. 2	60. 6	67. 2	62. 5	61. 2	59. 5	59. 5	66. 1	61. 6	60. 3	309. 1	305. 8	317. 4	(5)	(5)
1956	60. 8	59. 7	62. 2	63. 6	62. 3	60. 8	59. 6	62. 1	63. 5	62. 2	309. 9	300. 8	329. 1	(5)	(5)
1957	60. 3	61. 5	68. 8	61. 6	63. 7	60. 4	61. 5	68. 8	61. 7	63. 8	304. 8	305. 7	305. 8	(5)	(5)

See footnotes at end of table.

TABLE 26.—*Economic factors in the egg economy: Actual and estimated values of endogenous variables, 1948–57*[1]—Continued

Year	Pullets raised, January–June, C_F[4]					Layers sold, L_C[4]					Domestic egg consumption January–June, Q'_E				
	Actual	Estimated				Actual	Estimated				Actual	Estimated			
		Simultaneous approach		Least squares			Simultaneous approach		Least squares			Simultaneous approach		Least squares	
		Model I	Model II	Model I	Model II		Model I	Model II	Model I	Model II		Model I	Model II	Model I	Model II
	Mil.	*Mil.*	*Mil.*	*Mil.*	*Mil.*	*Mil.*	*Mil.*	*Mil.*	*Mil.*	*Mil.*	*Bil.*	*Bil.*	*Bil.*	*Bil.*	*Bil.*
1948	386.0	385.7	415.3	410.9	410.9	274.8	283.5	303.1	269.6	269.6	28.5	28.6	30.2	28.4	29.9
1949	447.7	448.7	452.3	427.5	427.5	244.7	253.1	256.7	249.3	249.3	30.4	27.9	30.7	29.3	30.0
1950	393.6	362.4	430.2	394.0	394.0	275.2	261.1	328.8	262.5	262.5	31.0	27.2	34.9	31.5	31.4
1951	398.7	410.4	394.4	418.2	418.2	249.8	256.0	240.1	250.6	250.6	30.5	34.6	29.3	31.0	30.3
1952	370.2	379.3	385.2	358.8	358.8	243.0	253.2	249.0	259.3	259.3	30.5	30.5	30.6	31.2	31.2
1953	375.1	344.6	397.3	410.2	410.2	237.8	209.3	262.0	212.9	212.9	30.3	33.4	31.9	30.5	31.0
1954	369.8	375.0	373.8	359.8	359.8	235.6	247.1	245.9	255.6	255.6	29.8	27.0	31.4	29.9	30.2
1955	330.2	308.4	371.2	357.5	357.5	227.0	224.9	287.4	239.6	239.6	30.0	35.4	34.5	31.8	30.8
1956	349.4	338.2	346.0	356.3	356.3	219.1	215.9	223.8	219.0	219.0	30.7	35.0	30.0	31.6	30.6
1957	305.6	291.7	338.9	301.8	301.8	223.0	208.2	264.8	202.7	202.7	31.0	27.3	34.2	30.8	31.6

Year	Net into-storage movement, January–June, S' [4]					Retail price, per dozen, P_R [6]					Farm price, per dozen, P_F [7]				
	Actual	Estimated				Actual	Estimated				Actual	Estimated			
		Simultaneous approach		Least squares			Simultaneous approach		Least squares			Simultaneous approach		Least squares	
		Model I	Model II	Model I	Model II		Model I	Model II	Model I	Model II		Model I	Model II	Model I	Model II
	Bil.	*Bil.*	*Bil.*	*Bil.*	*Bil.*	*Ct.*	*Ct.*	*Ct.*	*Ct.*	*Ct.*	*Ct.*	*Ct.*	*Ct.*	*Ct.*	*Ct.*
1948	3. 5	3. 4	1. 8	2. 9	2. 9	68. 4	67. 4	60. 3	66. 5	71. 3	47. 2	46. 4	40. 7	45. 6	49. 5
1949	1. 6	4. 1	1. 3	2. 5	2. 5	65. 9	59. 3	59. 2	60. 8	66. 6	45. 2	40. 0	39. 6	40. 0	45. 3
1950	2. 7	6. 4	−1. 2	2. 2	2. 2	57. 1	61. 8	45. 9	60. 0	64. 0	36. 3	42. 1	28. 7	39. 2	43. 4
1951	2. 2	−1. 9	3. 4	2. 2	2. 2	69. 7	65. 6	69. 0	68. 4	64. 3	47. 8	42. 8	46. 1	46. 6	42. 6
1952	2. 2	2. 2	2. 0	2. 4	2. 4	63. 6	69. 9	68. 2	70. 8	71. 2	41. 6	47. 9	46. 5	48. 8	49. 2
1953	1. 4	−1. 7	−. 2	1. 3	1. 3	66. 8	63. 6	52. 5	63. 2	65. 3	47. 7	42. 0	32. 4	41. 6	43. 2
1954	2. 0	4. 8	. 4	. 8	. 8	56. 2	62. 6	62. 7	59. 3	66. 0	36. 6	44. 4	44. 3	43. 7	46. 9
1955	2. 0	−3. 4	−2. 5	−. 6	−. 6	58. 1	53. 2	38. 7	56. 4	55. 2	38. 9	34. 0	22. 2	37. 0	35. 8
1956	1. 5	−2. 8	2. 2	3. 0	3. 0	57. 7	57. 2	55. 9	59. 8	58. 8	38. 7	38. 5	37. 1	40. 6	39. 6
1957	1. 4	5. 1	−1. 8	. 9	. 9	54. 9	57. 0	43. 9	58. 2	62. 8	35. 2	38. 1	27. 3	39. 7	43. 8

See footnotes at end of table.

TABLE 26.—*Economic factors in the egg economy: Actual and estimated values of endogenous variables, 1948–57*[1]—Continued

Year	Retail price, per dozen, January–June, P'_R					Farm price, per dozen, January–June, P'_F[8]				
	Actual	Estimated				Actual	Estimated			
		Simultaneous approach		Least squares			Simultaneous approach		Least squares	
		Model I	Model II	Model I	Model II		Model I	Model II	Model I	Model II
	Ct.	*Ct.*	*Ct.*	*Ct.*	*Ct.*	*Ct.*	*Ct.*	*Ct.*	*Ct.*	*Ct.*
1948	63.9	59.4	68.0	61.9	67.3	44.0	41.4	47.2	42.2	46.6
1949	63.2	61.1	62.3	59.9	63.2	43.3	43.8	43.2	39.6	43.2
1950	49.2	54.4	58.4	59.0	59.9	30.5	27.6	40.5	39.2	40.2
1951	64.6	71.4	57.4	60.6	57.3	43.4	39.2	36.2	40.2	37.1
1952	56.4	64.9	66.0	64.7	65.0	35.7	43.1	44.4	43.4	44.4
1953	63.6	73.9	59.5	61.4	59.7	44.9	28.4	37.7	40.4	38.7
1954	57.2	46.3	63.0	62.5	62.7	38.6	44.9	44.6	44.1	44.1
1955	53.9	86.0	56.1	60.7	57.4	35.8	26.2	37.7	42.3	39.2
1956	58.0	76.4	54.7	57.9	54.7	39.8	35.2	36.3	39.5	36.4
1957	49.3	43.6	59.3	56.7	59.7	30.7	30.0	40.4	38.7	41.7

[1] Estimated values for the simultaneous approach were obtained from the reduced form forecasting equations of Model I and Model II (see text, pp. 85 and 86, and Appendix, p. 146). Estimated values for least squares equations were obtained from Model I and Model II (see text, pp. 72 and 75) except as noted below.

[2] Least squares estimates from equations (19a) and (19c), multiplied by population (the variable H, see p. 154).

[3] Least squares estimates derived from subtracting the variable A (see p. 152) from the least squares estimates of domestic egg consumption.

[4] Least squares estimating equation the same for Model I and Model II.

[5] No least squares estimates made for this variable as it was included in an identity equation in both Model I and Model II.

[6] Least squares estimates obtained from fitting equations (19a) and (19c) with ΔP_R dependent.

[7] Least squares estimates obtained from equations (25a) and (25b), using for ΔP_R values estimated from equations (19a) and (19c), with ΔP_R dependent.

[8] Least squares estimates obtained from equations (26a) and (26b), using for $\Delta P'_R$ values estimated from equations (27a) and (27c).

TABLE 27.—*Analysis of variation between actual and estimated values in the egg economy obtained from alternative models and methods of fit, for specified periods* [1]

Variable	1948–54					1955–57				
	Total variation in variable	Ratio of unexplained variation to total variation [2]				Total variation in variable	Ratio of unexplained variation to total variation [2]			
		Simultaneous approach		Least squares			Simultaneous approach		Least squares	
		Model I	Model II	Model I	Model II		Model I	Model II	Model I	Model II
Domestic egg consumption, Q_E (billions)	5. 24	*1. 64	22. 99	1. 84	2. 62	0. 69	*4. 07	178. 57	21. 48	21. 46
Farm egg production, Q_F (billions)	9. 88	*. 84	12. 90	. 95	1. 52	1. 82	*1. 46	63. 63	7. 36	7. 78
Layers on farms, L_F (millions)	389. 25	1. 09	*. 96	(3)	(3)	23. 21	*4. 07	18. 89	(3)	(3)
Pullets raised, January–June, C_F (millions)	9, 579. 94	*. 22	. 31	. 29	. 29	2, 481. 36	*. 32	1. 13	. 33	. 33
Layers sold, L_C (millions)	2, 303. 43	*. 62	2. 01	. 65	. 65	98. 66	*2. 37	54. 91	5. 79	5. 79
Domestic egg consumption, January–June Q'_E (billions)	11. 03	4. 98	2. 24	*. 20	. 31	. 14	438. 14	221. 29	29. 2	*7. 21
Net into-storage movement, January–June, S' (billions)	8. 03	6. 75	3. 09	*. 36	*. 36	. 14	438. 14	221. 29	*66. 14	*66. 14
Retail price, per dozen, P_R (cents)	395. 85	. 44	1. 27	*. 29	. 61	11. 05	2. 59	45. 30	*1. 65	6. 52
Farm price, per dozen, P_F (cents)	407. 12	. 54	1. 11	*. 44	. 66	16. 93	1. 92	20. 31	*1. 62	4. 98
Retail price, per dozen, January–June, P'_R (cents)	617. 24	. 64	. 48	*. 37	. 48	82. 59	16. 97	1. 40	*1. 22	1. 59
Farm price, per dozen, January–June, P'_F (cents)	526. 09	. 76	. 62	*. 40	. 54	85. 85	1. 33	1. 28	*1. 24	1. 68

[1] Models fitted to first difference values for the years 1932–41 plus 1947–54. See table 26, p. 87, for values of variables and details of models.

[2] Unexplained variation computed as the sum of the squared differences in each year between the year-to-year changes for a variable and its value estimated by specified model and method of fit. Total variation computed as the sum of the squared differences in each year of the year-to-year changes for a variable. [3] Least squares equations were not fitted for this variable.

*Signifies estimate for which ratio of unexplained variation to total variation is smallest for the specified variable.

However, the ratio of the unexplained variation, estimated by a specified model and method of fit, to the total variation in a variable can be very large due to the estimated value for one year being very poor, although for other years the estimated values obtained from that model and method of fit may be closer to the actual values than a model and method of fit that had a smaller ratio of unexplained variation to total variation.

Based on percentage differences between actual and estimated values for the years beyond the period for which the models were fitted (table 28), it appears that model I, fitted by the simultaneous approach, gives the best estimates of the endogenous variables in the egg economy among the models and methods of fit that were used. The reason for the better estimates appears to stem from the number of predetermined variables used in model I. As the reduced form forecasting equations (p. 146) show, each estimated value of the endogenous variables in the model is obtained as a weighted linear combination of all the predetermined variables in the model. It would appear that the greater the number of relevant predetermined variables used in a model, the smaller the difference between the estimated value and the actual value of an endogenous variable because more information about the economic system is being utilized.

As observed in the egg model, the addition of certain predetermined variables to the model increased the degree of correlation among the predetermined variables. While the exact effect of high intercorrelation among the predetermined variables in a simultaneous approach is not measurable, it appears, from considering the effect on a least squares solution, to contribute to larger standard errors of the regression coefficients than if the intercorrelation was not present. However, as long as the values of the predetermined variables in the model stay within, or close to, their range of values during the period for which the model was fitted, the effect of high intercorrelation among the predetermined variables on estimated values apparently is minimized. As the values for 1955–57 of the predetermined variables in the model of the egg economy are within, or close to, their range of values for the 1932–41 plus 1947–54 period, estimated values of the endogenous variables from both the simultaneous approach and least squares fits of model I are closer to the actual values of the endogenous variables than the estimates derived from the simultaneous approach and least squares fits of model II. However, if the values of the predetermined variables should depart widely from their previous levels, model II, which had smaller standard errors of the regression coefficients, would probably give better estimates than model I, although the former uses less information.

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TABLE 28.—*Variables in the egg economy: Percentage differences between actual and estimated values obtained from alternative models and methods of fit, 1955–57* [1]

Variable	1955				1956				1957			
	Simultaneous approach		Least squares		Simultaneous approach		Least squares		Simultaneous approach		Least squares	
	Model I	Model II	Model I	Model II	Model I	Model II	Model I	Model II	Model I	Model II	Model I	Model II
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Domestic egg consumption, Q_E	*0.7	11.6	3.8	1.7	*−1.8	2.3	4.6	2.5	*2.0	14.1	2.2	5.6
Farm egg production, Q_F	*.0	11.1	3.5	1.3	*−2.0	2.1	4.4	2.3	*1.8	13.9	2.2	5.6
Layers on farms, L_F	*−1.1	2.7	(2)	(2)	*−2.9	6.2	(2)	(2)	*.3	*.3	(2)	(2)
Pullets raised, January–June, C_F	*−6.6	12.4	8.3	8.3	−3.2	*−1.0	2.0	2.0	−4.5	10.9	*−1.2	*−1.2
Layers sold, L_C	*−.9	26.6	5.6	5.6	−1.5	2.1	*(3)	*(3)	*−6.6	18.7	−9.1	−9.1
Domestic egg consumption, January–June, Q'_E	18.0	15.0	6.0	*2.7	14.0	−2.3	2.9	*−.3	−11.9	10.3	*−.6	1.9
Retail price, per dozen, P_R	−8.4	−33.4	*−2.9	−5.0	*−.9	−3.1	3.6	1.9	*3.8	−20.0	6.0	14.4
Farm price, per dozen, P_F	−12.6	−43.4	*−4.9	−7.9	*−.5	−4.1	4.9	2.3	*8.2	−22.4	12.8	24.4
Retail price, per dozen, January–June, P'_R	59.6	*4.1	12.6	6.5	31.7	−5.7	*−.2	−5.7	*−11.6	20.3	15.0	21.1
Farm price, per dozen, January–June, P'_F	−26.8	*5.3	18.2	9.5	−11.6	−8.8	*−.8	−8.5	*−2.3	31.6	26.6	35.8

[1] Models fitted to first difference values for the years 1932–41 plus 1947–54. See table 26, p. 87, for values of variables and details of models.

[2] Least squares equations were not fitted for this variable.

[3] Less than 0.05 percent.

*Signifies the smallest percentage difference between actual and estimated values of each variable in each year. Computations not shown for net into-storage movement, January–June, S', as estimated values included many stock reductions while actual storage movement in each year increased stocks.

An additional consideration in appraising the results of an analysis is to determine the independence of the residuals of the fitted equations. If the assumption does not hold that the residuals are independent, then the estimators of the parameters in the system are not efficient and the confidence regions calculated without taking the serial correlation into account may be highly misleading. In a recent article, Durbin (*13*) extended the test for serial correlation in least squares regression to testing for serial correlation in systems of simultaneous regression equations. Using the procedure suggested by Durbin, the results of the test for independence in the residuals from model I and model II, fitted by the simultaneous approach, are inconclusive (table 29). Therefore, in using the results from the analyses in this bulletin, the reader should keep in mind that some limitations are involved in the confidence regions of the regression coefficients and the measurements of elasticity coefficients.

TABLE 29.—*Measures of serial correlation in the residuals of fitted equations, for specified models and method of fit* [1]

Reduced form equation for estimating	Simultaneous approach			
	Model I		Model II	
	d′	4-d′	d′	4-d′
ΔQ_E	1.41	2.59	1.77	2.23
ΔQ_F	1.36	2.64	1.76	2.24
ΔP_R	2.80	1.20	2.26	1.74
ΔL_P	1.17	2.83	1.17	2.83
ΔC_F	1.65	2.35	1.88	2.12
ΔL_C	2.02	1.98	1.84	2.16
$\Delta P'_F$	2.55	1.45	3.07	.93
ΔP_F	2.96	1.04	2.39	1.61
$\Delta P'_R$	2.02	1.98	2.83	1.17
$\Delta Q'_S$	1.83	2.17	1.98	2.02
$\Delta S'$	1.84	2.16	1.98	2.02

[1] Serial correlation measured by the statistic:

$$d'=\frac{\sum_{t=2}^{N}(d_t-d_{t-1})^2}{\sum_{t=1}^{N}d_t^2}$$

where d_t is the unexplained residual for observation t from the reduced form forecasting equations of each model. See text, p. 146.

In making a choice among the alternative fitted models to use in forecasting values for any of the endogenous variables in the egg industry, the reader should consider the data required for a forecast. For example, in using the reduced form forecasting equations from the simultaneous approach of either model I or model II to estimate the endogenous variables in the egg industry, the data required are the predetermined variables included in the model. These include the average number of eggs produced per layer during the year (Q_A), the number of hens and pullets of laying age with pullets not yet laying on farms, January 1, (L_J), the difference between civilian domestic disappearance of eggs and farm production of eggs (A), the mortality of hens, including a balancing residual (M), and the predetermined variables from outside the egg industry, such as population (H), income (I), the general price level (P_O), the price of feed (P_G), and so forth. However, if the same variables that were defined as being endogenous in the simultaneous approach are to be estimated from the least squares fits of the structural equations in either model I or model II, values for some of the endogenous variables whose values we are attempting to estimate must also be used. In equation (19c) on page 75, for example, it is necessary to estimate the price of eggs, per dozen, at retail (P_R) in order to forecast per capita egg consumption (Q_E/H). As an alternative, we could have fitted equation (19c) by least squares with P_R as the dependent variable. If we followed this procedure, it would be necessary to estimate values of Q_E/H in order to forecast the value of P_R. By looking at the equations in the least squares fit of model I (p. 72) or model II (p. 75), the reader will observe that each equation contains at least two variables whose values are determined within the egg industry. Because of the nature of the method of least squares, the value of one of these variables must be estimated before a forecast of the value of the other variable can be made. In addition, values for the predetermined variables in the least squares equations must also be estimated, just as in using the simultaneous approach. The latter method, therefore, has the advantage of not requiring values of any of the endogenous variables in the egg industry to be estimated before a forecast can be made. The simultaneous approach, on the other hand, requires estimates of all of the predetermined variables in the model when a forecast is to be made whereas least squares requires estimates of only those variables that appear in the particular equation being used.

In evaluating the forecasting properties of the fitted models, forecasts obtained from least squares fits of the structural equations in model I and model II were compared with forecasts obtained from the simultaneous approach reduced form equations (table 26). As previously mentioned, forecasted values of the endogenous variables in a model also can be obtained from a least squares fit of the reduced form equations of the model as well as from the structural equations whose coefficients were fitted simultaneously. These latter equations are essentially the equations for model I and model II given on page 71 and page 75, respectively. The least squares reduced form equations for model I and model II do not provide direct measures of the basic economic relationships that exist in a model. However, they are useful in forecasting values of variables. As there is interest in the relative merits of alternative forecasting models, some comparisons were made between the reduced form equations of model II fitted by the simultaneous approach (see Appendix p. 146) and the least squares fit of the same reduced form equations.

The two least squares reduced form equations that were computed expressed ΔQ_E and $\Delta P'_F$, respectively, as functions of the predetermined variables which are in model II (ΔH, $\Delta I/H$, ΔP_O, ΔQ_A, ΔA, ΔL_J, ΔM, $\Delta P'_G$, ΔP_G, ΔW, $\Delta P'_O$, $\Delta Q'_F$, and ΔF). The variable ΔQ_E was selected because it illustrates a case in which the least squares fit of the struc-

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tural equation gave a smaller ratio of unexplained variation to total variation for 1955–57 than did the simultaneous approach reduced form equation (table 27). The variable P'_F was selected for the opposite reasons. Based on these limited computations,[33] it appears that we cannot specify a priori what type of fitted equation will forecast best. Consequently, we would continue to base our decision on the type of considerations specified above (p. 94).

