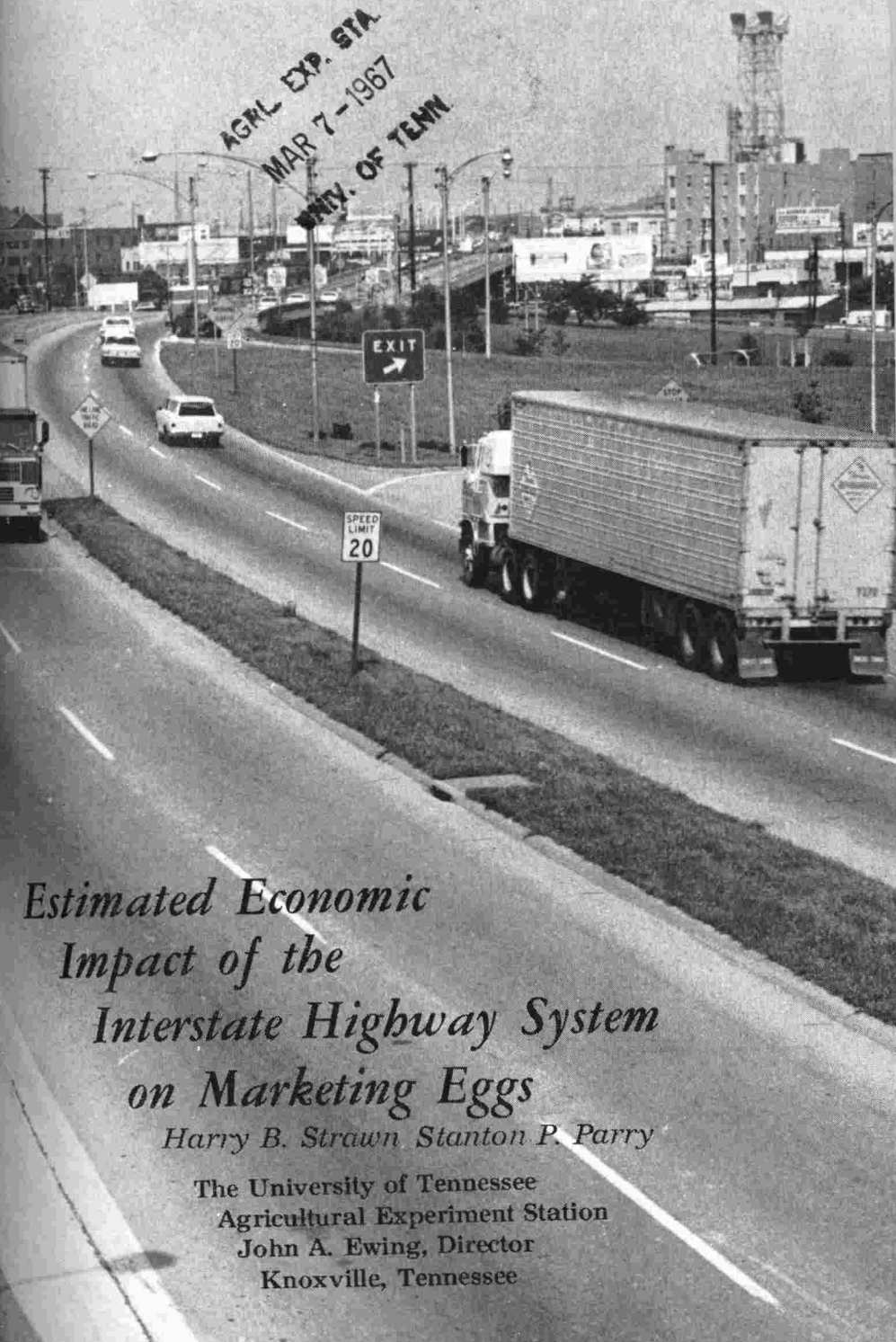


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Bulletin 405 May 1966

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*Estimated Economic
Impact of the
Interstate Highway System
on Marketing Eggs*

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SUMMARY

Since World War II, Tennessee has been a deficit state in the production of commercial eggs, and this situation shows no sign of changing in the near future.

Regional shifts of commercial egg production and consumption in the national egg-trading system have greatly changed the national egg-movement patterns and increased the relative importance of the Southeastern states in egg marketing during the last decade.

States bordering Tennessee to the east, south, and west have become net exporters of commercial eggs, thus offering Tennessee consumers a readily available source of eggs and increasing the pressures for efficient egg production within the state.

The average size of Tennessee egg-marketing firms is small in terms of investment and employment. Many of these firms maintain small fleets of van-type trucks for local delivery. Their delivery routes rarely encompass more than one county.

Cost functions indicated that the impact of the Interstate Highway System on national commercial egg-shipping patterns would be through economies in required transit time due to higher operating speeds rather than by improved route alignment.

A transportation model was used to estimate the optimum shipping patterns before and after the Interstate Highway System was completed. The effects of the Interstate Highway System on the optimal routing of commercial eggs were found to be slight.

While differences in transfer cost did occur, they were not great and might easily be dissipated by inefficiencies in other areas of the egg marketing process.

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Estimated Economic Impact Of the Interstate Highway System On Marketing Eggs

by

Harry B. Strawn and Stanton P. Parry*

INTRODUCTION

The Interstate Highway System bears the official designation of the National System of Interstate and Defense Highways. The system consists of 41,000 miles of planned, integrated, high capacity, high speed routes connecting the nation's centers of commerce and population and providing connecting links with important continental routes into Canada and Mexico (Figure 1). While these routes will comprise only about 1 percent of the total highway mileage in the continental United States, they are expected to carry over 20 percent of the nation's highway traffic when they are completed in 1972.

It has been estimated that the Interstate Highway System will yield a savings equivalent of about \$9 billion because of reduced vehicle operating costs and reduction in travel time in 1973, and increasing amounts thereafter.¹ These routes will have great influence on the cost of moving agricultural products and on the location of agricultural production and processing.

Since the Interstate Highway System is expected to decrease the time and cost required to move agricultural commodities from producing areas to consuming areas by truck, the locational advantages of those areas situated near the consuming centers are ex-

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¹United States Department of Commerce, **Highway Progress, 1963** (Annual Report of the Bureau of Public Roads, Fiscal Year 1963, Washington: Government Printing Office, 1963), pp. 12-13.

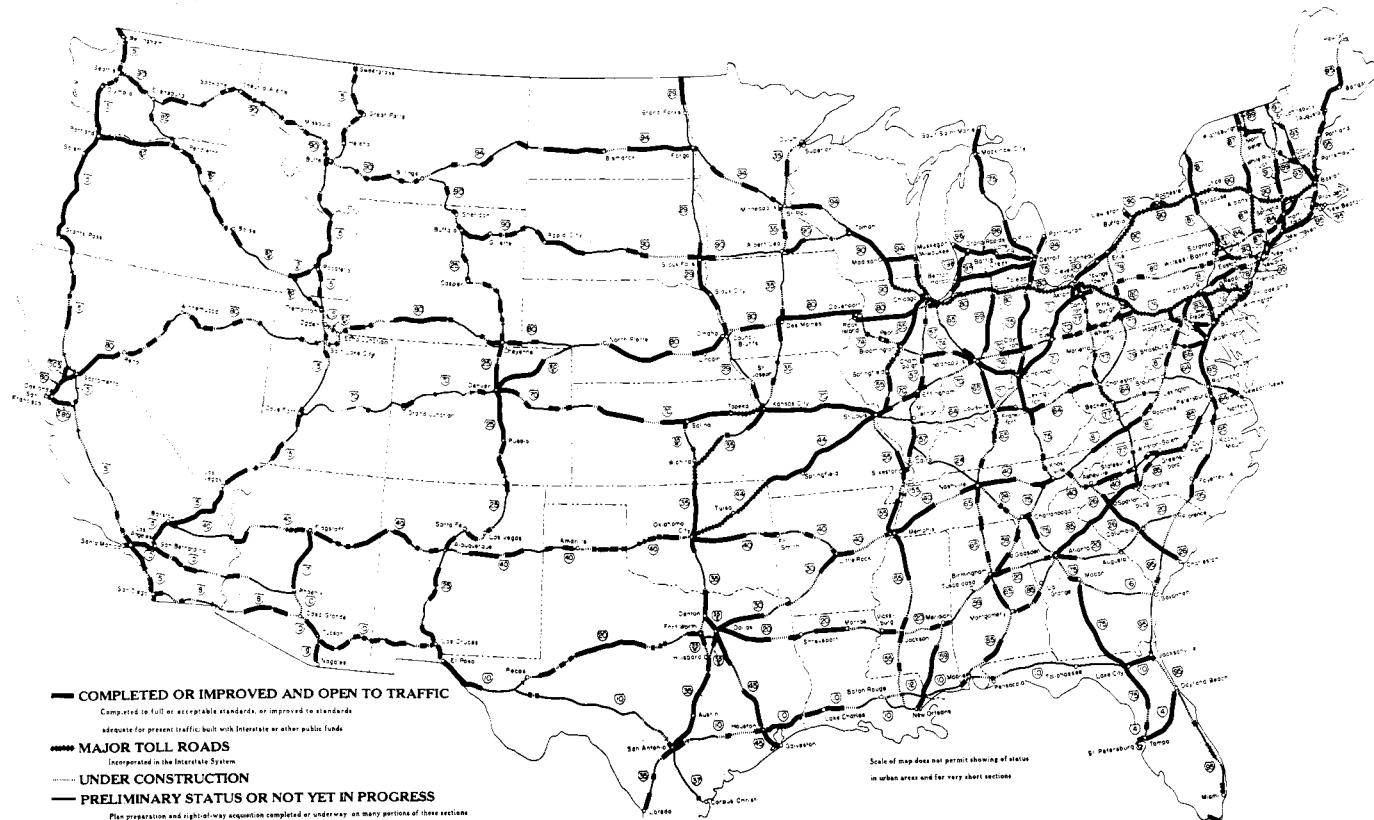


Figure 1. The national system of Interstate and Defense highways as of June 30, 1966. Source: U. S. Department of Commerce.

pected to be reduced. A decrease in transfer cost will be of more benefit to those producers located at greater distances from the deficit areas because transportation accounts for a larger share of their total costs. The net effects of the reduced time and cost of moving agricultural commodities will be to reduce the price differentials between geographically separated markets and to place greater relative importance on the effects of regional differences in processing costs, economies of scale in processing, and real or psychological differences in product quality.