Seasonal Variation of Factors in the Egg Economy

The monthly average price received by farmers for eggs climbs from a low in the spring to a peak in late summer and the fall, the movement being inversely related to monthly production. When production is large, prices are usually low; when production is small, prices are usually high. The seasonal peaks and troughs in production and prices are less pronounced now than formerly (fig. 10) because of changes in production practices and breeding. The seasonal variation in shell egg prices has a smaller amplitude than the

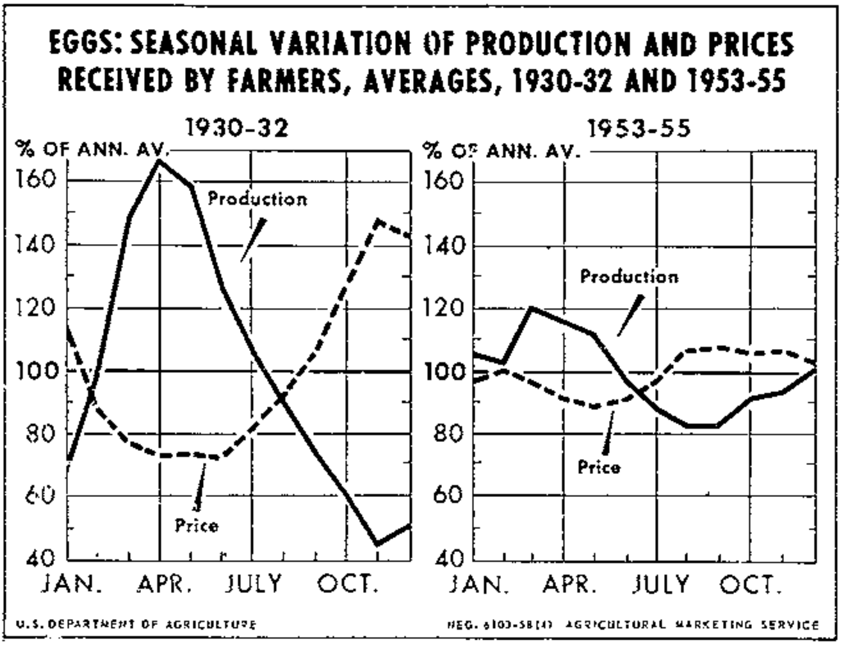

FIGURE 10.—Movement in egg prices is inversely related to monthly production. When production is large, prices are usually low; when production is small, prices are usually high. Because of changes in production practices and breeding, the seasonal peaks and troughs in production and prices are less pronounced now than formerly.

[33] The ratios of unexplained variation to total variation obtained for 1955–57 for ΔQ_E were: simultaneous approach structural equation, 32.7; least squares structural equation, 9.2; simultaneous approach reduced form equation, 178.6; and least squares reduced form equation, 7.7. For $\Delta P'_F$, the corresponding values were: simultaneous approach structural equation, 1.5; least squares structural equation, 1.7; simultaneous approach reduced form equation, 1.3; and least squares reduced form equation, 6.2.

variation in production due to the demand in the spring for eggs for storage and liquid egg production. With a part of the large spring egg production diverted from immediate consumption channels, prices do not decline to the level that would prevail if the entire production of eggs had to be marketed in shell form within a short period after being produced. By the same token, egg prices in the fall do not rise to a level consistent with the decline in production because of the availability of eggs from storage.

Production and Related Factors

Monthly variation in egg production stems from interrelated economic and physiological factors. Most chicks for laying flock replacement are started in spring because weather conditions then are most favorable to chick growth. This timing, also, is more or less consistent with the economic incentives to start chicks. Pullets start laying at about 5 or 6 months of age and produce for about a year. As layers near completion of a laying year, their production tends to fall off. Practically all layers which are retained beyond a laying year go through a rest period which lasts several weeks, during which molting occurs. With chicks started in the spring, peak production tends to come in late winter and the following spring, followed by declining production until a complete, or almost complete, halt in output occurs in the fall when layers are molting. For example, in the years 1930-32, almost 75 percent of the commercial hatchery production of baby chicks[34] was in the 3 months, March, April, and May (23, 28, and 24 percent, respectively). As table 30 shows, until the end of the 1940's, peak output for the United States occurred in April and the low in November, although the seasonal pattern of production was shifting steadily. By the 1950's, the peaks and troughs of egg production in the United States took place in March and September, respectively. A price pattern inversely related to production provided sufficient motivation for producers to start chicks at an earlier date so that layers would be at a high rate of production when prices were high. In the years 1955-56, less than 65 percent of nonbroiler chicks hatched by commercial hatcheries were produced in March, April, and May (23, 25, and 16 percent, respectively). In addition, reduction in the seasonal variation of the monthly number of eggs laid per layer (discussed below) contributed to the changing monthly production pattern. Through improved breeding of laying-type chickens, and also as a result of improved management practices, declines in rate of lay per layer due to molting have been materially reduced.

Table 30 also gives index numbers of seasonal variation of production by regional groupings. Data are shown only for 1955, for purposes of comparison with data for the United States. The changing seasonal movement brought out by the data for the United States also is present in the regional totals. The index of seasonal variation in the East North Central Region more closely resembles the average for the United States than the other regions. The greatest amplitude occurs in the South Central and the West North Central re-

[34] Includes broilers as well as nonbroiler chicks. For these years, however, broiler chicks were a small part of commercial hatchery production.

TABLE 30.—*Eggs: Index numbers of seasonal variation of production on farms, United States and by regions* [1]

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
United States:												
1930	66	97	151	*168*	160	128	108	92	75	60	*45*	50
1935	73	92	148	*167*	159	126	105	89	73	62	*50*	56
1940	82	97	142	*155*	148	120	102	88	75	66	*58*	67
1945	93	107	142	*144*	136	113	97	83	73	69	*66*	77
1950	105	107	*128*	125	120	102	91	82	*78*	82	85	95
1955	106	102	*119*	115	112	98	90	84	*84*	92	95	103
Region: [2]												
North Atlantic	107	96	*107*	102	100	*92*	92	94	96	104	103	107
East North Central	111	103	*118*	113	110	96	86	*80*	82	93	100	108
West North Central	112	108	*126*	122	118	100	87	76	*73*	82	91	105
South Atlantic	102	103	*126*	120	114	99	90	85	*85*	90	89	96
South Central	93	103	*133*	130	123	102	90	84	*83*	89	84	87
Western	102	95	*109*	105	105	97	96	95	*95*	101	98	102

[1] Computed by a method which uses adjusted ratios to moving averages; described in (*42*). Numbers in italics indicate high and low values for the year based on unrounded data.

[2] Seasonal adjustment factors for the year 1955.

gions, while the least amplitude occurs in the North Atlantic and Western regions. As table 31 shows, the amplitude of seasonal variation in production is inversely related to size of egg-laying operation. Larger, more specialized farms tend to have better layers and to be less seasonal in starting replacement chicks, thereby obtaining a more evenly distributed annual egg output than smaller, less specialized farms.

Index numbers of seasonal variations of number of eggs produced per 100 layers and of number of layers on farms for the United States and major regions are given in tables 32 and 33. Both these series exhibit a changing seasonal pattern, with the reduction in the seasonality of rate-of-lay greater than the reduction in the seasonality of numbers of layers. By lessening the impact of molting on rate of lay, seasonal variability in the former series was reduced. The seasonally decreased drop in the rate of lay became a contributing factor to reduced culling, thereby lessening seasonal variation in the number of layers series.

TABLE 31.—*Eggs: Variability in indexes of seasonal variation in production and rate of lay, compared with size of flock, by regions, 1955*

Region	Coefficient of variation [1]		Percentage of egg laying flocks with 400 or more chickens [2]
	Production	Rate of lay	
	Percent	*Percent*	*Percent*
Western	4.7	6.5	10.2
North Atlantic	5.8	5.8	25.9
East North Central	12.7	11.2	6.4
South Atlantic	13.7	14.2	3.4
West North Central	18.1	15.4	7.5
South Central	18.5	19.9	1.4

[1] Standard deviation expressed as a ratio of the arithmetic mean. Because the arithmetic mean for a seasonal index equals 100, the coefficient of variation equals the standard deviation.

[2] Among commercial farms reporting chickens 4 months old and over on hand on the day of enumeration (fall, 1954). From (*52*, pp. 538–552).

The smallest amplitude in the index number of seasonal variations of rate of lay is the series for the North Atlantic and Western regions while the largest amplitude is in the series for the South Central and West North Central regions. Variation in rate of lay appears to be inversely related to size of flock, with regions having principally large size flocks having less variation in rate of lay than regions having principally small size flocks (table 31). Similar comments are applicable to the index numbers of seasonal variation of numbers of layers on farms during the month.

TABLE 32.—*Eggs: Index numbers of seasonal variation of number produced per 100 layers, United States and by regions* [1]

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
United States:												
1930	58	86	139	161	*161*	136	121	105	84	62	*43*	44
1935	64	82	135	159	*160*	135	119	104	82	64	*47*	50
1940	71	86	130	148	*150*	129	117	103	84	68	*54*	59
1945	82	96	130	138	*138*	122	112	99	82	71	*62*	69
1950	93	97	120	124	*126*	112	105	95	*84*	80	78	85
1955	97	95	116	116	*118*	108	102	94	*87*	88	87	93
Region: [2]												
North Atlantic	99	93	108	107	*110*	102	101	98	94	96	*94*	97
East North Central	100	96	114	115	*118*	107	101	92	*84*	88	90	97
West North Central	99	98	118	120	*123*	111	103	91	*80*	*80*	83	93
South Atlantic	93	97	*121*	121	120	108	101	94	87	88	*83*	87
South Central	86	96	128	*130*	129	112	101	91	84	85	*78*	79
Western	96	92	*108*	108	110	104	103	99	94	96	*92*	96

[1] Computed by a method which uses adjusted ratios to moving averages; described in (*42*). Numbers in italics indicate high and low values for the year based on unrounded data.

[2] Seasonal adjustment factors for the year 1955.

TABLE 33.—*Eggs: Index numbers of seasonal variation of number of layers on farms during the month, United States and by regions* [1]

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
United States:												
1930	*114*	111	108	103	98	93	88	*86*	89	96	103	111
1935	*114*	112	108	104	98	92	87	*85*	88	96	104	112
1940	*114*	112	108	103	98	92	86	*84*	88	97	105	112
1945	*113*	111	108	103	98	92	86	*83*	88	98	106	112
1950	*112*	109	106	100	95	90	86	*86*	93	102	109	112
1955	110	107	103	99	94	90	*87*	89	96	104	109	*110*
Region: [2]												
North Atlantic	108	103	99	95	91	*89*	91	96	102	107	*110*	*110*
East North Central	111	108	104	99	94	89	*85*	87	96	106	111	*111*
West North Central	*113*	111	107	102	97	90	85	*83*	90	102	109	112
South Atlantic	109	106	103	99	95	92	*89*	90	97	103	108	*110*
South Central	108	105	102	98	95	90	*89*	92	99	105	108	*109*
Western	106	103	100	97	95	93	*93*	96	100	104	*106*	106

[1] Computed by a method which uses adjusted ratios to moving averages; described in (*42*). Numbers in italics indicate high and low values for the year based on unrounded data.

[2] Seasonal adjustment factors for the year 1955.

Prices Received by Farmers

Index numbers of seasonal variation of average prices received by farmers for eggs in the United States and nine major regions are presented in table 34. As shown in figure 10, seasonal variation of the United States average price received by farmers for eggs is inversely related to the seasonal variation of the production of eggs in the United States. We previously have pointed out that the peaks and troughs of monthly egg prices are not as great as the variation in monthly production because of the diversion of eggs for storage and liquid egg production in spring and their release on the market in fall and later periods. In the period 1952–56, more than 80 percent of annual liquid egg production was in the first 6 months of the year when egg prices average lower than the last 6 months of the year. During January–June, the net movement of eggs was into-storage, while the net movement in July–December was out-of-storage. The effect of these factors is to raise the price level for eggs in the spring, and to lower it in the fall. Because storage eggs are discounted from fresh eggs, and because the greater part of liquid egg production is processed into frozen and dried egg, which can be carried over into the next year, shell egg prices in the fall are not as greatly affected by liquid egg and storage supplies as shell egg prices in the spring are affected by the demand for eggs for storage and processing into liquid egg.

The seasonal variation in the average price received by farmers for eggs is smallest in the regions in which the average size of laying flocks is large. Those regions which have the smallest amplitude in their seasonal variation in production also have the smallest

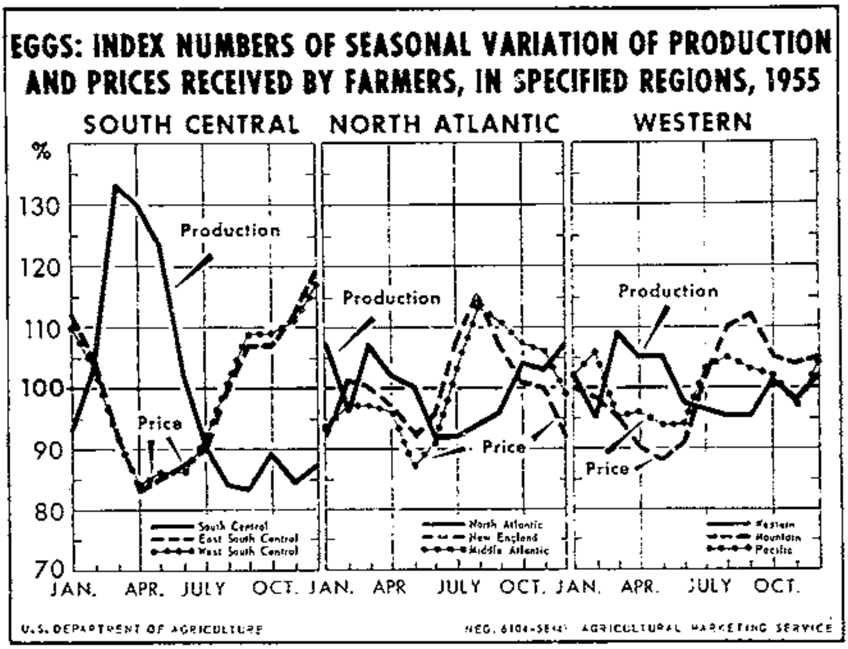

FIGURE 11.—Regions that have a small amplitude in their seasonal variation in production also have a small amplitude in seasonal variation in price.

TABLE 34.—*Eggs: Index numbers of seasonal variation of prices, United States and by regions and specified markets* [1]

Price and area or market	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Received by farmers:												
United States:												
1930	116	92	78	*73*	74	74	80	91	106	126	*147*	145
1935	107	95	78	*77*	79	79	86	94	110	124	*141*	131
1940	100	87	*82*	83	84	85	94	98	112	122	*132*	123
1945	104	91	88	*85*	86	89	96	101	107	115	*120*	120
1950	95	*87*	89	90	89	91	98	106	112	116	*116*	112
1955	99	105	100	93	*90*	92	98	*107*	107	104	104	103
Region: [2]												
New England	*92*	101	100	97	92	96	108	*115*	107	101	100	92
Middle Atlantic	93	97	97	96	*87*	91	103	*113*	111	107	106	99
North Central:												
East	96	105	103	94	*90*	90	96	*111*	109	104	104	100
West	98	*115*	110	99	98	95	*91*	102	98	103	96	96
South Atlantic	106	102	91	*86*	86	90	98	105	108	109	109	*111*
South Central:												
East	112	105	92	*83*	85	87	90	100	107	107	112	*119*
West	110	103	92	*84*	86	86	92	101	109	109	111	*117*
Mountain	100	98	95	90	*88*	91	102	110	*112*	105	104	105
Pacific	102	*106*	95	96	*94*	94	103	105	103	102	97	104
At wholesale, grade A: [2]												
Large:												
Chicago	91	98	96	93	*88*	92	104	114	*114*	111	106	94
Los Angeles	96	102	94	93	*92*	95	104	106	*110*	110	100	100
New York	93	99	97	94	*91*	92	99	109	110	*117*	104	95
Medium, Chicago	99	108	104	101	93	95	109	*111*	97	*89*	97	98

[1] Computed by a method which uses adjusted ratios to moving averages; described in (*42*). Numbers in italics indicate high and low values for the year based on unrounded data.

[2] Seasonal adjustment factors for the year 1955.

amplitude in seasonal variation in price (fig. 11). The inverse relationship of regional price and regional production is not as strong as the comparable relationship for the United States because the greater degree of aggregation in the country as a whole tends to smooth out the effect of individual State aberrations, as well as to mask the effect of interstate shipments. By shipping eggs from surplus to deficit production areas (see p. 106), differences between regions and between terminal markets in the regions are lessened.

Prices in Central Markets, by Grades

Index numbers of seasonal variation of wholesale market prices for Grade A, large eggs at Chicago, New York City, and Los Angeles tend to parallel the seasonal variation in prices received by farmers in the surrounding areas, with the exception that the peak in terminal market prices occurs later than the peak in the average price received by farmers in the corresponding regions. Terminal market prices are for established grades while reported mid-month farm prices are for a "mixture" of grades. Therefore, part of the difference in seasonal variation between terminal market prices and prices received by farmers is due to different grade composition.

The seasonal variation of prices for grade A, medium eggs broadly follows the seasonal movement of prices for grade A, large eggs, though prices for mediums peak earlier in the fall, and have a secondary springtime peak. However, the margin between the index numbers of seasonal variation in the two series varies from season to season. In the spring, when supplies of large size eggs are plentiful, prices for large size eggs are seasonally low, and the spread between the index numbers of seasonal variation in prices for large and medium eggs is narrow. In September, October, and November, when medium size eggs are in plentiful supply and supplies of large size eggs are less than in the spring, the spread between the indexes of seasonal variation is greatest. Because large size eggs are preferred to medium size eggs of similar grades, supplies of large size eggs are dominant in determining the price relationship between large and medium eggs.

Egg-Feed Ratio and Feed Costs

Table 35 presents index numbers of seasonal variation of the egg-feed ratio for the United States and major regions. The seasonal swings in the egg-feed price ratios parallel the seasonal movement in egg prices. Seasonal variation in the average price paid by farmers for poultry rations is less pronounced than the seasonal variation in egg prices and, to an extent, follows the general swing in egg prices. Seasonal variation in the average price received by farmers for corn, a major item in poultry rations, reaches a peak in August and a low in November. Index numbers of seasonal variation of these two series are given in table 36.

TABLE 35.—*Eggs: Index numbers of seasonal variation of egg-feed price ratios, United States and by regions* [1]

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
United States:												
1930	118	92	77	73	73	*72*	79	89	105	126	*150*	147
1935	108	93	79	77	80	*77*	83	90	109	124	*146*	133
1940	99	86	*81*	82	82	85	93	100	111	123	*135*	124
1945	105	92	88	*85*	86	88	94	98	105	115	*124*	120
1950	94	89	89	88	*88*	90	96	105	112	117	*120*	112
1955	99	106	96	94	*90*	92	97	107	*106*	104	105	104
Region:[2]												
New England	92	98	97	95	*92*	96	108	*115*	109	103	103	93
Middle Atlantic	94	97	94	96	*87*	91	104	*112*	110	107	107	100
North Central:												
East	95	104	97	92	*88*	89	96	110	*110*	108	108	102
West	97	*109*	103	98	96	95	*92*	106	102	100	102	100
South Atlantic	106	100	90	85	*85*	90	98	104	108	109	111	*112*
South Central:												
East	112	104	91	*82*	84	84	89	98	107	110	117	*123*
West	109	102	87	*83*	84	86	92	101	111	112	113	*118*
Mountain	99	98	90	*88*	88	91	101	112	*114*	108	105	106
Pacific	100	105	94	95	*93*	94	106	105	*111*	99	96	102

[1] Computed by a method which uses adjusted ratios to moving averages; described in (*42*). Numbers in italics indicate high and low values for the year based on unrounded data.

[2] Seasonal adjustment factors for the year 1955.

TABLE 36.—*Feed: Index numbers of seasonal variation in cost of poultry ration and prices received by farmers for corn, United States* [1]

Month	Poultry ration [2]	Corn [3]	Month	Poultry ration [2]	Corn [3]
January	99	92	July	101	110
February	99	94	August	101	*112*
March	100	95	September	101	110
April	101	98	October	99	98
May	*102*	103	November	*97*	*91*
June	101	106	December	98	91

[1] Numbers in italics indicate high and low values for the year based on unrounded data.

[2] Computed by a method which uses adjusted ratios to moving averages; described in (*42*). Based on 1927–56.