This analysis considers the potential effect of the interstate system on egg production and marketing in Tennessee.² As such it is an exploratory study, but it should disclose factors which tend to produce geographical shifts in production and consumption. Information from these types of studies should be useful to the managers of agricultural marketing firms in making production decisions, especially capital-budgeting decisions.

Commercial eggs—shell eggs for human consumption—are of considerable importance to Tennessee producers. In 1964, the cash receipts from farm marketings of eggs and value of home consumption amounted to approximately \$30 million.³

MARKETING FIRMS

In Tennessee, most of the direct benefits of the interstate system should accrue to marketing firms. The effects of the Interstate Highway System on these marketing firms will depend largely on their proximity to the several interstate routes. Tennessee egg marketing firms are generally relatively small in terms of the investment in plant and equipment and number of workers employed. They typically grade, candle, and carton or recase the eggs, depending on whether individual customers want cartoned eggs for the retail trade or cases of eggs for restaurant or institutional use. They also provide controlled temperature and humidity egg storage rooms where eggs are held for processing and later shipment for local egg delivery. These egg delivery routes

²Any one of a number of commodities produced in Tennessee could have been selected for this phase of the experiment. Availability of data, relative ease of long distance shipment of eggs, and limited product change in form from production to consumption led to selection of commercial eggs for initial review.

³"Poultry and Egg Situation," ERS, USDA, November, 1965, p. 25.

usually include local urban areas and rarely encompass more than one county.

Completion of the Interstate Highway System will give large egg-marketing firms the alternative of importing eggs to supplement local supplies at a somewhat lower cost than was feasible before the advent of the system. The price of imported eggs should place a ceiling on local farm level prices because modern temperature-controlled trucks can deliver eggs to Tennessee with little deterioration in egg quality.

Chain stores are also very important intermediate handlers of commercial eggs. The regional warehouses of many chains include egg handling facilities. Other chains purchase eggs from separate marketing firms packaged under the chain's trade name. These chains are large-volume handlers that demand a constant supply of high-quality eggs at moderate prices. Their buying patterns reflect their estimate of the best combination of egg quality and price that they can obtain. The Interstate Highway System influences their purchase patterns by decreasing the price effects of seasonal variations in local egg supply and by placing a lower ceiling on delivered-egg prices than previously existed.

PRODUCERS

Tennessee egg producers should not be greatly influenced by the system directly since the network of interstate highways is not generally considered to be an important link in the farm-to-market system of secondary roads. Most egg producers wash their eggs, and many grade them before they leave the farm. Also, most farmers sell their eggs to local haulers who distribute them to consumers, retail stores, and restaurants, or deliver them to other egg-marketing firms. Many farmers establish private egg routes and retail or wholesale eggs personally. In either case the length of haul is short, and few special trucks or other kinds of equipment are needed. The impact of the Interstate Highway System would indirectly affect producers by price decreases in local markets due to cheaper in-shipment of eggs. This decrease would depend on the size of the local market and its nearness to interstate routes. The effect on egg prices should be greater in the large city markets of Nashville, Knoxville, Chattanooga, and Memphis, because the large

aggregate demand for eggs in these cities justifies the shipment of truckload lots from distant surplus areas.

CONSUMERS

The impact of the decreased transfer costs for eggs on consumers is very difficult to estimate because egg prices reflect a complex interaction of supply and demand, marketing margins, transfer costs, and competitive environment. The price elasticity of demand for eggs at the retail level has been estimated at approximately -0.3 ,⁴ which would indicate a small consumer response to changes in egg prices. The cost economies achieved by the Interstate Highway System might be taken up partly or entirely by increased markups in the marketing margins, depending on the intensity of present and future competition in the industry.

The objectives of the study were threefold:

1. To describe production location patterns for commercial eggs as they existed before the Interstate Highway System was initiated.
2. To estimate transfer time and cost functions for moving commercial eggs from surplus areas to deficit areas of the United States via:
 - a) Pre-Interstate Highway System.
 - b) Post-Interstate Highway System.
3. To estimate the impact of the Interstate Highway System on production and distribution patterns for commercial eggs in the United States, with implications for Tennessee producers.

Estimates of egg production and consumption were obtained by counties for the 48 contiguous states. These counties were then grouped according to trading regions delineated by Rand McNally, **Commercial Atlas and Marketing Guide**, 1962. In some cases trading regions were combined to facilitate computation.

The analytical model used in this study to determine the optimum pattern of shipments in the national egg-trading system was

⁴Brandow, G. E., "Interrelations Among Demands for Farm Products and Implications for Control of Market Supply," Bulletin 680, Pennsylvania State University, August, 1961.

the linear programming transportation model, a partial equilibrium model that has proved very effective under its required conditions. These conditions include assumptions of pure competition; i.e., prices for a homogeneous commodity would differ in various geographically-separated markets by an amount not greater than the transfer costs among the markets.

The egg-trading system was assumed to be a national system because eggs were found to flow freely among the various states and municipal divisions. The only regulations that applied to egg movements were safety and hours regulations and state laws on weight limitations.⁵

Eggs are exempt from regulation by the Interstate Commerce Commission, and their transportation rates were not a matter of public record. Virtually all egg movements occurred by motor truck, and the trucks were generally owned by the individual shippers or were contract vehicles. The lack of public records of egg-transportation costs necessitated the use of estimating equations relating the transfer costs to distance traveled in miles before and after the Interstate Highway System was initiated.

Solving the transportation model using pre-interstate highway transfer costs yielded the optimum flow pattern of eggs over the existing network of roads under existing supply and demand conditions. Intermarket price comparisons were made by constructing an equilibrium cost matrix. Both intermarket price comparisons and equilibrium returns to producers were estimated from this matrix. The cost of using non-optimum routes was estimated by constructing an opportunity cost matrix which was obtained by subtracting the equilibrium cost matrix from the cost-flow matrix comprising the final solution of the transportation model.⁶

The transportation problem was solved again, using post-Interstate Highway System cost estimates for moving eggs. This solution yielded the optimum pattern of egg shipments when the same quantity of eggs was moved over the Interstate Highway System. Equilibrium-cost and opportunity-cost matrices were again constructed to determine the effects of the new highway system on the national egg-trading economy.

⁵Letter from Fred L. Faber, Agricultural Economist, Marketing Economics Division, Economic Research Service, U. S. Department of Agriculture, Washington, D. C., to author, dated May 7, 1964.

⁶Cell values of zero in this matrix indicated alternative routes which could be used without increasing total transfer costs.

SUPPLY AND DEMAND FOR EGGS

Total Egg Supply

The supply of commercial eggs available for consumption during a given period consists of commercial egg production during that period plus net changes in inventories of stored eggs, plus net imports. Since foreign trade and storage inventory changes accounted for only a small proportion of total domestic egg production in any one year (Table 1), annual egg production was assumed to equal yearly egg consumption for purposes of this analysis. The continental United States was therefore considered to be a closed egg-trading system.

Table 1. Commercial storage stocks of eggs: exports and imports of eggs, United States, 1950-1964

of eggs, United States,							
Year	Total production ^a	Average cold storage holdings ^b	Imports ^b	Exports ^c	Percentage of Production		
					Cold storage %	Imports %	Exports %
Million Dozen							
1950	5,404	52.5	20	169	.972	.370	3.127
1951	5,322	57.5	8	182	1.080	.150	3.420
1952	5,323	58.5	8	72	1.099	.150	1.353
1953	5,307	46.0	7	58	.867	.132	1.093
1954	5,402	53.5	4	64	.990	.074	1.185
1955	5,407	71.0	2	65	1.313	.037	1.202
1956	5,500	80.5	2	64	1.464	.036	1.164
1957	5,441	78.0	1	50	1.434	.018	.919
1958	5,441	58.5	2	44	1.075	.037	.809
1959	5,542	55.0	1	54	.992	.018	.956
1960	5,342	58.0	3	44	1.086	.056	.824
1961	5,328	49.5	3	42	.929	.056	.788
1962	5,367	49.0	2	32	.913	.037	.596
1963	5,318	47.0	1	43	.884	.019	.809
1964	5,379 ^d	45.0	2	32	.837	.037	.595

a. Including allowance for nonfarm production.

b. Shell eggs equivalent of eggs and egg products.

c. Shell eggs and shell equivalent of egg products, including exports made from government-owned stocks acquired for price support and other purposes.

d. Preliminary.

Source: **Agricultural Statistics, 1962 and 1965**, United States Department of Agriculture (Washington: Government Printing Office), pp. 506 and 428, respectively.

Domestic Production of Commercial Eggs

Total egg production is a function of the number of hens on farms, hen mortality, and rate-of-lay. Regional differences in hen mortality are insignificant.⁷ Regional differences in rate-of-lay exist, but this difference is largely due to the data which include hatching egg production for broilers. Heavy breed hens used in broiler production lay fewer eggs than the commercial-egg types; therefore, the rate-of-lay estimates tend to be biased against those states having heavy broiler production.⁸ The major item determining the quantity of commercial eggs produced in an area is the density of laying hens (Table 2). In terms of total egg production, California has the largest output—followed by Iowa, Pennsylvania, and Georgia.

Historically, significant shifts in the pattern of commercial egg production have occurred. The South Atlantic states made the largest proportionate increases in recent years. The 1964 breakdown of domestic egg production indicated that this region accounted for 16 percent of the total U. S. egg production compared

⁷A. P. Stemberger, *North Carolina Eggs in Interregional Competition*, Agricultural Economics Information Series No. 73 (Raleigh: North Carolina State College, 1960), p. 15.