[3] Average of ratios to 12 month moving average, centered, adjusted to total 1,200 and to eliminate abnormal fluctuations. Based on 1922–41. From (*35*, p. 78).

Price Differences Due to Location and Quality

The analysis of factors that affect the price, demand, and supply of eggs has been based on aggregate data for the United States. The use of aggregate data may obscure the movement of divergent trends—regional, State, and local—in the components of the total. Results obtained in the previous sections should be thought of as a summation of all the individual cases.

In order to make the results more useful to persons who have an interest in a lower level of aggregation, the following section relates the average price received by farmers in the United States to regional prices at the farm level, as well as to prices at several different stages of the marketing process.

Overall Pattern by Areas

Average prices received by farmers for eggs vary considerably from one part of the country to another. These regional variations in price reflect surplus and deficit production areas, as well as distances from markets, differences in the quality of eggs produced, and differences in the seasonality of production in each region. The map in figure 12 shows the average level of prices received by farmers for eggs from 1953 to 1957. Lines are drawn through areas having approximately equal prices.

Prices received by farmers for eggs generally average the lowest in North Dakota, South Dakota, Nebraska, and other States of the West North Central region. Prices generally increase with movement away from the West North Central region. The highest average prices are received in New England, Florida, and Arizona.

Table 37 shows that these regional price variations are roughly related to whether a region is a surplus or deficit production area in relation to consumption. Annual surpluses and deficits can be indicated by computing the percentage that per capita production in each region is of per capita consumption in the United States. These estimates are inexact because they assume that nonfarm pro-

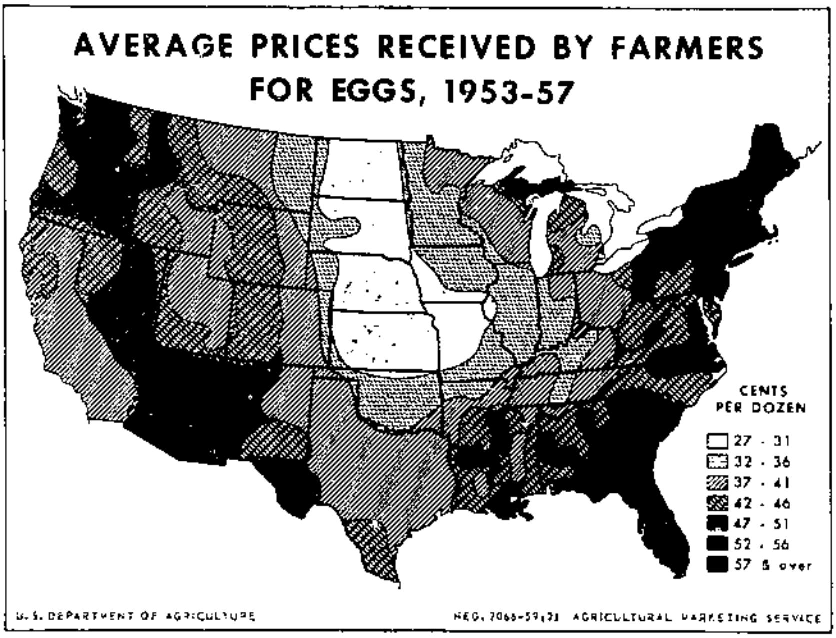

FIGURE 12.—Regional variations in price chiefly reflect surplus and deficit production areas, as well as distances from markets, differences in the quality of eggs produced, and differences in the seasonality of production in each region.

TABLE 37.—*Eggs: Production per capita and average farm price as percentages of United States consumption per capita and average farm price, respectively, United States and by regions, average 1953-55*

Region	Per capita production as a percentage of United States per capita consumption [1]	Farm price as a percentage of United States average farm price
	Percent	*Percent*
New England	83	130
Middle Atlantic	74	121
East North Central	103	92
West North Central	327	80
South Atlantic	71	117
East South Central	86	99
West South Central	78	96
Mountain	80	102
Pacific	100	110
United States [2]	107	100

[1] Production includes farm production as well as an allowance for nonfarm production. These were, as a percentage of farm production: 10 percent, 1953 and 1954; 9 percent, 1955.

[2] Production exceeds consumption because of changes in stocks of eggs, and because quantities of eggs are exported, used for hatching, and purchased by the Armed Forces for use outside the United States.

duction and eggs used for hatching are distributed among States and regions in the same way as farm production, and that per capita consumption is uniform in each State. Nevertheless, they probably indicate the general picture of regional surpluses and deficits.

United States Average Price Received by Farmers as Related to Prices at Terminal Markets

Average prices received by farmers for eggs are reported only for several days near the 15th of each month, whereas terminal market prices for specified grades are quoted daily. Estimates can be made of the probable level of prices received by farmers for other parts of the month by determining the normal relationship between the average price received by farmers and terminal market prices.

Table 38 shows the statistical relationship between the United States average price received by farmers and the wholesale market price for grade A, large, eggs at Chicago, New York City, and Los Angeles, by months, for the years 1943–55. The wholesale market quotations are for the 15th of the month and the three preceding business days, except that when the 15th of the month fell on a Saturday or Sunday, the series of four daily prices was arranged to end on the Friday immediately preceding the 15th. Daily prices used were averages of high and low quotations. To estimate the price received by farmers, the wholesale price quotation at Chicago, New York City, or Los Angeles is multiplied by the appropriate factor in column 1 and the factor in column 2 is added to that product. Comparisons are based only on data from 1943 to 1955 because consistent wholesale price series related to United States grades are not available for the three cities before 1943. During a part of the 1943–46 period the margins between farm and wholesale

TABLE 38.—*Eggs: Relation of average price received by farmers, per dozen, United States, to wholesale price of Grade A, large, eggs, per dozen, monthly, Chicago, New York City, and Los Angeles, 1943–55* [1]

Month	Factor by which the wholesale price is multiplied [3]	Factor to be added to the wholesale price [4]	Average error of estimate [5]	Percentage of explained variation [6]
	Chicago [2]			
		Cents	*Cents*	*Percent*
January	1.075	−3.56	1.60	92.4
February	1.045	−4.09	1.32	94.0
March	.990	−3.02	1.54	91.5
April	.931	−1.33	1.68	91.9
May	.926	(7)	1.75	95.2
June	.857	1.70	1.59	93.3
July	.791	4.74	2.69	80.1
August	.797	4.34	1.81	91.4
September	.794	3.85	2.71	86.4
October	.762	4.98	2.62	87.8
November	.762	6.61	2.24	88.4
December	.786	9.12	1.89	92.9

See footnote at end of table.

TABLE 38.—*Eggs: Relation of average price received by farmers, per dozen, United States, to wholesale price of Grade A, large, eggs, per dozen, monthly, Chicago, New York City, and Los Angeles, 1943–55* [1]—Continued

Month	Factor by which the wholesale price is multiplied [3]	Factor to be added to the wholesale price [4]	Average error of estimate [5]	Percentage of explained variation [6]
	New York City [8]			
		Cents	*Cents*	*Percent*
January	0.949	−0.24	1.98	88.3
February	1.028	−5.14	1.53	92.0
March	.989	−5.06	1.18	95.0
April	.927	−2.88	1.43	94.2
May	.904	−1.57	1.38	92.3
June	.870	.02	1.21	96.1
July	.875	.39	2.56	81.9
August	.865	.61	2.48	84.0
September	.795	3.56	2.90	84.4
October	.885	−1.85	2.77	86.4
November	.763	6.85	2.51	85.3
December	.794	7.53	2.38	88.8
	Los Angeles [9]			
January	0.801	1.36	2.52	81.1
February	1.038	−8.65	1.57	91.6
March	.824	−.32	1.74	89.2
April	.809	.12	1.65	92.2
May	.773	1.43	1.72	92.6
June	.766	1.41	1.26	95.8
July	.756	1.54	2.47	83.2
August	.705	4.95	2.43	84.6
September	.737	2.03	2.70	86.5
October	.806	−1.11	2.34	90.3
November	.689	7.56	2.14	89.4
December	.646	10.45	1.74	94.0

[1] Price received by farmers on the 15th of the month; wholesale quotations are for the 15th of the month and the three preceding business days, except that when the 15th of the month fell on a Saturday or a Sunday, the series of four daily prices was arranged to end on the Friday immediately preceding the 15th. Daily prices used were averages of high and low quotations.

[2] Price quoted by the Federal Market News Service (*47*) for extras, No. 1 and 2 (or, in the event that such a grade was not quoted, the nearest comparable grade). In recent years this has been taken as extras (60 percent or more A's) or the nearest comparable grade. Price for white, brown and mixed color eggs prior to 1950; brown and mixed 1950–55.

[3] Simple regression coefficient with the average price received by farmers as the dependent variable.

[4] Constant value (a) in the regression equation.

[5] Standard error of estimate.

[6] Coefficient of determination times 100.

[7] Less than 0.005.

[8] Price quoted by Urner-Barry Company (*63*) for mid-western mixed colors, extras, No. 1 large (or, in the event that such a grade was not quoted, the nearest comparable grade). In recent years this has been taken as extras (70 percent A's) or the nearest comparable grade.

[9] Price quoted by the Federal-State Market News Service (*50*) for large, grade A eggs, color not specified. In recent years this has been taken as minimum 40 percent AA.

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egg prices were affected by ceiling price regulations of the Office of Price Administration. The effect of the ceiling regulations probably did not greatly disrupt the marginal relationships in those years because egg prices for the greater part of the period were not pressing against the limits imposed by the ceiling regulations.

The change in the factors from month to month reflects seasonal differences in production. In the months of peak egg production, a change of one cent in the wholesale price of eggs is associated with an almost corresponding change in the price received by farmers for eggs. However, in the summer and fall months of the year, a 1-cent change in the wholesale market is associated with about a three-quarter cent change in the farm price. The lessened responsiveness at the farm level to changes in the wholesale market in the summer and fall months may reflect, in part, the impact upon price of cold storage eggs moving into consumption channels.

Prices in Principal Producing States as Related to Prices at Terminal Markets Through Which They Normally Sell

Because nearby producing areas do not supply sufficient eggs to meet the demand of large urban areas, the surplus production regions of the East North Central and West North Central States ship eggs to urban areas throughout the entire United States. Table 39 lists the 1953–55 percentage distribution of receipts of shell eggs at 10 markets in the United States, by region or origin. As would be expected, each urban area draws its main source of supply from the region in which it is situated, although considerable quantities are also obtained from more distant areas.

Because of the added cost of transporting eggs from more distant sources, as well as the influence on price of alternative markets to which surplus regions can ship their eggs and the loss of quality associated with shipping time, average prices received by farmers for shell eggs in States located close to an urban market more nearly reflect price movements in the terminal market than do prices received by farmers in the more distant supply areas. This variation in price response associated with distance from market is shown in table 40, which relates the average price received by farmers in the States which are the major sources of supply for Chicago, New York, and Los Angeles to the wholesale prices in those cities.

Price Differentials in Terminal Markets Due to Differences in Quality and Size

At a given market, differences in egg prices arise because of variations in the quality and weight of the eggs being marketed. At terminal markets, most trading in eggs is conducted on the basis of uniform wholesale grade and size designations (table 41). While data showing the percentage distribution by grade and size of egg receipts at terminal markets in the United States were not available for the years of this study, published data for Canada (*5*) show for 1953–55 that almost three-fifths of receipts at registered grading stations are grade A, extra large and large, one-fifth grade A, medium, less than 10 percent of graded receipts are grade B, and other grades and sizes account for smaller percentages.

TABLE 39.—*Eggs: Percentage distribution of receipts of shell eggs at 10 markets, by region of origin, average 1953–55* [1]

Region of origin	Boston	New York	Phila-delphia	Atlanta	Cleve-land	Cincin-nati	Chicago	St. Louis	San Fran-cisco	Los Angeles
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
New England	81. 3	2. 5	(2)	--------	(2)	--------	(2)	--------	--------	--------
Middle Atlantic	5. 2	51. 4	70. 4	(2)	0. 2	0. 8	(2)	--------	--------	--------
East North Central	2. 5	4. 6	3. 4	15. 5	82. 6	85. 4	50. 7	30. 6	(2)	0. 1
West North Central	10. 9	41. 0	22. 9	55. 3	17. 0	9. 1	49. 1	68. 0	20. 9	11. 4
South Atlantic	--------	. 3	3. 2	28. 1	--------	. 2	(2)	--------	--------	--------
East South Central	--------	. 1	(2)	1. 1	. 2	4. 5	. 1	. 6	--------	(2)
West South Central	--------	--------	--------	--------	--------	--------	--------	. 8	(2)	. 1
Mountain	--------	--------	--------	--------	--------	--------	(2)	--------	5. 7	4. 4
Pacific	--------	--------	--------	--------	--------	--------	--------	--------	73. 4	84. 0
United States	100. 0	100. 0	100. 0	100. 0	100. 0	100. 0	100. 0	100. 0	100. 0	100. 0

[1] Excludes shipments totaling less than 10,000 cases from a State to a particular city. Also, nearby receipts, which bypass the wholesale market channels, may not have been fully reported.

[2] Less than 0.05 percent.

TABLE 40.—*Eggs: Relation of average price received by farmers, per dozen, selected States, to prices, per dozen, in specified terminal markets, 1943–55* [1]

State	Factor by which the wholesale price is multiplied [3]	Factor to be added to the wholesale price [4]	Average error of estimate [5]	Percentage of explained variation [6]
	Relation to Chicago price [2]			
		Cents	*Cents*	*Percent*
Iowa	0.808	−2.44	1.43	90.0
Illinois	.861	−3.89	1.07	94.8
Minnesota	.821	−2.13	1.24	92.5
Wisconsin	.948	−4.45	1.23	94.4
	Relation to New York City price [7]			
Iowa	.864	−6.00	1.01	95.0
New Jersey	1.251	−6.07	2.57	86.1
New York	1.289	−9.67	3.23	80.6
	Relation to Los Angeles price [8]			
California	1.017	−5.94	1.27	96.2

[1] Annual average prices based on: (1) price received by farmers on the 15th of the month; and (2) wholesale quotations for the 15th of the month and the 3 preceding business days, except that when the 15th of the month fell on a Saturday or a Sunday, the series of 4 daily prices was arranged to end on the Friday immediately preceding the 15th. Daily prices used were averages of high and low quotations.

[2] Price quoted by the Federal Market News Service (*47*) for extras, No. 1 and 2 (or, in the event that such a grade was not quoted, the nearest comparable grade). In recent years this has been taken as extras (60 percent or more A's) or the nearest comparable grade. Price for white, brown and mixed color eggs prior to 1950; brown and mixed 1950–55.

[3] Simple regression coefficient with the average price received by farmers as the dependent variable.

[4] Constant value (a) in the regression equation.

[5] Standard error of estimate.

[6] Coefficient of determination times 100.

[7] Price quoted by Urner-Barry Co. (*63*) for mid-western mixed colors, extras, No. 1 large (or, in the event that such a grade was not quoted, the nearest comparable grade). In recent years this has been taken as extras (70 percent A's) or the nearest comparable grade.

[8] Price quoted by the Federal-State Market News Service (*50*) for large, grade A eggs, color not specified. In recent years this has been taken as minimum 40 percent AA.

TABLE 41.—*Shell eggs: Summary of United States wholesale grades and weight classes*

Wholesale grade designation	Minimum percentage of eggs of specific qualities required [1]				Maximum tolerance permitted (lot average)				
	AA Quality	A Quality or better	B Quality or better	C Quality or better	B Quality, C Quality, Dirties, and Checks	C Quality, Dirties, and Checks	Dirties and Checks	Checks	Loss
					Percent	*Percent*	*Percent*	*Percent*	*Percent*
U.S. Specials—Percent AA Quality [2]	20	Balance	None permitted except for tolerances.	None permitted except for tolerances.	7.5				2
U.S. Extras—Percent A Quality [2]		20	Balance	do		11.7			3
U.S. Standards—Percent B Quality [2]			20	Balance			11.7		4
U.S. Trades—Percent C Quality [2]				83.3			11.7		5
U.S. Dirties—Percent								11.7	5
U.S. Checks—Percent									5

See footnotes at end of table.

TABLE 41.—*Shell eggs: Summary of United States wholesale grades and weight classes*—Continued

Weight class	Per 30 dozen eggs		Weights for individual eggs at rate per dozen	
	Average net weight on a lot [3] basis	Minimum net weight individual case [4] basis	Minimum weight	Weight variation tolerance for not more than 10 percent, by count, of individual eggs
	At least—			
Extra large	50½ pounds	50 pounds	26 ounces	Under 26 but not under 24 ounces.
Large	45 pounds	44 pounds	23 ounces	Under 23 but not under 21 ounces.
Medium	39½ pounds	39 pounds	20 ounces	Under 20 but not under 18 ounces.
Small	34 pounds	None	None	None.

[1] Substitution of eggs possessing higher qualities for those possessing lower specified qualities is permitted.
[2] The actual total percentage must be stated in the grade name.
[3] Lot means any quantity of 30 dozen or more eggs.
[4] Case means standard 30 dozen egg case as used in commercial practice in the United States.

Source: (*38*, p. 9).

While higher prices are received for better quality and larger size eggs, the price relationships among different classifications of eggs change throughout the course of a year due to seasonally varying supplies of the different qualities and sizes of eggs. Seasonal variation in the production of high quality eggs arises because hot weather adversely affects the physiological makeup of the laying hens. In addition, hot weather contributes to a more rapid deterioration of egg quality while eggs are in marketing channels. The seasonal variation in egg size is associated with the age of a layer; pullets first coming into production lay smaller eggs than they do after they have laid several months. Consequently, proportions of large size eggs are greatest in spring, while proportions of medium and smaller size eggs are greatest in fall. The varying seasonal relationship between medium and large size eggs is shown in table 42, which lists the percentages that monthly receipts of medium size eggs are to monthly receipts of large size eggs at registered grading stations in Canada for 1951–55.

TABLE 42.—*Eggs: Percentage that receipts of grade A, medium, are to grade A, large, monthly, and monthly and yearly averages, 1951–55* [1]

Period	1951	1952	1953	1954	1955	Average 1951–55
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
January	32. 1	39. 1	33. 5	35. 8	31. 7	34. 4
February	22. 5	28. 1	25. 1	24. 4	22. 5	24. 5
March	17. 9	22. 3	19. 7	19. 4	16. 4	19. 1
April	17. 0	20. 2	18. 0	17. 5	16. 0	17. 7
May	17. 5	19. 8	18. 4	18. 8	17. 0	18. 3
June	18. 1	20. 8	19. 5	22. 3	20. 7	20. 3
July	22. 4	27. 7	25. 4	32. 2	30. 3	27. 6
August	36. 6	40. 7	41. 8	52. 0	46. 4	43. 5
September	64. 6	68. 3	71. 2	71. 3	66. 7	68. 4
October	98. 9	90. 5	90. 2	79. 7	82. 0	88. 3
November	81. 9	74. 0	76. 4	64. 1	68. 5	73. 0
December	57. 9	49. 9	56. 7	46. 3	48. 3	51. 8
Year	35. 1	36. 7	36. 0	36. 3	35. 4	35. 9

[1] Monthly receipts at Canadian registered grading stations, from: Poultry Products Market Review (*5*).

If consumers were indifferent to the quality and size of the eggs they purchase, prices for the different grades and sizes would tend to be equal. Consumers, however, are not indifferent to the quality and size of eggs. The consumer preference studies discussed on page 60 indicate that consumers prefer high quality eggs and are willing to pay a price differential for quality. Storers also prefer high quality eggs because they keep a fresh condition longer than lower quality eggs. The demand for grade A eggs, therefore, differs from the demand for grade B and other grade eggs. In relation to size, the consumer purchase data from the 1955 expenditure survey (page 50) show that for almost all income groups, more large and extra large size eggs were purchased than medium, small, and peewee size eggs. While a comparison of purchases by size reflects the ratio of available supplies of large size eggs to eggs of other size, consumers naturally prefer a large size egg to a smaller size egg if both are offered at the same price.

Unfortunately, quantity data by grade and size designations are not available to obtain empirical measurements of the elasticities of substitution among the various grades and sizes of eggs. In the absence of the needed data to derive empirical measurements, the following section formulates and discusses a model for obtaining substitute relationships among grades and sizes.

Figure 13 presents a simplified diagram of the demand and price structure for eggs, by grade and size. We assume that the price and quantity of eggs are simultaneously determined within the specified time period of a year, and that consumer income is the major factor that influences the level of egg prices, given the quantity of eggs to be consumed. Basically, this assumption results in a simplified version of equation (8) in the 11-equation model of the egg economy.