⁸*Ibid.*, p. 14.

Table 2. Estimated hen and egg production densities by states and areas for the continental United States, 1964

State and area	Land area in square miles	Av. no. hens and pullets during year (000)	Birds per square mile	Total egg production ^a (000,000)	Egg production per square mile
Maine	31,012	4,000	129	897	28,924
New Hampshire	9,014	1,526	169	336	37,275
Vermont	9,276	684	74	151	16,279
Massachusetts	7,867	2,640	336	587	74,616
Rhode Island	1,058	376	355	82	77,505
Connecticut	4,899	3,409	696	733	149,622
New York	47,939	8,517	178	1,813	37,819
New Jersey	7,521	9,267	1,232	1,815	241,324
Pennsylvania	45,007	14,631	325	3,114	69,189
North Atlantic	163,593	45,050	275	9,528	58,242
Ohio	40,972	11,275	275	2,435	59,431
Indiana	36,185	10,364	286	2,247	62,098
Illinois	95,930	9,547	100	2,032	21,182
Michigan	57,019	5,827	102	1,265	22,186
Wisconsin	54,705	8,087	148	1,784	32,611

Table 2. (continued)

State and area	Land area in square miles	Av. no. hens and pullets during year (000)	Birds per square mile	Total egg production ^c (000,000)	Egg production per square mile
East North Central	244,811	45,100	184	9,763	39,880
Minnesota	80,009	13,005	163	2,925	36,558
Iowa	56,032	17,766	317	3,940	70,317
Missouri	69,138	7,391	107	1,484	21,464
North Dakota	69,457	2,034	29	386	5,557
South Dakota	76,378	6,650	87	1,446	18,932
Nebraska	76,612	6,910	90	1,446	18,874
Kansas	82,048	4,764	58	970	11,822
West North Central	509,674	58,520	115	12,597	24,716
Delaware	1,978	627	317	124	62,690
Maryland	9,874	1,355	137	270	27,345
Virginia	39,838	5,948	149	1,250	31,377
West Virginia	24,079	1,591	66	329	13,663
North Carolina	49,067	10,960	223	2,324	47,364
South Carolina	30,272	4,828	159	1,021	33,728
Georgia	58,274	14,509	249	3,014	51,721
Florida	54,252	6,303	116	1,412	26,027
South Atlantic	267,634	46,121	172	9,744	36,408
Kentucky	39,863	4,770	120	913	22,903
Tennessee	41,762	4,850	116	921	22,054
Alabama	51,060	9,218	178	1,950	38,190
Mississippi	47,223	8,890	188	1,829	38,731
Arkansas	42,499	8,845	208	1,842	43,342
Louisiana	45,106	2,713	60	505	11,196
Oklahoma	68,840	2,686	39	519	7,534
Texas	262,840	12,741	48	2,494	9,489
South Central	609,240	54,713	90	10,973	18,011
Montana	145,736	950	7	195	1,338
Idaho	82,708	1,149	14	251	3,035
Wyoming	97,411	276	3	58	595
Colorado	103,884	1,299	13	264	2,541
New Mexico	121,510	754	6	160	1,317
Arizona	113,575	778	7	166	1,462
Utah	82,339	1,330	16	299	3,631
Nevada	109,788	52	1	11	100
Washington	66,709	4,647	70	1,051	15,755
Oregon	96,248	2,527	26	565	5,870
California	156,573	32,936	210	7,409	47,320
Western	1,176,481	46,698	40	10,429	8,865
48 states	2,971,433	296,202	100	63,034	21,213

a. Harry Hansen (ed.), *The World Almanac*, 1964 (New York: The New York World Telegram and the Sun, 1964), p. 174.

b. United States Department of Agriculture, *Agricultural Statistics*, 1964 (Washington: Government Printing Office, 1965), p. 425.

c. *Agricultural Statistics*, 1964, p. 425.

to 8.6 percent in 1947-49 (Table 3). Over the same period the South Central Region, which includes Tennessee, increased its proportion from 15.4 percent to 18.9 percent. The West North Central region showed the largest proportionate decrease in egg production, from 29.0 percent of the national production in 1947-49 to 22.5 percent in 1964.

Egg Production in Tennessee

In the Census of 1959 one-fourth of the counties in the State reported no commercial poultry farms; only three counties reported 100 or more.⁹ Tennessee egg production is somewhat more concentrated in the eastern half of the State which can be partly explained by the fact that the terrain there is more mountainous and makes large-scale field cropping operations difficult. East Tennessee is, in general, more populous and farther from surplus egg producing states. All these combine to give local commercial

⁹Poultry includes chickens, chicken eggs, turkeys, and other poultry products. From available data it was impossible to separate egg products from other categories.