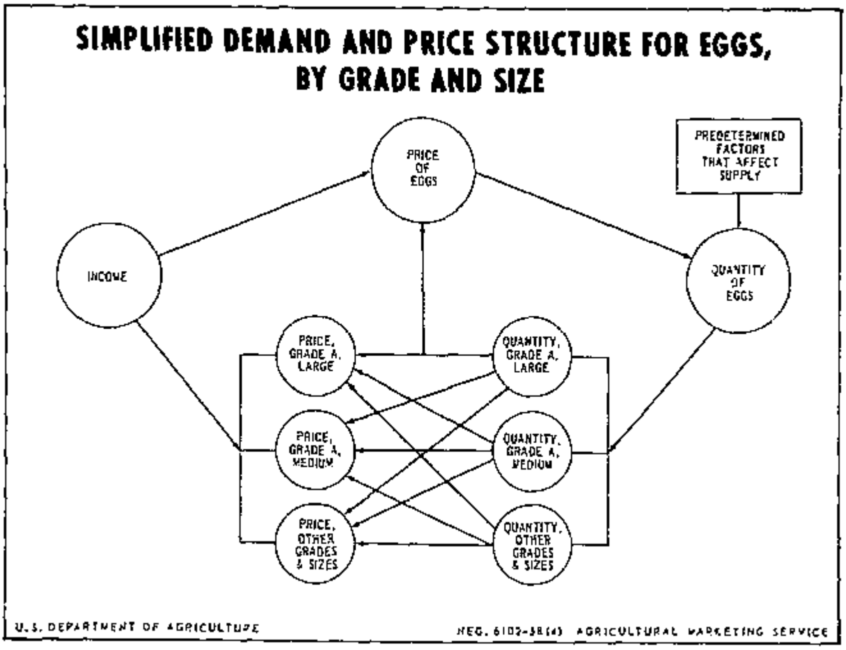

FIGURE 13.—This diagram shows the major factors that affect the prices of different grades and sizes of eggs.

The total quantity consumed is assumed to be sold on a grade and size basis, but the aggregate can be thought of as a total without grade and size designations. In the diagram, the total quantity consumed is divided among "grade A, large," "grade A, medium," and the category "other grades and sizes." The simultaneous relationship between price and consumption is shown as channeled through a sector which relates price and quantity by grade and size. Within this sector, it is assumed that the proportions of the total quantity consumed by grade and size are fixed. With the given proportions of grades and sizes, price relationships adjust to equate the demand for the various grade and size classifications with the quantity available for consumption. The prices received form a weighted average price for eggs, and this price, in turn, influences the total quantity of eggs consumed.

This simplified model assumes that the quantity of eggs consumed equals the quantity produced. The assumption also is made that, although the total quantity of eggs consumed is simultaneously determined with price, the proportions of the total quantity consumed by grade and size are fixed. This is a simplifying assumption because, as stated in earlier sections, changes in price, through their influence on the number of replacement chicks and the number of layers sold and consumed on farms where produced, affect the size and quality of eggs marketed. For example, in a year of large replacements, a greater proportion of the eggs marketed would be pullet eggs than in a year when the number of replacement chicks started was small. Consequently, there is a simultaneous relationship within the span of a calendar year between price and the proportion of eggs marketed as grade A, large, grade A, medium, and so forth.

The simultaneous relationship, however, is not as strong for the individual grades and sizes as for the relationship between average egg price and total egg consumption because it is the weighted average price for the various grades and sizes marketed that influences the total quantity of eggs marketed. This is indicated schematically by the direction of the arrows showing the paths of influence.[35]

Under these assumptions, the prices for grade A, large, grade A, medium, and all other eggs can be determined by solving the following system of equations:

$$Q_{al}=a_1+b_{12}P_{al}+b_{13}P_{am}+b_{14}P_o+c_{11}I+u_1 \qquad (31)$$

$$Q_{am}=a_2+b_{22}P_{al}+b_{23}P_{am}+b_{24}P_o+c_{21}I+u_2 \qquad (32)$$

$$Q_o=a_3+b_{32}P_{al}+b_{33}P_{am}+b_{34}P_o+c_{31}I+u_3 \qquad (33)$$

$$Q_a=Q_{al}+Q_{am}+Q_o \qquad (34)$$

$$Q_a=a_5+b_{52}P_a+c_{51}Z+u_5 \qquad (35)$$

$$P_{al}/P_a=a_6+b_{62}Q_{al}/Q_a+c_{61}I+u_6 \qquad (36)$$

$$P_{am}/P_a=a_7+b_{72}Q_{am}/Q_a+c_{71}I+u_7 \qquad (37)$$

$$P_o/P_a=a_8+b_{82}Q_o/Q_a+c_{81}I+u_8 \qquad (38)$$

where the endogenous variables are:

Q_{al}=Quantity of eggs, grade A, large.
Q_{am}=Quantity of eggs, grade A, medium.
Q_o=Quantity of eggs, all other.
Q_a=Quantity of eggs, grade A, large; grade A, medium; and all other.
P_{al}=Price of eggs, grade A, large.
P_{am}=Price of eggs, grade A, medium.
P_o=Price of eggs, all other.
P_a=Price of eggs, weighted average, grade A, large; grade A, medium; and all other.[36]

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[35] To allow for this aspect of simultaneity, it would be necessary to introduce in the 11-equation model of the egg economy separate price and supply equations for each grade and size designation.

[36] The model assumes that:

$$P_a=(P_{al}\cdot Q_{al}+P_{am}\cdot Q_{am}+P_o\cdot Q_o)\cdot\frac{1}{Q_a}$$

and the predetermined variables are:

I=Consumer disposable income.
Z=Predetermined factors that affect the supply of eggs.

In this notation, the a's represent the constant term in each equation, the b's and c's represent structural coefficients that apply to the endogenous and predetermined variables, respectively, and the u's represent random error terms. Equation (34) is an identity and, therefore, is not fitted. As there are eight endogenous variables and eight equations, this is a complete system.

Lacking the quantity data to obtain price generating equations and elasticities of substitution by grades and sizes, we are limited to measuring the average relationships between the prices of designated grade and size categories of eggs. Tables 43 and 44 show the average relationship at Chicago, by months, between the price of grade A, large, eggs and grade A, medium, eggs, and the price of grade A, large, eggs and standard eggs. The large values in the fall months for the constant values in the regression equations reflect the fact that large size, high quality eggs are a smaller proportion of total egg supplies in those months than at any other time of the year.

TABLE 43.—*Eggs: Relation of average price, per dozen, of grade A, large, to grade A, medium, monthly, wholesale market, Chicago, 1946–55* [1]

Month	Factor by which the medium price is multiplied [2]	Factor to be added to the medium price [3]	Average error of estimate [4]	Percentage of explained variation [5]
		Cents	*Cents*	*Percent*
January	0.922	6.55	1.78	90.4
February	.825	9.26	1.25	94.4
March	.924	5.29	.91	96.9
April	1.025	1.81	1.13	97.0
May	.984	3.45	1.04	97.8
June	1.037	2.33	.97	98.4
July	.966	6.13	1.58	95.2
August	.954	7.71	2.08	93.0
September	.820	17.35	1.96	94.7
October	.902	18.26	2.65	92.0
November	1.024	10.87	3.45	85.1
December	.998	4.93	2.34	94.6

[1] Prices are for the 15th of the month and the 3 preceding business days, except that when the 15th of the month fell on a Saturday or a Sunday, the series of four daily prices was arranged to end on the Friday immediately preceding the 15th. Daily prices used were averages of high and low quotations reported by the Federal Market News Service (*47*). Grade A, large, and grade A, medium, quotations are for extras, No. 1 and 2 (or, in the event that such a grade was not quoted, the nearest comparable grade). In recent years this has been taken as extras (60 percent or more A's) or the nearest comparable grade.

[2] Simple regression coefficient with the average price of grade A, large, eggs as the dependent variable.

[3] Constant value (a) in the regression equation.

[4] Standard error of estimate.

[5] Coefficient of determination times 100.

TABLE 44.—*Eggs: Relation of average price, per dozen, of grade A, large, to standards, monthly, wholesale market, Chicago, 1946–55* [1]

Month	Factor by which the standard price is multiplied [2]	Factor to be added to the standard price [3]	Average error of estimate [4]	Percentage of explained variation [5]
		Cents	*Cents*	*Percent*
January	0.970	4.15	1.77	91.1
February	.957	4.14	.19	99.9
March	1.032	1.37	.49	98.9
April	1.070	.33	.60	99.2
May	.992	3.09	.36	97.4
June	1.037	3.44	.85	98.8
July	1.004	6.60	2.72	87.3
August	1.010	4.81	1.81	94.7
September	.890	16.16	2.03	94.3
October	.911	16.98	3.61	85.2
November	1.125	4.47	3.35	85.9
December	1.026	3.35	2.66	93.7

[1] Prices are for the 15th of the month and the 3 preceding business days, except that when the 15th of the month fell on a Saturday or a Sunday, the series of four daily prices was arranged to end on the Friday immediately preceding the 15th. Daily prices used were averages of high and low quotations reported by the Federal Market News Service (47). Grade A, large, quotations are for extras, No. 1 and 2 (or in the event that such a grade was not quoted, the nearest comparable grade). In recent years this has been taken as extras (60 percent or more A's) or the nearest comparable grade.

[2] Simple regression coefficient with the average price of grade A, large, eggs as the dependent variable.

[3] Constant value (a) in the regression equation.

[4] Standard error of estimate.

[5] Coefficient of determination times 100.

Futures Market for Eggs

In equation (17) of the model of the egg economy on page 65, the variable F introduced the futures market as a factor that influences the net into-storage movement of shell, frozen, and dried eggs during January–June. Storage movement arises, it was shown, because of the seasonal nature of egg production. In the spring months of peak production, eggs are put into storage or broken into liquid eggs for drying and freezing. The shell eggs put into storage in the spring are withdrawn in the fall and winter when supplies of fresh shell eggs are less than the quantity demanded at the prevailing price. The withdrawal of frozen and dried egg extends over a longer period because of their relatively easy storage for extended periods. Table 45 shows the net into-storage movement from January–June of shell, frozen, and dried eggs (shell equivalent) and the percentage that storage stocks are of farm egg production in the same period. The declining ratio reflects the trend in the seasonality of production. Until the 1940's, the into-storage movement tended to be from March–July. With the changing production pattern, the into-storage season now lasts from about February–June.

TABLE 45.—*Net into-storage movement of shell, frozen, and dried eggs (shell equivalent), production, and the percentage of eggs stored, January through June, 1927–58* [1]

Year	Net into-storage movement [2]	Farm production	Storage as a percentage of production
	1,000 cases	*1,000 cases*	*Percent*
1927	10, 793	69, 839	15. 5
1928	9, 974	68, 652	14. 5
1929	7, 889	66, 951	11. 8
1930	11, 747	70, 274	16. 7
1931	8, 444	68, 042	12. 4
1932	5, 447	65, 117	8. 4
1933	10, 511	64, 508	16. 3
1934	9, 711	62, 505	15. 5
1935	8, 111	58, 228	13. 9
1936	7, 234	60, 506	12. 0
1937	10, 910	65, 433	16. 7
1938	6, 206	64, 430	9. 6
1939	8, 770	66, 812	13. 1
1940	8, 131	67, 522	12. 0
1941	8, 204	69, 670	11. 8
1942	12, 715	81, 611	15. 6
1943	(3)	93, 291	(3)
1944	(3)	100, 958	(3)
1945	7, 173	95, 361	7. 5
1946	14, 992	95, 581	15. 7
1947	5, 855	92, 095	6. 4
1948	9, 653	88, 839	10. 9
1949	4, 446	88, 798	5. 0
1950	7, 416	93, 639	7. 9
1951	6, 124	90, 791	6. 7
1952	6, 011	90, 942	6. 6
1953	4, 002	88, 031	4. 5
1954	5, 460	88, 372	6. 2
1955	5, 430	89, 006	6. 1
1956	4, 035	89, 517	4. 5
1957	3, 906	90, 131	4. 3
1958	2, 180	87, 606	2. 5

[1] Reported storage holdings of dried eggs commenced Nov. 1, 1943.
[2] Excludes Government holdings.
[3] Government holdings not separately available.

Because there are costs of warehousing, spoilage, and interest charges of carrying the stock attendant with storing eggs, the futures price for eggs tends to be above the spot price from January through about June. This span parallels the into-storage period. Keynes (*26*, p. 144) points out that "the existence of surplus stocks must cause the forward price to rise above the spot price, i.e. to establish, in the language of the market, a 'contango,' and this contango must be equal to the cost of the warehouse, depreciation, and interest charges of carrying the stocks." In the latter half of the year, spot prices tend to be above the futures price because refrigerator eggs, which are discounted from fresh eggs, can be delivered on the futures contracts in this period (fig. 14). A re-

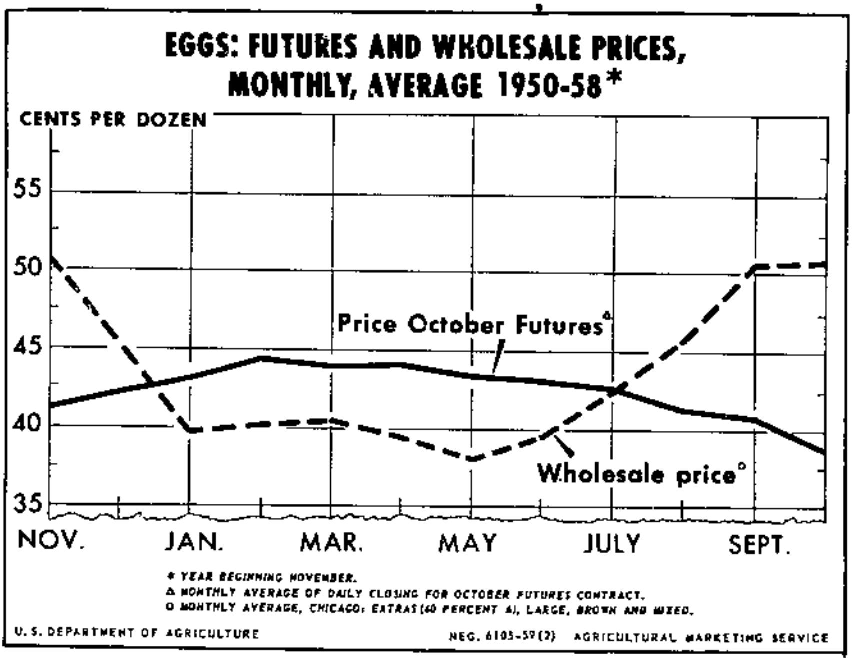

FIGURE 14.—Because of carrying charges, prices of October futures tend to be above the spot price until the end of the into-storage movement. Future prices are below spot prices in the out-of-storage months because of price discounts on refrigerated eggs, which can be delivered on the contract.

frigerator egg is defined as an egg that has been in storage for 29 days or longer.

While eggs will keep in storage for nearly a year, they maintain good condition for only 6 or 7 months. Eggs decrease in weight at an almost regular rate while in storage, averaging a net loss of about 1 pound per case for a period of 9 months. The storer of eggs, therefore, does not have the same commodity to sell after storage that he originally purchased. Because refrigerator eggs are deliverable on a futures contract, the price of refrigerator eggs and the price of the currently deliverable futures contract should be approximately the same. Traders who are short on futures would profit by making delivery when refrigerator eggs are cheaper than the current futures price while traders who are long on futures would profit by taking delivery when refrigerator eggs are higher priced than the current futures price, with due allowance for delivery costs.

Hedging

The storage operation involves a risk because there is no guarantee that the stored eggs can be sold at prices sufficient to cover the original cost and carrying charges on the purchased eggs. Risk on storage, however, can be minimized or eliminated by hedging transactions in the futures market.[37]

[37] Trading in egg futures was begun in 1919 on the Chicago Mercantile Exchange. In 1924 the New York Mercantile Exchange inaugurated trading in egg futures, but the volume of trading on this exchange has never reached large proportions. These markets were established to furnish (a) hedging facilities to dealers, (b) a broad, liquid market, and (c) continuous price quotations (57, p. 4).

The hedging transaction consists in either buying or selling in the spot market, and offsetting the spot transaction with either a sale or a purchase of a futures contract. We have therefore:

$$(F_0 - P_0) + (P_1 - F_1) - C = b \quad (39)$$

where:

F_0 and F_1=futures contract price in respective time periods
P_0 and P_1=spot price in respective time periods
C=costs of warehousing, spoilage, and interest charges of carrying the stock
b=gain or loss

For a short hedger (one who has made a spot purchase and sold a futures contract) to make a gain, $b>0$; for a long hedger (one who has made a spot sale and purchased a futures contract) to make a gain, $b<0$; if $b=0$, the hedge is perfect. Obviously, for unhedged stocks:

$$P_1 - (P_0 + C) = b \quad (40)$$

and, if $b>0$, holding unhedged stocks is profitable.

Changes in the Basis

The symbolistic formulation of the hedging transaction brings out the major aspect of hedging, the importance of parallel movements in the futures and cash markets. Under the restraint of parallel movements in both markets, a gain in a futures transaction is offset by a loss in a cash transaction, and vice versa. Changes in the relationship between cash and futures prices, therefore, are the major concern of hedgers, rather than the actual price changes. Table 46 shows for the period 1946–58 the difference, in cents per dozen, between the monthly average wholesale price for eggs at Chicago and the monthly average price for the nearest futures contract. The difference between these price quotations is usually referred to as the "basis." In the months of into-storage movement the average monthly basis should approximate the cost of storing eggs until the time of storage withdrawal. In the fall of 1956, the approximate cost of storing eggs was: 14 cents per case, per month, for storage; 12 cents per case for handling charges; $1.20–$1.30 per case (on 35 cent eggs) for interest and insurance; or about 4 to 5 cents per dozen for eggs stored 6 to 7 months. The "basis" in each of the months of into-storage movement averages to the approximate storage costs, with variations around the average as a percentage of the average greatest in January and July when the direction of storage movement changes. The averages in table 46 tend to mask the daily fluctuations that occur in the futures market because they are derived as the monthly average of the daily closing prices. Within any particular day, variation in the price of an egg futures contract is administratively limited by the exchange on which the trade is taking place. In recent years, the limitation has been 2 cents per dozen above or below the previous day's settlement price.[38]

[38] The settlement price is the last sale price of the day unless there is a lower offer or a higher bid at the close.

TABLE 46.—*Eggs, difference per dozen: Monthly average price, nearest future, and Chicago average wholesale price, 1944–58*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Cents	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
1944	3.55	5.08	4.43	4.03	5.54	4.22	1.04	−2.26	−10.39	−13.62	(1)	(1)
1945	−5.83	−.84	4.33	5.94	7.36	5.97	3.35	−4.71	−6.82	−6.62	−15.46	−13.75
1946	−2.44	4.80	4.14	6.74	5.14	7.05	1.03	−3.59	−9.01	−15.29	−19.83	−14.12
1947	−2.09	.80	−.02	1.40	3.78	3.25	1.08	−.56	−5.21	−11.96	−13.64	−11.39
1948	2.48	2.36	2.92	5.30	6.87	6.63	4.17	−1.96	−9.61	−16.93	−13.90	−11.47
1949	.83	3.41	2.35	.34	1.85	1.67	−1.11	−2.79	−7.55	−10.72	−9.41	−2.32
1950	6.05	5.30	3.71	5.03	6.59	4.05	.14	−3.92	−13.55	−18.05	−17.84	−18.14
1951	1.93	3.59	2.36	4.28	5.02	1.45	.27	−5.19	−9.95	−15.26	−15.67	−5.41
1952	5.86	7.05	5.82	4.97	7.30	4.21	−3.56	−6.66	−9.44	−18.58	−12.00	−9.75
1953	1.33	4.52	3.26	4.16	4.39	2.34	−.52	−5.60	−8.45	−10.06	−10.94	−6.56
1954	−1.39	1.86	5.17	4.91	6.09	5.43	−1.52	−5.38	−13.25	−12.27	−9.97	−5.54
1955	6.48	3.44	4.55	6.59	7.23	5.04	1.59	−6.96	−9.70	−13.53	−15.04	−9.04
1956	.18	4.41	3.81	4.27	5.08	3.04	−1.58	−4.81	−9.52	−9.48	−9.31	−3.76
1957	7.95	6.49	6.62	4.89	4.90	2.97	−2.73	−6.65	−10.41	−13.87	−9.40	−5.76
1958	4.53	2.65	−.90	4.24	3.69	3.15	.22	−4.74	−7.47	−6.48	−5.66	−4.11

[1] Insufficient data Chicago average wholesale price.

Relationship of Storage Movement to the Basis

Storers of eggs can be assumed to have some normal level of stocks in mind in relation to their previous experience with requirements for eggs in the fall. Departures from this level would be influenced by the "basis." If the "basis" was less than the cost of storing eggs and carrying them to fall, storers would put fewer eggs into storage than they would otherwise store; if the basis was greater than the cost of storage, more eggs would be put into storage. Figure 15 shows for the years 1927–58 [39] the net into-storage movement, ex-

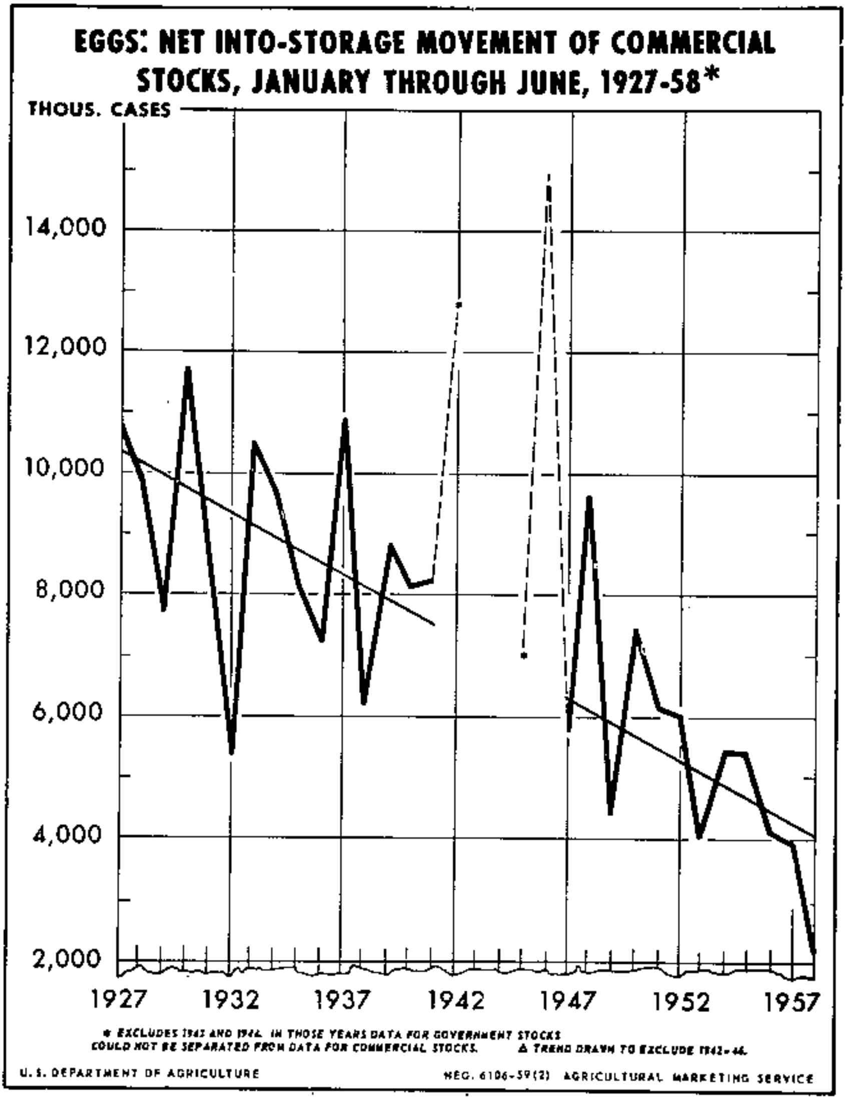

FIGURE 15.—We would expect a larger "basis" for years in which net into-storage movement is above the trend line than for years below the trend line.

[39] Years 1943 and 1944 are excluded because records of commercial and Government stocks cannot be separated.

cluding Government stocks, for January–June. The trend line, which indicates an approximation to normal, was drawn with the observations for the war years 1942–46 excluded. We would expect a larger "basis" for the years above the trend line than for the years below the trend line.

In figure 16, year-to-year changes in the relationship of the average net into-storage movement of shell, frozen, and dried egg (shell equivalent basis) for February–June and the average "basis" for those months are plotted. Only the postwar years 1947–58 are shown because a prewar comparison is complicated by changes in the specifications for wholesale quotations, contract terms, storage costs, and so forth. A distinct relationship is apparent between changes in the net into-storage movement and changes in the basis, with a basis greater than the previous year associated with a net into-storage movement larger than that in the previous year. Both 1952 and 1957 appear to be exceptions. The scatter of the data, however, indicate that when there is no change in the "basis" from the previous year, a small reduction in the net into-storage movement from the previous year occurs. This would be expected from the downward trend of net into-storage movement indicated in figure 15.

In relation to the downward trend in into-storage movement, only the observations for 1951 and 1957 depart from the premise that deviations from the trend of into-storage movement are related to the size of the "basis." From the actual observed "basis," we would have expected an into-storage movement below trend in 1951 and above trend in 1957. It is not readily apparent whether these deviations were the result of random influences, error in estimating the trend in into-storage movement, or the result of specific, but nonidentifiable factors in the egg market. However, the egg market in 1951 (spring) was characterized by uncertainty over ceiling price regulations of the Office of Price Stabilization and the future course and duration of the Korean War, factors which could have contributed to the above-trend storage in 1951 even though the "basis" was small. For 1957, no explanation is apparent, but large purchases of dried egg for the School Lunch Program were made in the first half of the year which may have influenced the actions of storers, breakers, and traders engaged in hedging and speculative operations.

Explanation of how changes in the "basis" occur, however, is complicated and incomplete. It is assumed that in an equilibrium position the "basis" is equal to the cost of storage and, at this spread between the futures price and the spot price for eggs, changes in into-storage movement are roughly governed by trend requirements. In turn, departures from trend requirements are influenced by changes in the "basis." Because the supply of eggs in the into-storage period is greater than current requirements for immediate consumption, the price which storers of eggs are willing to pay determines the spot price. In the into-storage period the equilibrium spot price for eggs equals the price of the nearest futures contract less storage costs. Therefore, the spot price for eggs during the months of into-storage movement can be considered as a discounted futures price.

The futures price for a commodity represents the consensus of opinion of buyers and sellers in the futures market as to what the price of a specified commodity will be at some distant date. For

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eggs during the into-storage period, the price of the September, October, and subsequent futures contracts is to a large extent determined by the expected price for refrigerator eggs in the months of contract settlements because refrigerator eggs are deliverable on the contracts. As the sentiment of hedgers and speculators as to the correctness of the expected price for refrigerator eggs changes, the current futures price shifts, altering the "basis" temporarily until storage activity restores the spread between spot and futures prices

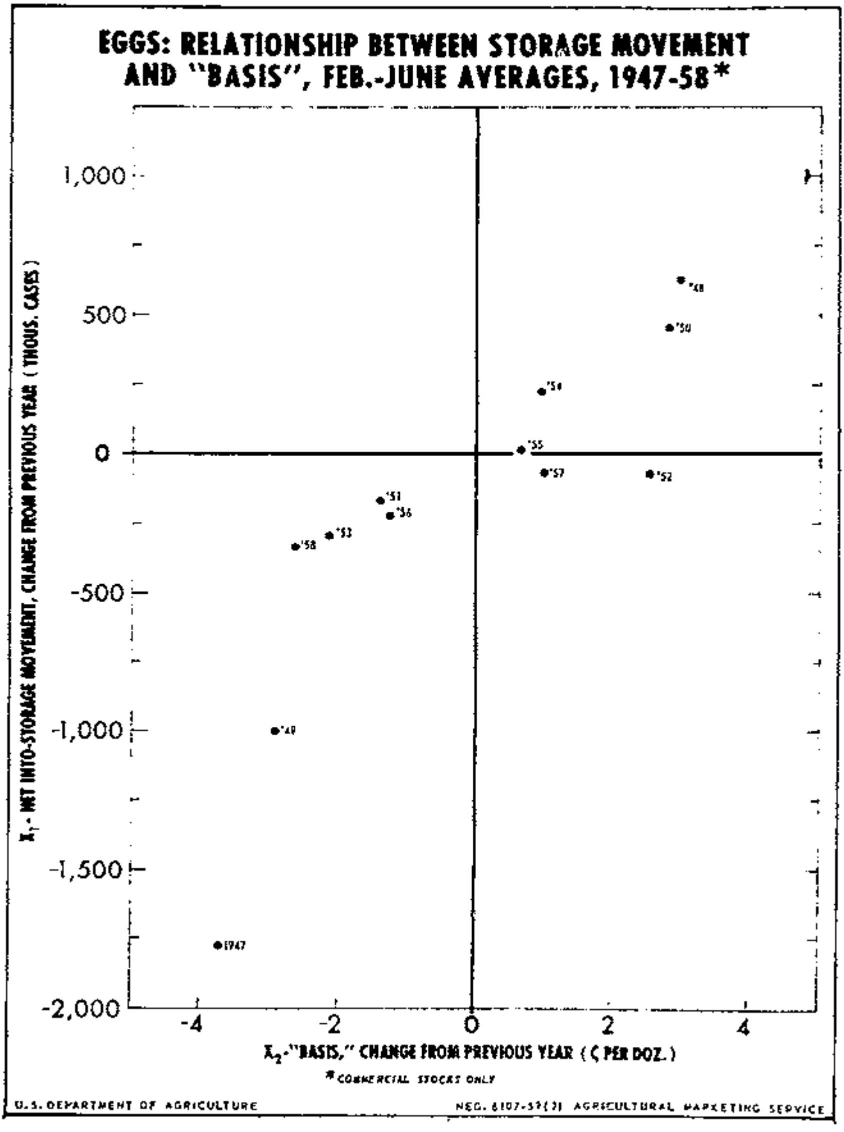

FIGURE 16.—Year-to-year changes in the net into-storage movement in February-June are related to year-to-year changes in the average "basis" for those months; a "basis" greater than the previous year being associated with net into-storage movement larger than that in the previous year.

to the cost of storage. The factors upon which traders in the egg futures market form their expectations of distant prices involves all those which are expected to affect supply and demand at the time when a contract becomes deliverable. The more important factors are probably the expected size of egg production, the quantity of eggs in storage, the rate of withdrawal from storage, and the overall level of activity of the economy in the fall and winter months. For each of these factors, the trader in spring can have only an "ex ante" measure. Consequently, a model of how traders form their expectations would be necessary.

The major factor that traders probably consider as influencing the price of refrigerator eggs is the quantity of eggs to be produced in the fall. Hence, some relationship should be observable among futures prices of fall contracts in the spring and variables that relate to egg production in the fall. The most important information relating to fall egg production that develops during the spring is the indicated size of the replacement hatch and the number of layers culled. However, data on replacements and culling are not available per se but must be deduced by traders from movements in a number of related poultry statistics. If the estimates of replacement pullets raised and layers sold and consumed on farms where produced, derived on pages 29 and 33, are used as estimates of traders expectations, no measurable relationship with futures prices in the spring is observable for the post-World War II years. However, the lack of relationship may be due to the inappropriateness of using the estimated replacement pullets raised and layers sold series, which are "ex post" measurements (that is, they measure facts which have occurred), as measures of "ex ante" factors. Only in cases where the "ex ante" and "ex post" measurements correspond do the estimated series indicate the expectations upon which traders act in the futures market in spring.

In the model of the egg economy, however, the effect of the price of futures enters only indirectly through the net into-storage variable, S, which appears in equations (16) and (17). Consequently, changes in the net into-storage movement must be explained in the model. It was shown above that changes in the net into-storage movement are related to changes in the "basis;" and that changes in the "basis" reflect the interaction of movement in the spot and futures market. To explain movement in the futures market entails the construction of an expectation model. Because such a model is difficult to construct with available data, an alternative approach to explaining net into-storage movement was adopted in the model for eggs.

Relationship of Storage Movement to Previous Speculative Activity

In order for springtime storers of eggs to protect their purchases in the cash market by a hedging transaction, a body of people must be willing to take a long position in the futures market. Without a sufficiently large group of speculators to provide a liquid market on which eggs can be hedged, storers of eggs are exposed to large risks from price fluctuations. As the "basis" changes, affording storers the incentive to put more or less eggs into storage than normal, the amount of hedges to be placed to cover the cash market transactions changes concurrently. Consequently, the number of speculative long commitments needed to support the hedges also changes. Therefore, we would expect a positive relationship between net into-storage movement and the number of speculative long commitments. Figure 17 shows the existence of a rough association between changes in the January–June net into-storage movement and changes in the number of speculative long commitments. The data on commitments separate small traders (any trader whose position in one futures contract is less than 25 carlots of eggs) only by their positions as long or short and do not show whether the commitment is speculative (including spreading or straddling) or hedging. In the into-storage period, however, it seems reasonable to assume that the greater number of small traders who are long on futures hold a speculative position (table 47).

The incentives that prompt traders to hold a speculative position are probably innumerable, but as important factors that affect the behavior of traders we might cite their previous experience in the egg futures market, as well as institutional factors such as interest rates, the tax structure on capital gains, margin requirements, movements and activity in other commodity markets, and the general economic condition of the economy. In reference to previous experience in the egg futures market, we hypothesize that if the speculative operation in a particular year is profitable, traders will

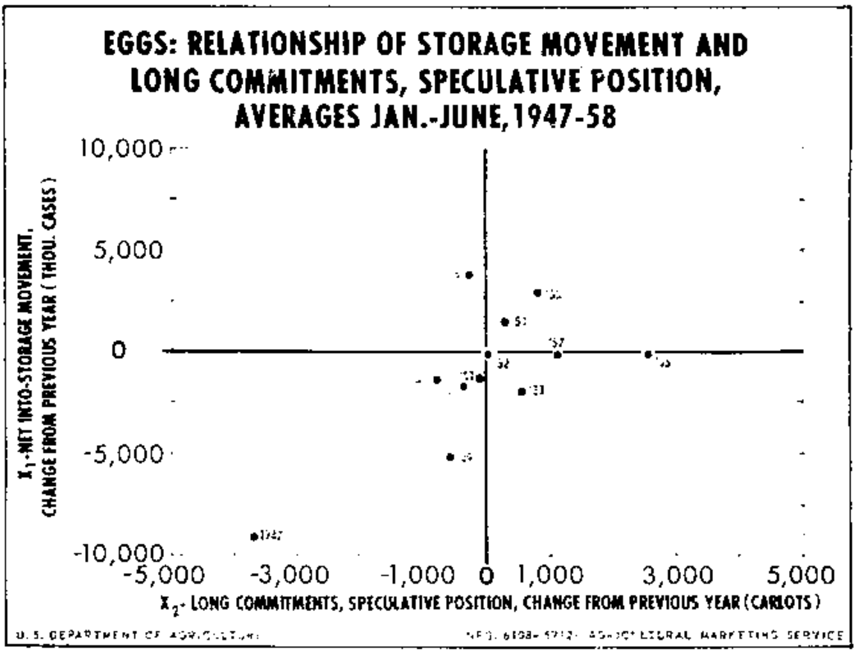

FIGURE 17.—A rough association exists between changes in the January-June net into-storage movement and changes in the number of speculative long commitments. As the "basis" changes, affording storers the incentive to put more or less eggs into storage than normal, the amount of hedges to be placed to cover the cash market transactions changes concurrently. Consequently, the number of speculative long commitments needed to support the hedges also changes.

TABLE 47.—*Eggs: Net into-storage movement and long commitments, average monthly number of futures contracts outstanding, by type of trader, January–June, 1946–58* [1]

Year	Net into-storage movement [2]	Futures contracts outstanding, long commitments		
		Large traders, speculative	Small traders [3]	Total
	1,000 cases	*Carlots*	*Carlots*	*Carlots*
1946	14, 092	1, 558	4, 399	5, 957
1947	5, 855	446	1, 815	2, 261
1948	9, 653	347	1, 675	2, 022
1949	4, 446	437	1, 020	1, 457
1950	7, 416	581	1, 699	2, 280
1951	6, 124	686	1, 520	2, 206
1952	6, 011	361	1, 880	2, 241
1953	4, 002	798	2, 004	2, 802
1954	5, 460	824	2, 305	3, 129
1955	5, 430	1, 686	3, 995	5, 681
1956	4, 035	1, 427	3, 491	4, 918
1957	3, 906	434	5, 639	6, 073
1958	2, 180	1, 955	3, 768	5, 723

[1] Average of the number of contracts outstanding on the 15th and 30th of each month on the Chicago and New York Mercantile Exchange.

[2] Shell, frozen, and dried eggs, shell equivalent. Excludes Government holdings.

[3] Includes hedging as well as speculative positions.

Derived from (*56*).

show a greater willingness to enter the market the following spring, while unfavorable experiences lead to a lesser willingness. This hypothesis is not confirmed by data for the post-World War II years (fig. 18); however, the apparent lack of relationship could be the result of failure to include the other variables, in addition to previous speculative outcomes in the futures market, that influence the number of speculative long positions taken. Assuming this premise, we can, by substitution, form a relationship between the net into-storage movement and the previous year's profit or loss on a speculative long contract (figure 19). This relationship, with the addition of a shift variable to allow for the lessening seasonality of production, comprises equation (17) of the model of the egg economy. The direct substitution of the variable F into equation (17) ignores some statistical considerations in fitting (see Appendix, p. 150), but they appear to be justified because of the lack of data and in order to simplify the computations involved. The results obtained by statistically fitting equation (17) of the egg model gave coefficients consistent with economic expectations. Based on those coefficients which differed significantly from zero at the 5-percent level of probability, a 1-cent change from year-to-year in the gain or loss from a speculative long position on the previous year's futures

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contract would be associated with about a 1.2 egg, per person, change in the same direction in the net into-storage movement of shell, frozen, and dried egg, after allowing for the shift in seasonality of production. Associated with this change would be a standard error of about 0.2 eggs.

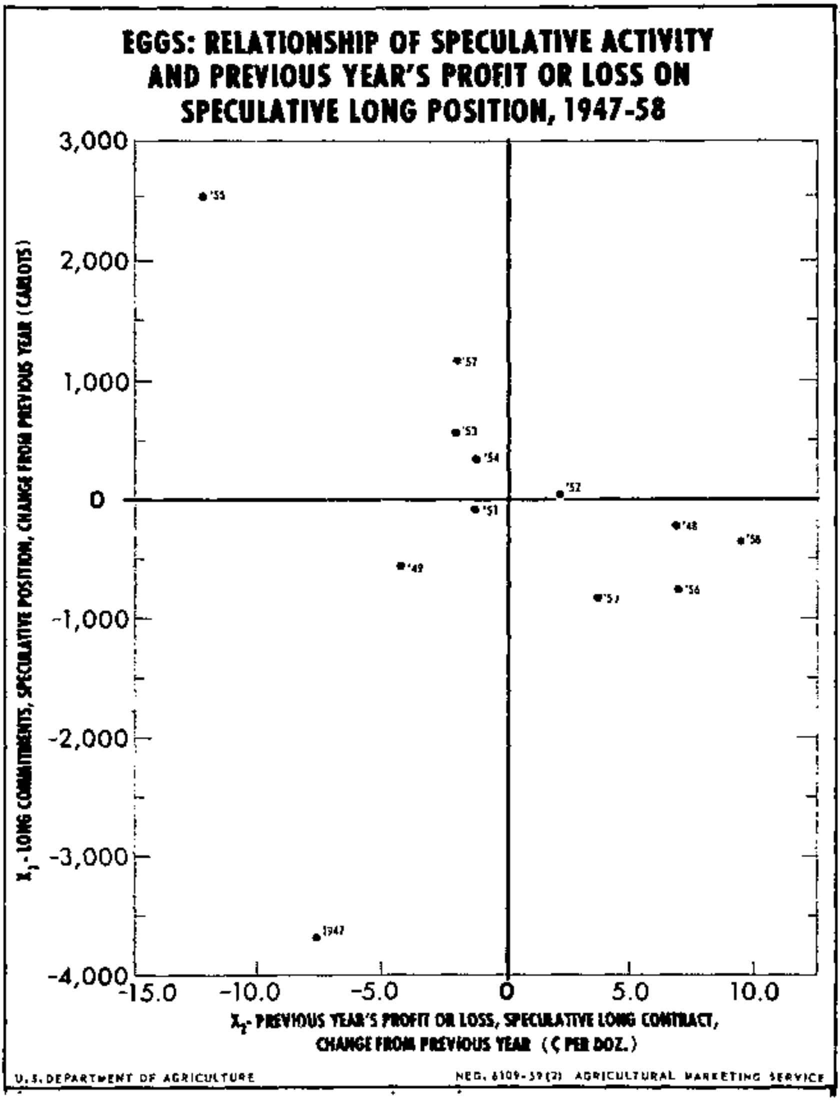

FIGURE 18.—Available data do not reveal a relationship between year-to-year changes in speculative activity and year-to-year changes in the previous year's profit or loss on speculative long positions. The lack of apparent relationship could be the result of failure to include the other variables that influence the number of speculative long positions taken.