Table 3. Relative egg production by regions of the continental United States for the years 1950-1964

Year	North Atlantic East	North Central West	North Central South	Atlantic South	Central	West	48 States
	Percent						
1947-49 average	16.3	20.7	29.0	8.6	15.4	10.0	100.0
1950	17.2	19.9	28.3	8.8	14.9	10.9	100.0
1951	17.5	19.9	28.6	8.7	14.2	11.1	100.0
1952	18.3	19.7	27.6	9.0	13.4	12.3	100.0
1953	18.5	19.4	27.4	9.0	13.4	12.3	100.0
1954	18.4	19.6	27.8	9.0	12.6	12.6	100.0
1955	18.5	19.6	27.9	9.3	12.3	12.4	100.0
1956	18.5	19.6	27.0	9.8	12.8	12.3	100.0
1957	18.2	18.8	27.1	10.4	13.1	12.4	100.0
1958	17.7	18.8	26.6	10.8	13.3	12.8	100.0
1959	17.0	18.0	25.6	12.0	14.2	13.2	100.0
1960	16.3	17.5	24.6	13.1	14.3	14.2	100.0
1961	15.7	16.6	23.9	13.6	15.1	15.1	100.0
1962	15.1	16.3	22.5	14.2	16.1	15.8	100.0
1963	15.1	15.5	20.0	15.5	17.4	16.5	100.0
1964	14.9	14.6	18.8	16.0	18.9	16.8	100.0

Source: United States Department of Agriculture, **Poultry and Egg Situation**, No. 224 (Washington: United States Government Printing Office, March, 1963), p. 23 and **Poultry and Egg Situation**, No. 238, September, 1965, p. 16.

egg producers and haulers more opportunities for developing profitable egg-selling routes in the eastern area.

Consumption of Eggs

While total U. S. population has been increasing, per capita consumption of eggs has been declining since 1952 (Figure 2). Total egg consumption remained about the same during this period with the decline in per capita egg consumption being offset by the rapid growth in population. Population growth is the most important factor in determining egg consumption which is relatively unresponsive to changes in egg prices or consumers' incomes.¹⁰ The effects of other factors—such as national origin, race, and age of consumers—are very difficult to measure quantitatively. Increased urbanization of the population will tend to cause egg production and consumption to become more geographically separated.

SURPLUSES AND DEFICITS OF EGGS BY STATES

Regional shifts in production and consumption of commercial eggs have combined to alter the movement patterns within the national egg-trading system. North Carolina, South Carolina, Georgia, Alabama, Arkansas, and Mississippi have had large proportionate increases in egg production and have become net exporters of eggs in the last 10 years. Figure 3 gives some indication of the relative change in egg production by states since 1953. The magnitude of increase in egg production in California has been sufficiently large to enable that state to move from a deficit area in 1958 to a surplus area in 1964. Figure 4 indicates the estimated surplus and deficit position of states in the national egg-trading system during 1964.

Since 1946, Tennessee has been a deficit state in the production of commercial eggs. This condition shows no sign of changing in the near future. Figure 5 shows the estimated deficit of eggs in Tennessee for the period extending from 1953 to 1964. Aggregate production and consumption of eggs have remained relatively constant during this 11-year period.

¹⁰Price and income elasticities for eggs at the retail level have recently been estimated to be approximately -0.30000 and 0.16000 respectively. G. E. Brandow, *Interrelationships Among Demands for Farm Products and Implications for Control of Market Supply*, Agricultural Experiment Station Bulletin 680 (University Park: Pennsylvania State University, 1961), p. 17.