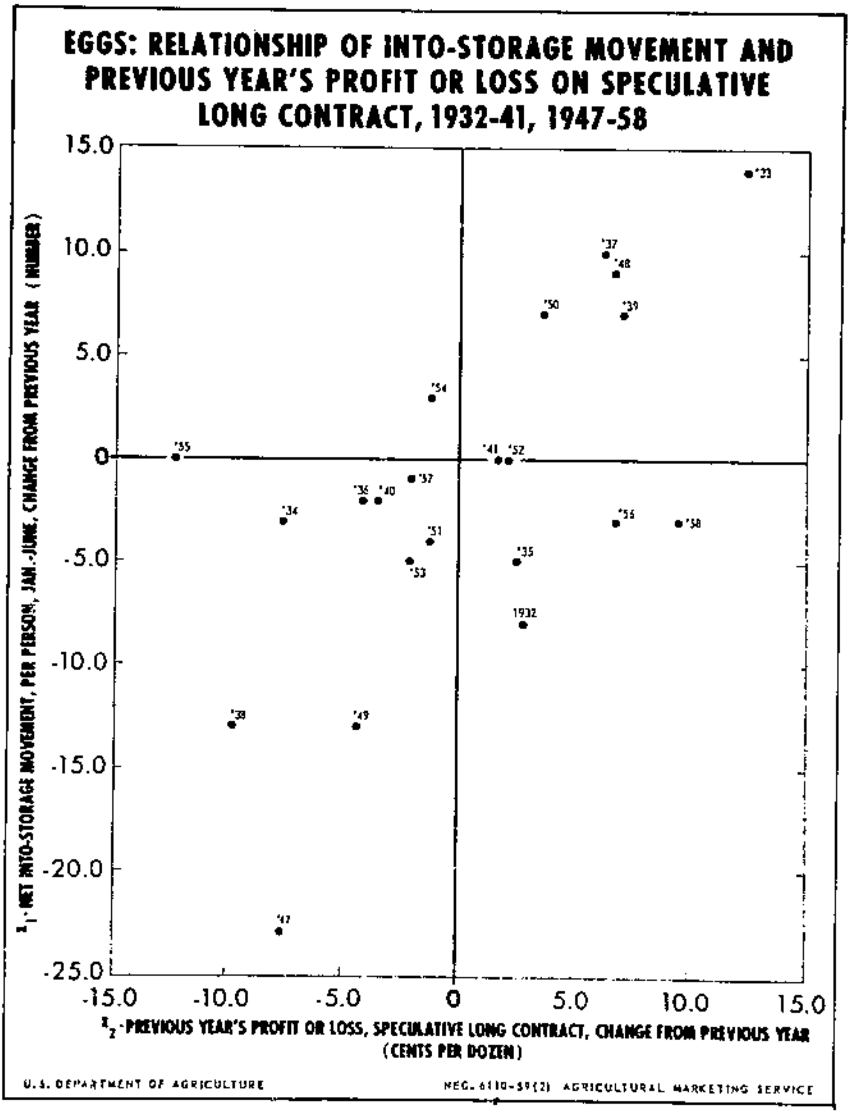

FIGURE 10.—If traders have made more, or lost less, on the previous year's speculative long contract than they did the year before, net into-storage movement for January-June, per person, generally increases from the previous year.

Government Programs

Since the early 1930's, several Government programs have involved agricultural commodities. These programs can be broadly classified as:[40]

(1) Commodity Credit Corporation price supports through which the Department of Agriculture provides nonrecourse price support loans to eligible farmers, thus providing an outlet (not an additional use) for any quantity of a commodity which meets eligibility requirements, and at certain specified dollars-and-cents prices which remain unchanged throughout the announced price support period.

(2) Section 32 surplus removal under which the Department attempts to give farmers price assistance by widening markets for limited quantities of agricultural commodities which are temporarily in surplus supply.

(3) Supply programs such as Lend-Lease, UNRRA, ECA, and their successor agencies through which supplies of agricultural commodities have been procured for other Government agencies, foreign governments, and international relief organizations such as the International Children's Emergency Fund and the Red Cross.

(4) Operations under Section 6 of the National School Lunch Act which authorizes the Secretary of Agriculture to use a portion of the annual school lunch appropriation to purchase food commodities for distribution to participating schools in accordance with need, as determined by local school authorities.

The quantities of shell, frozen, and dried eggs purchased by the Department of Agriculture under these programs are listed in table 48. Purchases for distrbution to the School Lunch Program are included under price support and surplus removal programs. Only during World War II did government purchases of eggs constitute an appreciable share of annual farm production. The effect of a purchase program upon the price and supply of eggs, however, should be assessed in relation to production and prices during the period eggs are being removed from market channels, and not necessarily in relation to annual totals and averages. In the following sections brief descriptions of the government programs that have affected eggs are given.[41]

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[40] For a detailed account, see Henderson (*20*).

[41] The sections developed below are based mainly on unpublished records of the History Section, Agricultural Economics Division, Agricultural Marketing Service; Benedict and Stine (*1*); Levin (*31*); and (*49*).

Pre-World War II Programs

The first purchases of eggs by the Government after World War I were in 1933. Before 1933 the Federal Farm Board, established under the Agricultural Marketing Act of 1929, supplied egg cooperatives with funds to strengthen and enlarge their operations. The board in its operations stressed the development of nationwide farmer-owned cooperative marketing systems to which it made loans. With the borrowed funds the cooperatives attempted in various ways to promote orderly marketing and stabilize prices. In May 1933, the board was abolished and its assets transferred to the Farm Credit Administration.

In October 1933, the Federal Surplus Relief Corporation was chartered under the laws of Delaware as a nonprofit corporation without capital, under the direction of the Federal Emergency Relief Administration. In December 1933 and January 1934 the Department of Agriculture was authorized to purchase 314,000 cases of 1933 storage eggs and, in addition, State emergency relief administrations bought 313,000 cases for which they were reimbursed by the Federal Surplus Relief Corporation.

On November 18, 1935, the charter of the Federal Surplus Relief Corporation was amended to change the name of the corporation to the Federal Surplus Commodities Corporation and to transfer its direction from the Federal Emergency Relief Administration to the Department of Agriculture. Purchases of shell eggs, as shown in table 48, were made by the Federal Surplus Commodities Corporation in each year during 1936–40 with funds obtained under Section 32 authorization. Congress, in Section 32 of an act to amend the Agricultural Adjustment Act as amended, approved August 24, 1935, made available to the Secretary of Agriculture 30 percent of the annual customs receipts for use in encouraging the exportation and domestic consumption of Agricultural Commodities.

In addition to purchases of eggs for direct distribution, Section 32 funds were used for eggs under the Food Stamp Plan from 1939 through 1943. The food stamp program was carried on by the Department of Agriculture under authority of clause (2) of Section 32. Henderson (*20*, p. 66) describes the plan as operating as follows: "Persons certified by local welfare agencies as eligible for relief bought minimum quantities of orange-colored stamps, good in exchange for any foodstuff at retail stores, and received free a specified number of blue stamps, good in exchange only for abundant foods designated by the Department of Agriculture. Purchases of orange stamps insured that normal expenditures for food would be continued and that foods obtained with free blue stamps would represent a net addition to food consumption." The quantity of eggs used in each fiscal year under the Food Stamp Plan was: 1939, 5,000 cases; 1940, 407,000 cases; 1941, 1,548,000 cases; 1942, 1,975,000 cases; and 1943, 728,000 cases; in 1941–43 about 1 percent of annual farm production of eggs.

TABLE 48.—*Eggs: Purchases by United States Department of Agriculture under foreign supply, price support, and surplus removal programs, 1933–58* [1]

Year	Supply programs [2]			Price support and surplus removal programs [2]			Total purchases				
								Shell equivalent [3]		Shell, frozen, and dried [3]	
	Shell	Frozen	Dried	Shell	Frozen	Dried	Shell	Frozen	Dried	Total	Percentage of farm egg production
	1,000 cases	*1,000 pounds*	*1,000 pounds*	*1,000 cases*	*1,000 pounds*	*1,000 pounds*	*1,000 cases*	*1,000 cases*	*1,000 cases*	*1,000 cases*	*Percent*
1933				[4] 627			627			627	0. 6
1934											
1935											
1936				31			31			31	(5)
1937				501			501			501	. 5
1938				61			61			61	. 1
1939				268			268			268	. 2
1940				2, 317			2, 317			2, 317	2. 1
1941	1, 549	65, 558	35, 249	206			1, 755	1, 748	3, 480	6, 983	6. 0
1942			208, 266	502			502		20, 559	21, 061	15. 6
1943	219		208, 777	19			238		20, 610	20, 848	13. 8
1944			275, 444	5, 593			5, 593		27, 191	32, 784	20. 2
1945			35, 931	5			5		3, 547	3, 552	2. 3
1946		12, 015	97, 407		4, 223	100		433	9, 626	10, 059	6. 5
1947			29, 470		61, 320	46, 408		1, 635	7, 490	9, 125	5. 9
1948						27, 987			2, 763	2, 763	1. 8
1949						69, 263			6, 837	6, 837	4. 4

1950						82,424			8,137	8,137	5.0
1951											
1952				227			227			227	.1
1953											
1954											
1955											
1956				584			584			584	.3
1957				314		4,748	314		468	782	.5
1958			[6] 4,162						411	411	.2

[1] From The Poultry and Egg Situation, April 1950 (*49*, p. 13) and from records of the United States Agricultural Marketing Service.

[2] The distinction between purchases for supply programs and for price support is based on justification in the docket of the Commodity Credit Corporation (or predecessor organization which authorized the specific purchases).

[3] Converted to shell equivalent on the basis of 37.5 pounds of frozen egg obtained per case of shell eggs and 1.0 pound of dried egg obtained per 2.9615 dozens of shell egg.

[4] Includes 313 thousand cases of shell eggs purchased by State emergency relief administrations for which they were reimbursed by the Federal Surplus Relief Corporation.

[5] Less than 0.05 percent.

[6] Purchased under section 6 of the National School Lunch Act.

World War II Period

During 1941–46 purchases of eggs by the Department of Agriculture were principally for shipment abroad under provisions of the Lend-Lease Act approved by Congress on March 11, 1941. The largest quantity purchased for supply programs was in 1944—275 million pounds of dried egg (27 million cases, shell egg equivalent) or about 17 percent of farm egg production. Purchases for the supply programs were almost entirely of dried egg because this product is more compact and less perishable than shell and frozen egg, important considerations in time of war.

In order to stimulate an expansion in production so that ample supplies could be secured for the United States and its allies, the Secretary of Agriculture announced on April 3, 1941, a price support program for hogs, dairy products, chickens, and eggs at levels remunerative to producers; 22 cents per dozen for eggs, Chicago basis, with appropriate seasonal and other adjustments.[42] The action was the first overt price-support for eggs, and was promised through June 1943. The support levels announced in April 1941 were supplemented in July 1941 by those of the Steagall Amendment.[43] This amendment to an act to extend the life of the Commodity Credit Corporation directed the Department to support the price at 85 percent of parity for those nonbasic commodities for which the Secretary requested that production be increased. On October 2, 1942 the support provision was raised from 85 to 90 percent of parity, and the duration of supports was set at 2 years, beginning with the January 1 following the termination of hostilities.[44] With the exception of 1943 and 1944, when support levels were set at 98 and 95 percent of parity, respectively, support levels were set at 90 percent of parity until the provisions of the Steagall Amendment expired in 1949.

With price-support levels mandatory through 1949, 205 million pounds of frozen and dried egg (15.8 million cases, shell equivalent) were purchased for price support and surplus removal from 1947, when the supply programs terminated, to 1949.

Post-Steagall Operations

For 1950, the first year following the end of the Steagall guarantee, the Department of Agriculture elected to support egg prices at 75 percent of parity.[45] The Agricultural Act of 1949[46] had empowered the Secretary of Agriculture to support the price of eggs at any level from zero to 90 percent of parity. With a support level of 75 percent of parity, 82 million pounds of dried egg (8.1 million cases, shell equivalent) were purchased.

Support levels for eggs have not been announced since 1950. In April 1952, however, the Department announced a program to purchase with Section 32 funds up to 1½ million cases of shell eggs for distribution in the fall to nonprofit school lunch programs and

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[42] United States Department of Agriculture, Press release, 1922–41, April 3, 1941.

[43] Public Law 147—77th Congress, July 1, 1941, 55 Stat., 498.

[44] Public Law 729—77th Congress, October 2, 1942, 56 Stat., 765.

[45] United States Department of Agriculture, Press release, 2750–49, December 21, 1949.

[46] Public Law 439—81st Congress, October 31, 1949, 63 Stat., 1051.

other eligible outlets.[47] Under this program 226,000 cases were purchased.

Section 32 programs do not attempt to support the price of a commodity at any specified level of price nor does the Government stand ready to take the entire quantity offered. Section 32 purchases for surplus removal are made on a competitive bid basis with a price differential, approximating the historical situation, for location. The determination of the prices to be paid is dependent on the objectives of the program on one hand and the relationship of supply to demand for the commodity on the other. The limiting factor in all cases is the extent of outlets available.

In the fall of 1956, low prices to producers prompted the Secretary of Agriculture to announce that the Department was prepared to purchase shell eggs if such action seemed necessary to stabilize egg prices.[48] On September 18 the Department offered to purchase medium-size shell eggs for distribution for school lunch and institutional uses; Section 32 funds were to be used.[49] Purchases totaling 898,000 cases were made until the program was shifted in March 1957 to the procurement of dried egg. The Department statement said that shell egg purchases were being discontinued because sufficient quantities had been purchased to meet requirements of school lunch programs for the remainder of the school year.[50] However, because the need still existed to help stabilize producer prices, the Department offered to buy dried egg, which can be stored for a considerable period of time, for distribution for school lunch use. At the termination of the dried egg purchase program in June 1957,[51] 4.7 million pounds of dried egg (468,000 cases, shell equivalent) had been bought.

In the fall of 1958, the United States Department of Agriculture commenced purchases of dried eggs under Section 6 of the National School Lunch Act. This was the first time this authority was used to purchase eggs. Funds for these purchases were made available by transfer from Section 32 funds to Section 6 for the fiscal year ending June 30, 1959 under provision of the Department of Agriculture and Farm Credit Administration Appropriation Act, 1959. Section 6 funds are used to purchase foods, generally in abundant supply, for the National School Lunch Program. These purchases help schools to serve meals which better meet the nutritional needs of the children and which, because of the economy of large volume purchases, may be provided at a lesser cost to the schools.

Effect of Programs

The existence of purchase programs for a commodity can be assumed to lead to a price higher than would prevail without a program, but the magnitude of the price effect is difficult to assess

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[47] United States Department of Agriculture, Press release, 777-52, April 9, 1952.

[48] United States Department of Agriculture, Press release, 2642-56, September 7, 1956.

[49] United States Department of Agriculture, Press release, 2776-56, September 18, 1956.

[50] United States Department of Agriculture, Press release, 905-57, March 20, 1957.

[51] United States Department of Agriculture, Press release, 1942-57, June 19, 1957.

and depends, in part, on the type of program used. Evaluation of the price effect of a purchase program is further complicated by the impact of the program upon the supply response of an industry.

For the egg industry, the time of the year at which purchases are made influences the supply response of producers. Price support purchases made in the spring months when the greatest part of replacement chicks are started would have a greater affect upon production than purchases made at other times of the year. As shown in previous sections, the number of replacement pullets raised in a year is related to the egg-feed ratio prevailing in the first half of the year. If purchase operations raise egg prices in the spring, farmers respond by raising more replacement pullets, and thereby increase future production. If the purchase operation is carried out in the fall, the out-of-season hatch is probably affected to some degree, as well as culling, thereby increasing egg production, but to a lesser extent than spring purchase operations.

It would also seem that the type of purchase program used affects supply response. A purchase program coupled with a specified support price which remains unchanged throughout the announced price support period would have a different effect upon production than Section 32 or Section 6 programs which are carried out under a competitive bid basis. With an established support price under which future egg production could be marketed, farmers would frame their price expectations, and thereby their supply response, differently than in the absence of an established support price.

The establishment of mandatory price supports for eggs under the 1941 Steagall Amendment was done with the purpose of protecting prices to farmers who were enlarging production for anticipated war needs. Egg price support announcements gave farmers expectations of higher egg prices than would have prevailed in the absence of supports. Even though the timing of support announcements did not coincide with the seasons when farmers were making their production commitments, the expectation of the support price probably affected the out-of-season hatch to some degree, as well as culling, thereby increasing egg production. In addition, price support purchases, with their upward push on prices, were concentrated in the spring months. Egg prices were strengthened in the spring. Farmers responded by raising more replacement pullets. The subsequently increased production, in turn, led to the necessity of purchasing surplus eggs in order to achieve support levels. The effect of price support announcements and purchases, therefore, was to increase egg production over what it otherwise would have been, and to make the system somewhat self-perpetuating.

The purchase programs carried out with Section 32 funds in 1952 and the fall of 1956, and with Section 6 funds in the fall of 1958, probably had a lesser effect upon prices and production than purchase operations under the 1941 Steagall Amendment. The chief reasons would be the timing of purchases, mainly in the fall months, and the using of a competitive bid basis to determine purchase prices, rather than an announced support price as under the Steagall Amendment. In addition, as table 48 shows, purchases under these programs were less than one-half of one-percent of annual farm egg production, as compared with purchases ranging up to 20 percent of annual production under the Steagall Amendment.

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Appendix

Fitting the Simultaneous Model

The method by which individual equations in a system of simultaneous equations are fitted is determined by criteria of identification. Klein (*27*, p. 99) says "in studying the identifiability of any equation, we shall find either that the number of restrictions is more than enough, just enough, or less than enough to identify that equation. We call these cases overidentified, just-identified, or underidentified, respectively." Overidentified equations theoretically can be fitted by either the full information or the limited information method, although computations for the full information approach in general are "formidable." In the case of just-identified equations, a reduced form transformation of a least squares solution can be used. For underidentified equations, however, statistical estimation is not possible. A necessary, but not sufficient, condition for a just-identified equation is that the total number of endogenous and predetermined variables in the system less the number of variables in the particular equation equal the number of equations in the system less one. If this number of variables is greater than the number of equations less one, the equation is overidentified. All of the equations in both model I and model II of the system that need to be fitted by statistical means are overidentified; they were fitted by the method of limited information. Equations (9), (10), (11), and (18), (p. 64) were not fitted in either model I (p. 71) or model II (p. 75) because they are identities which involve no statistical coefficients or random error terms.

Linearized equations.—Because the equations in the egg model are stated in linear terms, the endogenous variables in the model used in nonlinear combinations $\left(\text{for example, } \frac{Q_E}{H}, Q_A \cdot L_F, \frac{P_F}{P_G}, \text{etc.}\right)$ were transformed into linear approximations by use of formulas given in Klein (*27*, pp. 120-121).[53] The linear approximations are then substituted for the original variables. Combinations of variables that are assumed to be entirely predetermined, however, are treated as a single composite without linearization as, within the analysis, they are assumed to be given.

The formulas given by Klein are:

$$XY = \overline{Y}X + \overline{X}Y - \overline{X}\,\overline{Y}$$

$$X/Y = \overline{X}/\overline{Y} + X/\overline{Y} - (\overline{X}/\overline{Y}^2)Y$$

where $\overline{X}$ and $\overline{Y}$ are the means of X and Y respectively. If either the product or the quotient is multiplied by a constant, then each term in the transformation is multiplied by the constant.

[53] Friedman and Foote (*17*, p. 66) point out that Chernoff and Rubin (*7*, pp. 210-212) suggest treating nonlinear combinations that involve endogenous variables as though each were a single variable, rather than using a transformation. Friedman and Foote, however, believe that the Klein approach used in this bulletin is to be preferred.

Rewriting the structural equations (p. 64) in linearized form, we obtain:

$$\left[\left(\frac{\overline{Q}_E}{\overline{H}}+\frac{1}{\overline{H}}Q_E\right)-\frac{\overline{Q}_E}{\overline{H}^2}H\right]=a_1+b_{12}P_R+c_{11}\frac{I}{H}+c_{12}P_M$$
$$+c_{13}P_C+c_{14}P_B+c_{15}P_T+c_{16}P_O+u_1 \quad (8.1)$$

$$Q_F=(\overline{Q}_A\cdot L_F-\overline{Q}_A\cdot\overline{L}_F)+(\overline{L}_F\cdot Q_A) \quad (9.1)$$

$$Q_E=Q_F+A \quad (10)$$

$$L_F=L_J+C_F-M-L_C \quad (11)$$

$$C_F=a_5+b_{52}\left[\left(\frac{\overline{P}'_F}{\overline{P}'_G}+\frac{1}{\overline{P}_G}P'_F\right)-\frac{\overline{P}'_F}{\overline{P}'^2_G}P'_G\right]+u_5 \quad (12.1)$$

$$L_C=a_6+b_{62}\left[\left(\frac{\overline{P}_F}{\overline{P}_G}+\frac{1}{\overline{P}_G}P_F\right)-\frac{\overline{P}_F}{\overline{P}_G^2}P_G\right]+u_6 \quad (13.1)$$

$$P_F=a_7+b_{72}P_R+b_{73}\left[\left(\frac{\overline{Q}_E}{\overline{H}}+\frac{1}{\overline{H}}Q_E\right)-\frac{\overline{Q}_E}{\overline{H}^2}H\right]+c_{71}W+u_7 \quad (14.1)$$

$$P'_F=a_8+b_{82}P'_R+b_{83}\left[\left(\frac{\overline{Q}'_E}{\overline{H}}+\frac{I}{\overline{H}}Q'_E\right)-\frac{\overline{Q}'_E}{\overline{H}^2}H\right]+c_{81}W+u_8 \quad (15.1)$$

$$P'_R=a_9+b_{92}\left[\left(\frac{\overline{Q}'_E}{\overline{H}}+\frac{1}{\overline{H}}Q'_E\right)-\frac{\overline{Q}'_E}{\overline{H}^2}H\right]+b_{93}\left[\left(\frac{\overline{S}'}{\overline{H}}+\frac{1}{\overline{H}}S'\right)-\frac{\overline{S}'}{\overline{H}^2}H\right]$$
$$+c_{91}\frac{I}{H}+c_{92}P'_M+c_{93}P'_C+c_{94}P'_B+c_{95}P'_T+c_{96}P'_O+u_9 \quad (16.1)$$

$$\left[\left(\frac{\overline{S}'}{\overline{H}}+\frac{1}{\overline{H}}S'\right)-\frac{\overline{S}'}{\overline{H}^2}H\right]=a_{10}+b_{102}$$
$$\left[\left(\frac{\overline{Q}'_F}{\overline{Q}_F}-\frac{\overline{Q}'_F}{\overline{Q}_F^2}Q_F\right)+\frac{1}{\overline{Q}_F}Q'_F\right]+c_{101}F+u_{10} \quad (17.1)$$

$$Q'_E=Q'_F-S' \quad (18)$$

Variables used in the M_{zz} and M_{zy} matrices of Model I.—The M_{zz} matrix usually contains all the predetermined variables in the system. In some cases, however, the number of predetermined variables in the system exceeds the number of available observations and modifications must be made. To prevent obtaining indeterminate results, we must have at least one more year of data than there are predetermined variables in the M_{zz} matrix.

In model I of the egg economy, there are 21 predetermined variables and 18 observations for each variable. At least four predetermined variables, therefore, must be omitted. For the reasons given in subsequent paragraphs, the predetermined variables P'_M, P'_C, P'_B, P'_T, P'_O, and M are excluded from the matrix of predetermined variables M_{zz}, leaving 15 variables in this matrix.

Although the five predetermined variables that relate to prices of competing or complementary goods during the first half of the year are excluded from the matrix of predetermined variables for the entire system, they are included when equation (16.1) is fitted individually. The method of limited information allows some predetermined variables to be dropped from the matrix of predetermined variables for the entire system, provided sufficient predetermined variables are used to provide identification, although the estimates of the coefficients are less efficient in a statistical sense than if all the predetermined variables in the system are used (*21*, pp. 69–70). The loss of efficiency, in this case, is assumed to be small because P'_M, P'_C, P'_B, P'_T, and P'_O, are highly correlated with their respective annual averages, P_M, P_C, P_B, P_T, and P_O.

The predetermined variable M is omitted from the M_{zz} matrix because representative data are not available. Experience in fitting models of this sort has indicated that improved results are obtained when variables that represent poorly the economic factor that should be in the structural model are omitted from the M_{zz} matrix. Such variables can be used in connection with fitting a particular equation but, in this case, the omitted variable is in an identity so that no statistical fitting is involved.

The linearized values of each of the predetermined variables used in combination with an endogenous variable in the structural equations are used only once in the M_{zz} matrix. For example, Q_E/H, when transformed into linearized form, is:

$$\left[\left(\frac{\overline{Q}_E}{\overline{H}}+\frac{1}{\overline{H}}Q_E\right)-\frac{\overline{Q}_E}{\overline{H}^2}H\right]$$

Similar last terms are involved for Q'_E/H and S'/H. As the respective last terms in each are perfectly correlated, only one, namely $[-(\overline{Q}_E/\overline{H}^2)H]$, is used in the M_{zz} matrix.

In computing the M_{zy} matrix, however, the entire linearized value of the combination of endogenous and predetermined variables is used. For example, for Q'_E/H, the following linearized form is included in the M_{zy} matrix:

$$\left[\left(\frac{\overline{Q}'_E}{\overline{H}}+\frac{1}{\overline{H}}Q'_E\right)-\frac{\overline{Q}'_E}{\overline{H}^2}H\right]$$

and for S'/H, we include:

$$\left[\left(\frac{\overline{S}'}{\overline{H}}+\frac{1}{\overline{H}}S'\right)-\frac{\overline{S}'}{\overline{H}^2}H\right]$$

This is done because a single structural coefficient applies to the entire combination.

The next step in the fitting process is to assign numbered Y's and Z's to the linearized forms of the variables, using Z's if they are predetermined and Y's if they are endogenous. In the outline below, the variables are designated as being included in either the M_{zz} matrix or the M_{zy} matrix, or as being excluded from the M_{zz} matrix but used in fitting the individual equations. The Y's included in the identities are omitted from the M_{zy} matrix as these equations need not be statistically fitted.

Model I, variables used in —

M_{zz} matrix		M_{zy} matrix	
$-\frac{\bar{Q}_E}{\bar{H}^2}H$	$=Z_1$	$\left[\frac{\bar{Q}_E}{\bar{H}}+\frac{1}{\bar{H}}Q_E-\frac{\bar{Q}_E}{\bar{H}^2}H\right]$	$=Y_1$
I/H	$=Z_2$	P_R	$=Y_2$
P_M	$=Z_3$	C_F	$=Y_3$
P_C	$=Z_4$	$\left[\frac{\bar{P}'_F}{\bar{P}'_G}+\frac{1}{\bar{P}'_G}P_F-\frac{\bar{P}'_F}{\bar{P}'^2_G}P'_G\right]$	$=Y_4$
P_B	$=Z_5$		
P_T	$=Z_6$	L_C	$=Y_5$
P_O	$=Z_7$		
$\bar{L}_F Q_A$	$=Z_8$	$\left[\frac{\bar{P}_F}{\bar{P}_G}+\frac{1}{\bar{P}_G}P_F-\frac{\bar{P}_F}{\bar{P}_G^2}P_G\right]$	$=Y_6$
A	$=Z_9$		
L_J	$=Z_{10}$	P_F	$=Y_7$
		P'_R	$=Y_8$
$-\frac{\bar{P}'_F}{\bar{P}'^2_G}P'_G$	$=Z_{11}$	$\left[\frac{\bar{Q}'_E}{\bar{H}}+\frac{I}{\bar{H}}Q'_E-\frac{\bar{Q}'_E}{\bar{H}^2}H\right]$	$=Y_9$
$-\frac{\bar{P}_F}{\bar{P}_G^2}P_G$	$=Z_{12}$	$\frac{\bar{S}'}{\bar{H}}+\frac{1}{\bar{H}}S'-\frac{\bar{S}'}{\bar{H}^2}H$	$=Y_{10}$
$\frac{1}{(\bar{Q}_E-A)}Q'_F$	$=Z_{13}$	P'_F	$=Y_{11}$
F	$=Z_{14}$	$\frac{\bar{Q}'_F}{\bar{Q}_F}-\frac{\bar{Q}'_F}{\bar{Q}_F^2}Q_F+\frac{1}{\bar{Q}_F}Q'_F$	$=Y_{12}$
W	$=Z_{15}$		

Predetermined variables excluded from M_{zz} matrix but used in individual equations

$P'_M=Z_{16}$
$P'_C=Z_{17}$
$P'_B=Z_{18}$
$P'_T=Z_{19}$
$P'_O=Z_{20}$

Variables used in fitting the individual equations.—The variables used in fitting by the method of limited information each of the seven equations of model I are listed below by their structural symbols. The endogenous variables are classified under Y^* and the predetermined variables under Z^*. The corresponding Y's and Z's are indicated in parentheses. The equation numbers correspond with model I, page 71.

Model I

Equation	Y^*	Z^*
(19)	Q_E/H, P_R (Y_1, Y_2)	I/H, P_M, P_C, P_B, P_T, P_O (Z_2, Z_3, Z_4, Z_5, Z_6, Z_7)
(23)	C_F, P'_F/P'_G (Y_3, Y_4)	
(24)	L_C, P_F/P_G (Y_5, Y_6)	
(25)	P_F, P_R, $\frac{Q_E}{H}$ (Y_7, Y_2, Y_1)	W (Z_{15})
(26)	P'_F, P'_R, $\frac{Q'_E}{H}$ (Y_{11}, Y_8, Y_9)	W (Z_{15})
(27)	P'_R, Q'_E/H, S'/H (Y_8, Y_9, Y_{10})	I/H, P'_M, P'_C, P'_B, P'_T, P'_O (Z_2, Z_{16}, Z_{17}, Z_{18}, Z_{19}, Z_{20})
(28)	S'/H, Q'_F/Q_F (Y_{10}, Y_{12})	F (Z_{14})

Deriving Reduced Form Equations

The sets of equations on pages 147 and 148 were derived by transposing each equation in model I and model II so that endogenous terms were on the left side of the equality sign and predetermined and constant terms in each equation were on the right. As an example, the linearized equation (12.1) (p. 143), expressed in changes from year-to-year (Δ's), is transposed below:

$$\Delta C_F - b_{52}\Delta\frac{P'_F}{\overline{P}'_G} = \left[a_5 + b_{52}\Delta\frac{\overline{P}'_F}{\overline{P}'_G}\right] - b_{52}\Delta\frac{\overline{P}'_F}{\overline{P}'^2_G}P'_G \qquad (12.2)$$

or

$$\Delta C_F - b_{52}\Delta\frac{P'_F}{\overline{P}'_G} = A_5$$

where A_5 equals the sum of the values on the right of the equality sign in (12.2).

Substituting the results from the fitted equations of model II (p. 75) into the linearized form of the equations, transposing, and multiplying coefficients, gives:[54]

Model II

$$7.163323\Delta Q_E + 2.966792\Delta P_R = -6.825033 + 2{,}400\Delta H + 0.015400\Delta\frac{I}{H} + 3.795735\Delta P_O \qquad (41)$$

$$\Delta Q_F - 148\Delta L_F = 309.2\Delta Q_A \qquad (42)$$

$$\Delta Q_E - \Delta Q_F = \Delta A \qquad (43)$$

$$\Delta L_F - \Delta C_F + \Delta L_C = \Delta L_J - \Delta M \qquad (44)$$

$$\Delta C_F - 5.971186\Delta P'_F = -2.639736 - 61.479308\Delta P'_G \qquad (45)$$

$$\Delta L_C + 5.231402\Delta P_F = -9.203071 + 58.445201\Delta P_G \qquad (46)$$

$$\Delta P_F - .825616\Delta P_R = 0.012279 - 0.007444\Delta W \qquad (47)$$

$$\Delta P'_F - 0.591891\Delta P'_R = -0.205350 + 0.120745\Delta W \qquad (48)$$

$$\Delta P'_R + 2.807865\Delta Q'_E + 2.545415\Delta S' = -2.271498 + 559.320000\Delta H + 0.020797\Delta\frac{I}{H} + 0.513049\Delta P'_O \qquad (49)$$

$$7.163323\Delta S' + 2.461849\Delta Q_F = -0.519296 + 140\Delta H + 0.041079\Delta Q'_F + 1.211173\Delta F \qquad (50)$$

$$\Delta Q'_E + \Delta S' = \Delta Q'_F \qquad (51)$$

[54] In computing ΔH, the year-to-year changes in the population series listed in table 49 were multiplied by 0.001.

The above equations constitute a new set of 11 simultaneous equations in which the sum of the variables on the right side of the equality sign can be thought of as a constant which varies for each year with the values of the predetermined variables. A new set of equations is derived for model I by the same procedure. By inverting the matrix of coefficients of the variables on the left hand side of the equations, and multiplying the inverse matrix by the vector which contains the constants for a specified year, estimates are obtained of the 11 endogenous variables included in the structural model. That is, write:

$$CY=A \tag{52}$$

where:

C = matrix of coefficients of endogenous variables
Y = vector of endogenous variables
A = vector of predetermined values

then:

$$Y=C^{-1}A \tag{53}$$

which, when written in the form of a system of linear equations gives the following series of reduced form equations for model I and model II:

Model I—Reduced-Form Equations

$$\Delta Q_E=0.000215\Delta A_1+0.000004\Delta A_2+0.997221\Delta A_3+0.000654\Delta A_4 +0.000654\Delta A_5-0.000654\Delta A_6+0.003828\Delta A_7+0.003524\Delta A_8 -0.007151\Delta A_9-0.003844\Delta A_{10}+0.145336\Delta A_{11} \tag{54}$$

$$\Delta Q_F=0.000215\Delta A_1+0.000004\Delta A_2-0.002779\Delta A_3+0.000654\Delta A_4 +0.000654\Delta A_5-0.000654\Delta A_6+0.003828\Delta A_7+0.003524\Delta A_8 -0.007151\Delta A_9-0.003844\Delta A_{10}+0.145336\Delta A_{11} \tag{55}$$

$$\Delta P_R=0.068008\Delta A_1-0.000002\Delta A_2-0.486557\Delta A_3-0.000319\Delta A_4 -0.000319\Delta A_5+0.000319\Delta A_6-0.001868\Delta A_7-0.001719\Delta A_8 +0.003489\Delta A_9+0.001876\Delta A_{10}-0.070911\Delta A_{11} \tag{56}$$

$$\Delta L_F=0.000001\Delta A_1-0.006757\Delta A_2-0.000019\Delta A_3+0.000004\Delta A_4 +0.000004\Delta A_5-0.000004\Delta A_6+0.000026\Delta A_7+0.000024\Delta A_8 -0.000048\Delta A_9-0.000026\Delta A_{10}+0.000982\Delta A_{11} \tag{57}$$

$$\Delta C_F=-0.327607\Delta A_1-0.006738\Delta A_2+4.236008\Delta A_3-0.997217\Delta A_4 +0.002783\Delta A_5+0.997217\Delta A_6-5.835083\Delta A_7+0.014994\Delta A_8 -0.030426\Delta A_9-0.016355\Delta A_{10}+0.618345\Delta A_{11} \tag{58}$$

$$\Delta L_C=-0.327608\Delta A_1+0.000019\Delta A_2+4.236027\Delta A_3+0.002779\Delta A_4 +0.002779\Delta A_5+0.997221\Delta A_6-5.835109\Delta A_7+0.014970\Delta A_8 -0.030378\Delta A_9-0.016329\Delta A_{10}+0.617363\Delta A_{11} \tag{59}$$

$$\Delta P'_F=-0.060809\Delta A_1-0.001251\Delta A_2+0.786268\Delta A_3-0.185099\Delta A_4 -0.185099\Delta A_5+0.185099\Delta A_6-1.083080\Delta A_7+0.002783\Delta A_8 -0.005648\Delta A_9-0.003036\Delta A_{10}+0.114774\Delta A_{11} \tag{60}$$

$$\Delta P_F = 0.055988\Delta A_1 - 0.000003\Delta A_2 - 0.723938\Delta A_3 - 0.000475\Delta A_4 - 0.000475\Delta A_5 + 0.000475\Delta A_6 + 0.997221\Delta A_7 - 0.002558\Delta A_8 + 0.005192\Delta A_9 + 0.002791\Delta A_{10} - 0.105503A_{11} \quad (61)$$

$$\Delta P'_R = -0.007448\Delta A_1 - 0.000153\Delta A_2 + 0.096307\Delta A_3 - 0.022672\Delta A_4 - 0.022672\Delta A_5 + 0.022672\Delta A_6 - 0.132662\Delta A_7 - 0.122145\Delta A_8 + 1.247868\Delta A_9 - 0.000372\Delta A_{10} - 20.552467\Delta A_{11} \quad (62)$$

$$\Delta Q'_E = -0.007782\Delta A_1 - 0.000160\Delta A_2 + 0.100624\Delta A_3 - 0.023688\Delta A_4 - 0.023688\Delta A_5 + 0.023688\Delta A_6 - 0.138610\Delta A_7 - 0.127621\Delta A_8 + 0.258980\Delta A_9 - 0.000389\Delta A_{10} - 4.263187\Delta A_{11} \quad (63)$$

$$\Delta S' = 0.007782\Delta A_1 + 0.000160\Delta A_2 - 0.100624\Delta A_3 + 0.023688\Delta A_4 + 0.023688\Delta A_5 - 0.023688\Delta A_6 + 0.138610\Delta A_7 + 0.127621\Delta A_8 - 0.258980\Delta A_9 + 0.000389\Delta A_{10} + 5.263187\Delta A_{11} \quad (64)$$

Model II—Reduced-Form Equations

$$\Delta Q_E = 0.135374\Delta A_1 + 0.000628\Delta A_2 + 0.030271\Delta A_3 + 0.092988\Delta A_4 + 0.092988\Delta A_5 - 0.092988\Delta A_6 + 0.486457\Delta A_7 + 0.555248\Delta A_8 + 0.328646\Delta A_9 + 0.012041\Delta A_{10} - 0.922795\Delta A_{11} \quad (65)$$

$$\Delta Q_F = 0.135374\Delta A_1 + 0.000628\Delta A_2 - 0.969729\Delta A_3 + 0.092988\Delta A_4 + 0.092988\Delta A_5 - 0.092988\Delta A_6 + 0.486457\Delta A_7 + 0.555248\Delta A_8 + 0.328646\Delta A_9 + 0.012041\Delta A_{10} - 0.922795\Delta A_{11} \quad (66)$$

$$\Delta P_R = 0.010203\Delta A_1 - 0.001517\Delta A_2 - 0.073090\Delta A_3 - 0.224519\Delta A_4 - 0.224519\Delta A_5 + 0.224519\Delta A_6 - 1.174552\Delta A_7 - 1.340648\Delta A_8 - 0.793517\Delta A_9 - 0.029073\Delta A_{10} + 2.228089\Delta A_{11} \quad (67)$$

$$\Delta L_F = 0.000915\Delta A_1 - 0.006753\Delta A_2 - 0.006552\Delta A_3 + 0.000628\Delta A_4 + 0.000628\Delta A_5 - 0.000628\Delta A_6 + 0.003287\Delta A_7 + 0.003752\Delta A_8 + 0.002221\Delta A_9 + 0.000081\Delta A_{10} - 0.006235\Delta A_{11} \quad (68)$$

$$\Delta C_F = -0.043155\Delta A_1 - 0.000200\Delta A_2 + 0.309133\Delta A_3 - 0.029643\Delta A_4 + 0.970357\Delta A_5 + 0.029643\Delta A_6 - 0.155075\Delta A_7 + 5.794182\Delta A_8 + 3.429524\Delta A_9 + 0.125651\Delta A_{10} - 9.629641\Delta A_{11} \quad (69)$$

$$\Delta L_C = -0.044070\Delta A_1 + 0.006552\Delta A_2 + 0.315686\Delta A_3 + 0.969729\Delta A_4 + 0.969729\Delta A_5 + 0.030271\Delta A_6 - 0.158361\Delta A_7 + 5.790430\Delta A_8 + 3.427304\Delta A_9 + 0.125570\Delta A_{10} - 9.623406\Delta A_{11} \quad (70)$$

$$\Delta P'_F = -0.007227\Delta A_1 - 0.000034\Delta A_2 + 0.051771\Delta A_3 - 0.004964\Delta A_4 - 0.004964\Delta A_5 + 0.004964\Delta A_6 - 0.025970\Delta A_7 + 0.970357\Delta A_8 + 0.574346\Delta A_9 + 0.021043\Delta A_{10} - 1.612685\Delta A_{11} \quad (71)$$

$$\Delta P_F = 0.008424\Delta A_1 - 0.001252\Delta A_2 - 0.060344\Delta A_3 - 0.185367\Delta A_4 - 0.185367\Delta A_5 + 0.185367\Delta A_6 + 0.030271\Delta A_7 - 1.106860\Delta A_8 - 0.655141\Delta A_9 - 0.024003\Delta A_{10} + 1.839546\Delta A_{11} \quad (72)$$

$$\Delta P'_R = -0.012210\Delta A_1 - 0.000057\Delta A_2 + 0.087467\Delta A_3 - 0.008387\Delta A_4 - 0.008387\Delta A_5 + 0.008387\Delta A_6 - 0.043877\Delta A_7 - 0.050082\Delta A_8 + 0.970357\Delta A_9 + 0.035552\Delta A_{10} - 2.724631\Delta A_{11} \quad (73)$$

$$\Delta Q'_E = 0.046525\Delta A_1 + 0.000216\Delta A_2 - 0.333271\Delta A_3 + 0.031958\Delta A_4 + 0.031958\Delta A_5 - 0.031958\Delta A_6 + .167183\Delta A_7 + 0.190824\Delta A_8 + 0.112947\Delta A_9 - 0.135461\Delta A_{10} + 0.682859\Delta A_{11} \quad (74)$$

$$\Delta S' = -0.046525\Delta A_1 - 0.000216\Delta A_2 + 0.333271\Delta A_3 - 0.031958\Delta A_4 - 0.031958\Delta A_5 + 0.031958\Delta A_6 - 0.167183\Delta A_7 - 0.190824\Delta A_8 - 0.112947\Delta A_9 + 0.135462\Delta A_{10} + 0.317141\Delta A_{11} \quad (75)$$

where values of the ΔA's are computed as described on page 146.