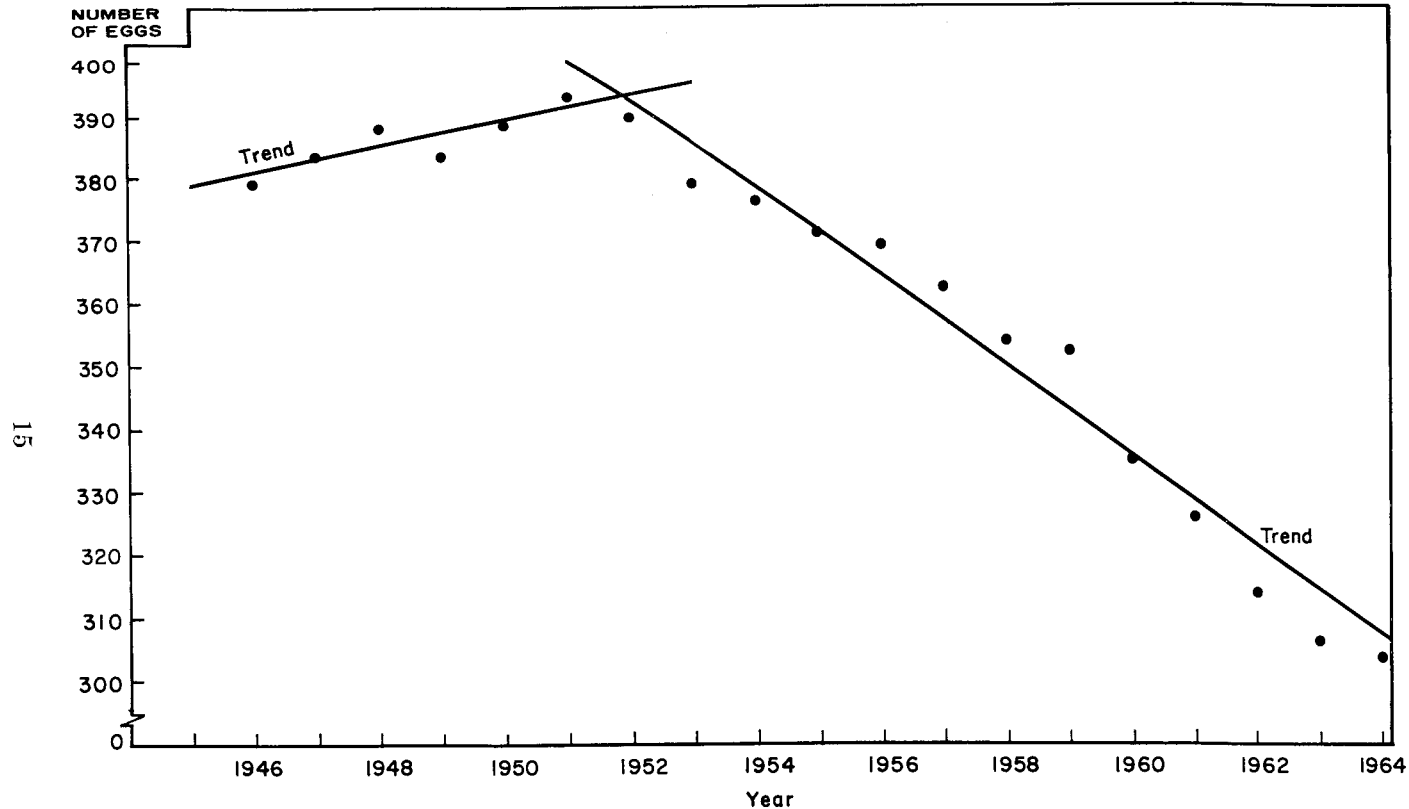


Figure 2. Trends in per capita egg consumption, United States, 1946-1965. Source: POULTRY AND EGG SITUATION, No. 239, November 1965, p. 27.