Elasticity of Quality [55]

The analysis of the demand for eggs obtained from cross-section data indicated that variation in the price paid for eggs by different income groups was due to variation in the quality (grade and size attributes) of eggs purchased. A change in price, therefore, is interpreted as a change in quality.

A measure of the elasticity of quality with respect to income was derived as the algebraic difference between the elasticities of expenditure and quantity with respect to income. The proof follows:

$$\frac{\partial r}{\partial y}\cdot\frac{y}{r} = \frac{\partial pq}{\partial y}\cdot\frac{y}{p.q} = \left[\frac{p\partial q}{\partial y} + \frac{q\partial p}{\partial y}\right]\cdot\frac{y}{pq} = \frac{\partial q}{\partial y}\cdot\frac{y}{q} + \frac{\partial p}{\partial y}\cdot\frac{y}{p} \quad (76)$$

where:

r=expenditure
p=quality (price)
q=quantity
y=income

Testing for Nonlinearity [56]

If the equation of a straight line is fitted to data that are from a nonlinear relationship, adjacent deviations tend to be of the same sign, indicating that the residuals from the regression line are not distributed randomly. A measure of the relationship between adjacent deviations can be obtained by modifying the statistic developed by Durbin and Watson (*13*):

$$d' = \frac{\sum_{t=2}^{N}(d_t - d_{t-1})^2}{\sum_{t=1}^{N} d_t^2} \quad (77)$$

where d_t is the unexplained residual for observation t, and t is arranged in order of magnitude of the independent variable. A table of upper (d_U) and lower (d_L) bounds for the critical values of d' and $4-d'$ [57] can then be consulted to determine if there is a significant departure from linearity.

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[55] Based on (*39*, p. 112).

[56] Based on (*39*, p. 52).

[57] The value d' relates to positive serial correlation and the value $4-d'$ to negative serial correlation. If d' or $4-d'$ is less than d_L, we assume the residuals may be either positively or negatively serially correlated. If both d' and $4-d'$ are greater than d_U, we assume that there is no serial correlation. If neither of the computed values is less than d_L, but one of them lies between d_L and d_U, the test is inconclusive.

For the regression of per capita consumption of eggs on per capita income, price level, and the price of eggs, (p. 57) the values obtained for d' and $4-d'$ indicate that, at the 5-percent probability level, there is no significant departure from linearity.[58]

Note on Equation (17)

The explanation of storage movement presented in the section on the futures market for eggs assumed:

$$X=f(Y,\ u) \qquad (78)$$

$$Y=f(Z,\ v) \qquad (79)$$

where:

X = net into-storage movement, January–June.
Y = number of speculative long commitments, January–June
Z = profit on speculative long position, previous year
u, v = random error terms

Then a linear form of the model is:

$$X=a_1+b_{11}Y+u_1 \qquad (78.1)$$

$$Y=a_2+b_{22}Z+v_1 \qquad (79.1)$$

and, by substitution:

$$X=a_1+b_{11}(a_2+b_{22}Z+v_1)+u_1 \qquad (80)$$

where the values to be used for obtaining estimates of X are the estimated values of Y, obtained by a least-squares fit of equation (79.1).

Equation (17) of the egg model (p. 65), however, leads to fitting $X=f(Z)$ directly by the limited information method. An equation of this sort is known technically as a partially reduced form equation.

Data Used in the 11-Equation Model

Table 49 shows the data that were used in fitting the statistical model described on page 64. All of these variables are self-explanatory or have been discussed except the series that relate to population. Because data on the quantity of food products taken by the military before 1941 were not available, estimates of per capita consumption for years prior to 1941 were based on total domestic disappearance, including members of the Armed Forces overseas. For 1941 to date, military takings were deducted from total domestic consumption and the per capita figures were based on the estimates of the population eating out of civilian food supplies.

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[58] The values obtained for d' and $4-d'$ were:
Residuals arranged by order of magnitude of X_2; $d'=2.58$, $4-d'=1.42$
Residuals arranged by order of magnitude of X_3; $d'=2.11$, $4-d'=1.89$
Residuals arranged by order of magnitude of X_4; $d'=2.26$, $4-d'=1.74$
For $N=17$, $K'=3$; $d_L=0.79$, $d_U=1.58$ at the 5-percent probability level.

The population eating out of civilian food supplies is defined as the civilian population residing in continental United States plus military personnel eating out of civilian food supplies (Armed Forces personnel on furlough, etc.) minus that part of the civilian population eating out of military supplies (primarily dependents of military personnel eating food bought at military commissaries).

The basic population estimates used in deriving the series on the population eating out of civilian food supplies were the Bureau of Census estimates of the total population adjusted for underenumeration of persons of all ages in the decennial censuses. However, since May 1957 estimates of per capita food consumption published by the Department of Agriculture have not been adjusted for underenumeration. Therefore, some consumption data published in this bulletin may not agree with other published consumption data. For eggs, figures on per capita disappearance based on the unadjusted population series are about 1.4 percent higher than the per capita figures based on the adjusted population series.

TABLE 49.—*Data from which year-to-year changes were obtained for use in the 11-equation model of the egg economy, 1931–58*

Year	Farm egg production		Civilian domestic disappearance of eggs	Difference between Q_E and farm egg production [1]	Average number of layers on farms	Rate of lay [2]	Jan. 1 numbers on farms			Pullets raised [2]	Layers sold and consumed on farms [4]	Mortality of layers	
	Year	January–June					All pullets	Hens	Total [3]			Reported	Reported plus residual [4]
	Q_F	Q'_F	Q_E	A	L_F	Q_A			L_J	C_P	L_C		M
	Bil.	*Bil.*	*Bil.*	*Bil.*	*Mil.*	*No.*	*Mil.*	*Mil.*	*Mil.*	*Mil.*	*Mil.*	*Mil.*	*Mil.*
1931	38.5	24.5	41.3	2.8	303.0	127	243.6	158.2	401.8	354.7	282.3	62.8	171.2
1932	36.3	23.4	39.1	2.9	299.1	121	229.6	156.2	385.8	367.8	270.6	62.9	183.9
1933	35.5	23.2	37.2	1.8	299.7	118	236.7	154.0	390.7	375.0	284.4	65.2	181.6
1934	34.4	22.5	36.5	2.2	290.7	118	238.3	147.0	385.3	322.2	283.0	66.1	133.8
1935	33.6	21.0	35.6	1.9	276.4	122	211.8	138.6	350.4	329.2	236.0	60.6	167.2
1936	34.5	21.8	37.0	2.5	284.9	121	226.4	136.2	362.6	357.5	254.9	64.4	180.3
1937	37.6	23.6	39.7	2.3	288.0	130	249.3	130.4	379.8	300.6	280.0	68.6	112.4
1938	37.4	23.2	40.3	3.1	275.9	135	215.0	138.0	353.0	325.3	240.0	67.5	162.4
1939	38.8	24.1	41.0	2.2	289.6	134	241.8	134.3	376.1	348.3	254.4	75.6	180.4
1940	39.7	24.3	42.1	2.4	296.6	134	253.6	139.1	392.7	316.9	275.6	78.1	137.4
1941	41.9	25.1	41.0	−.8	300.9	139	239.9	141.4	381.3	372.5	225.7	80.8	227.2
1942	48.6	29.4	41.8	−6.7	341.6	142	277.7	150.2	427.9	510.4	244.5	92.4	352.2
1943	54.5	33.6	44.7	−9.7	383.0	142	318.6	170.3	489.0	559.8	309.6	87.7	356.2
1944	58.5	36.3	45.6	−13.0	395.8	148	349.6	174.0	523.6	480.1	344.5	107.2	263.4
1945	56.2	34.3	51.9	−4.2	369.4	152	301.5	172.4	473.9	506.2	309.0	91.3	301.7
1946	56.0	34.4	52.5	−3.3	357.6	156	322.1	150.7	472.8	434.8	327.4	91.1	222.6
1947	55.4	33.2	54.6	−.6	345.1	160	281.0	150.5	431.4	437.0	281.3	83.7	242.0
1948	54.9	32.0	56.5	1.5	331.6	166	278.0	139.6	417.6	386.0	274.8	79.0	197.2
1949	56.2	32.0	56.6	.4	330.7	170	258.3	141.0	399.4	447.7	244.7	82.3	271.7

1950	59.0	33.7	58.5	−.6	339.5	174	286.8	137.0	423.8	393.6	275.2	84.5	202.7
1951	58.1	32.7	59.3	1.3	327.8	177	258.2	141.2	399.3	398.7	249.8	83.4	220.4
1952	58.1	32.7	59.8	1.8	320.5	181	261.4	135.8	397.2	370.2	243.0	87.6	203.9
1953	57.9	31.7	59.1	[5] 1.1	312.1	[5] 186	237.6	135.4	373.0	375.1	237.8	83.6	198.2
1954	58.9	31.8	59.8	.7	314.2	188	255.1	115.8	371.0	[5] 369.8	235.6	85.1	[5] 191.0
1955	59.5	32.0	60.2	.9	309.1	192	257.2	111.4	368.6	330.2	227.0	84.2	162.7
1956	60.9	32.2	60.8	.1	309.9	196	238.6	121.7	360.3	349.4	219.1	86.0	180.7
1957	60.4	32.4	60.3	.1	304.8	198	249.6	119.2	368.8	305.6	223.0	86.8	146.6
1958	60.7	31.6	59.7	1.0	301.3	201	224.6	127.9	352.5	337.7	210.6	80.8	178.3

See footnotes at end of table.

TABLE 49.—*Data from which year-to-year changes were obtained for use in the 11-equation model of the egg economy, 1931–58*—Continued

Year	Price of— Eggs per dozen, Farm, Year P_F	Price of— Eggs per dozen, Farm, January–June P'_F	Price of— Eggs per dozen, Retail, Year P_R	Price of— Eggs per dozen, Retail, January–June P'_R	Price of— Poultry ration per 100 pounds, Year P_G	Price of— Poultry ration per 100 pounds, January–June P'_G	Consumer disposable income I	Population, July 1, Total	Population, July 1, Eating out of civilian supplies H	Index number of unit labor cost in marketing food (1947–49=100) W	Net into-storage movement, eggs, January–June S'	Gain or loss on futures, previous year, speculative long position [4] F
	Ct.	*Ct.*	*Ct.*	*Ct.*	*Dol.*	*Dol.*	*Bil. dol.*	*Mil.*	*Mil.*		*Bil.*	*Ct.*
1931	17.6	16.1	31.4	28.3	1.49	1.68	63.8	--------	125.8	55	3.0	−7.8
1932	14.2	11.9	26.8	22.7	1.14	1.21	48.7	--------	126.6	48	2.0	−5.0
1933	13.8	12.4	25.2	21.8	1.35	1.18	45.7	--------	127.3	43	3.8	7.3
1934	17.0	14.6	29.0	25.5	1.71	1.54	52.0	--------	128.1	47	3.5	−.3
1935	23.4	21.9	34.5	31.9	1.88	2.01	58.3	--------	129.0	51	2.9	2.2
1936	21.8	19.6	34.0	30.2	1.89	1.64	66.2	--------	129.8	51	2.6	−1.8
1937	21.3	19.8	33.2	30.6	2.17	2.41	71.0	--------	130.6	56	3.9	4.5
1938	20.3	17.6	32.5	27.8	1.54	1.62	65.7	--------	131.6	54	2.2	−5.3
1939	17.4	16.2	29.2	26.2	1.54	1.49	70.4	--------	132.7	54	3.2	1.9
1940	18.0	16.4	30.1	26.6	1.68	1.73	76.1	--------	134.0	54	2.9	−1.6
1941	23.5	19.3	36.6	29.8	1.83	1.71	93.0	135.3	133.7	56	3.0	.1
1942	30.0	27.4	45.1	38.7	2.21	2.20	117.5	136.7	133.3	58	4.6	6.2

1943	37.1	35.0	53.8	48.6	2.66	2.51	133.5	138.6	130.6	61	([6])	3.9
1944	32.5	29.8	51.1	44.7	2.94	2.97	146.8	140.3	130.3	64	([6])	--------
1945	37.7	35.4	54.6	49.1	2.91	2.87	150.4	141.8	130.9	70	2.6	−2.9
1946	37.6	33.9	55.3	48.9	3.47	3.17	[5] 159.2	143.4	140.3	78	5.4	1.9
1947	45.3	40.5	65.8	59.0	4.17	3.74	[5] 169.0	146.1	144.6	90	2.1	−5.7
1948	47.2	44.0	68.4	63.9	4.29	4.70	[5] 187.6	148.7	147.2	103	3.5	1.1
1949	45.2	43.3	65.9	63.2	3.46	3.50	[5] 188.2	151.3	149.6	106	1.6	−3.2
1950	36.3	30.5	57.1	49.2	3.58	3.47	[5] 206.1	153.8	152.3	108	2.7	.5
1951	47.8	43.4	69.7	64.6	4.01	3.97	[5] 226.1	156.5	153.2	117	2.2	−.8
1952	41.6	35.7	63.6	56.4	4.21	4.24	[5] 237.4	159.2	155.5	[5] 120	2.2	1.3
1953	47.7	44.9	66.8	63.6	3.87	3.95	[5] 250.2	161.9	158.3	[5] 123	1.4	−.7
1954	36.6	38.6	56.2	57.2	3.86	3.90	[5] 254.4	164.7	161.3	125	2.0	−1.9
1955	38.9	35.8	58.1	53.9	3.61	3.75	274.4	167.6	164.6	125	2.0	−14.1
1956	38.7	39.8	57.7	58.0	3.55	3.50	290.5	170.5	167.6	127	1.5	−7.2
1957	35.2	30.7	54.9	49.3	3.47	3.54	305.1	173.6	170.7	128	1.4	[5] −10.2
1958	38.3	38.1	58.0	57.0	3.41	3.42	311.6	176.5	173.8	([7])	.9	.3

See footnotes at end of table.

TABLE 49.—*Data from which year-to-year changes were obtained for use in the 11-equation model of the egg economy, 1931–58*—Continued

Year	Index numbers of prices paid by consumers (1947–49=100)									
	Meats, poultry, and fish		Cheese		Bacon		Ready-to-eat cereals [8]		All items	
	Year	January–June	Year	January–June	Year	January–June	Year	January–June	Year	January–June
	P_M	P'_M	P_C	P'_C	P_B	P'_B	P_T	P'_T	P_O	P'_O
1931	43. 5	45. 1	45. 3	47. 5	48. 7	51. 2	68. 1	68. 9	65. 0	66. 3
1932	34. 1	35. 0	37. 3	38. 2	32. 2	33. 6	65. 0	65. 6	58. 4	59. 6
1933	29. 7	29. 1	36. 4	35. 3	30. 0	28. 6	64. 4	62. 9	55. 3	54. 2
1934	34. 0	32. 2	38. 1	37. 8	38. 8	34. 1	64. 8	67. 3	57. 2	56. 8
1935	43. 0	41. 7	40. 8	40. 8	55. 0	50. 7	(9)	(9)	58. 7	58. 6
1936	42. 6	42. 4	43. 1	41. 5	54. 5	55. 0	(9)	(9)	59. 3	58. 8
1937	45. 5	43. 5	45. 2	44. 9	55. 4	53. 4	(9)	(9)	61. 4	60. 9
1938	42. 6	42. 3	42. 4	43. 9	49. 7	50. 0	(9)	(9)	60. 3	60. 4
1939	41. 6	41. 8	40. 0	39. 6	43. 8	45. 4	56. 7	57. 4	59. 4	59. 3
1940	41. 2	39. 9	41. 4	41. 4	38. 3	37. 6	56. 8	56. 5	59. 9	59. 8
1941	46. 3	44. 5	48. 0	43. 6	48. 2	45. 5	57. 4	57. 4	62. 9	61. 0
1942	54. 2	52. 2	55. 8	55. 2	55. 4	54. 1	59. 2	58. 7	69. 7	68. 4
1943	57. 6	59. 0	60. 2	60. 2	57. 8	59. 6	58. 9	59. 8	74. 0	73. 7
1944	55. 9	56. 1	61. 1	60. 8	55. 0	55. 0	57. 5	57. 6	75. 2	74. 6
1945	56. 5	56. 4	60. 6	60. 8	55. 3	55. 2	58. 5	57. 8	76. 9	76. 4
1946	69. 4	57. 0	81. 4	63. 2	72. 3	56. 0	66. 3	59. 5	83. 4	78. 4
1947	93. 5	88. 0	95. 7	96. 7	105. 4	97. 5	86. 2	78. 8	95. 5	93. 1
1948	106. 1	101. 9	106. 6	104. 1	104. 3	103. 4	106. 3	105. 5	102. 8	101. 5
1949	100. 5	100. 0	97. 7	98. 1	90. 3	91. 3	107. 6	107. 6	101. 8	102. 0

1950	104.9	99.6	96.9	96.9	86.4	80.8	109.2	107.0	102.8	100.9
1951	117.2	116.4	110.4	110.8	91.1	91.7	121.0	118.1	111.0	110.2
1952	116.2	115.8	113.4	112.4	87.9	83.7	126.9	126.6	113.5	112.9
1953	109.9	108.9	113.1	113.8	107.0	98.7	127.7	127.6	114.4	113.8
1954	108.0	110.3	108.0	109.4	111.0	119.2	127.9	127.9	114.8	115.0
1955	101.6	102.7	108.0	107.8	89.7	91.5	128.0	128.0	114.5	114.3
1956	97.1	94.5	108.4	108.2	79.0	74.8	128.9	128.2	116.2	115.1
1957	105.2	102.3	109.3	109.0	101.5	95.5	136.1	134.7	120.2	119.2
1958	115.1	114.6	109.5	109.8	108.7	107.9	149.4	148.4	123.5	123.2

[1] Farm egg production equals $Q_A.L_F$.

[2] Per layer during the year.

[3] Do not necessarily add, due to rounding.

[4] See text for explanation.

[5] Data have been revised from those used in analyses. Revised figures are: A, 1953 (1.4); Q_A, 1953 (185); C_F, 1954 (386.0); M, 1954 (207.2); P_F, 1957 (35.8); P'_F, 1957 (31.4); I, 1946 (160.6), 1947 (170.1), 1948 (189.3), 1949 (190.0), 1950 (207.7), 1951 (227.5), 1952 (238.7), 1953 (252.5), and 1954 (256.9); W, 1952 (121), 1953 (124); F, 1957 (−9.2).

[6] Data not available. See text for explanation.

[7] Data not available at time of publication.

[8] Based on the price of corn flakes.

[9] Data not available for publication. Obtained from United States Bureau of Labor Statistics.

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