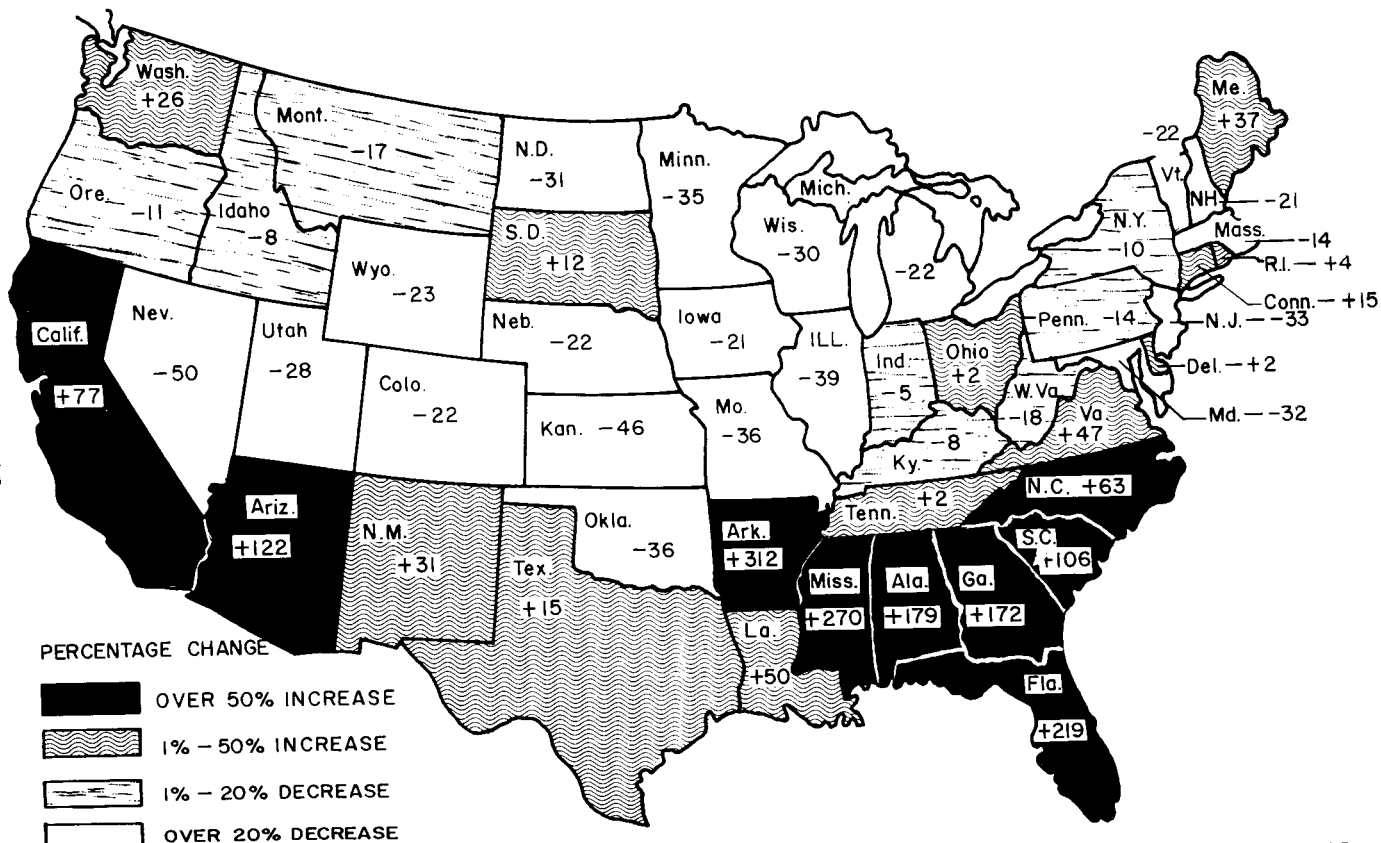


Figure 3. Percentage change in egg production by states, United States, 1957-1965. Source: AGRICULTURAL STATISTICS, pp. 511 and 425, respectively.

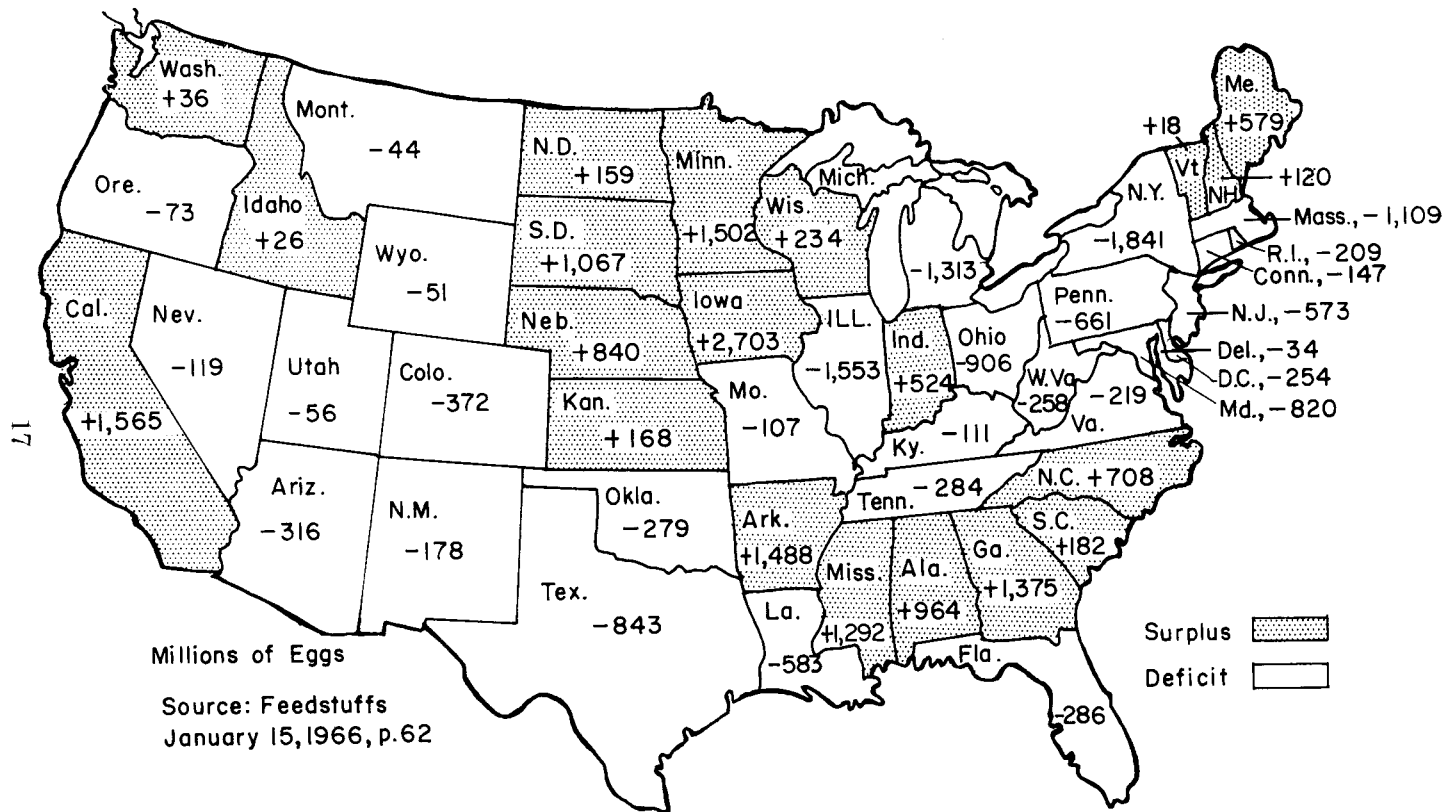


Figure 4. 1964 egg surplus—deficit positions of states based on a national per capita consumption of 314 eggs.

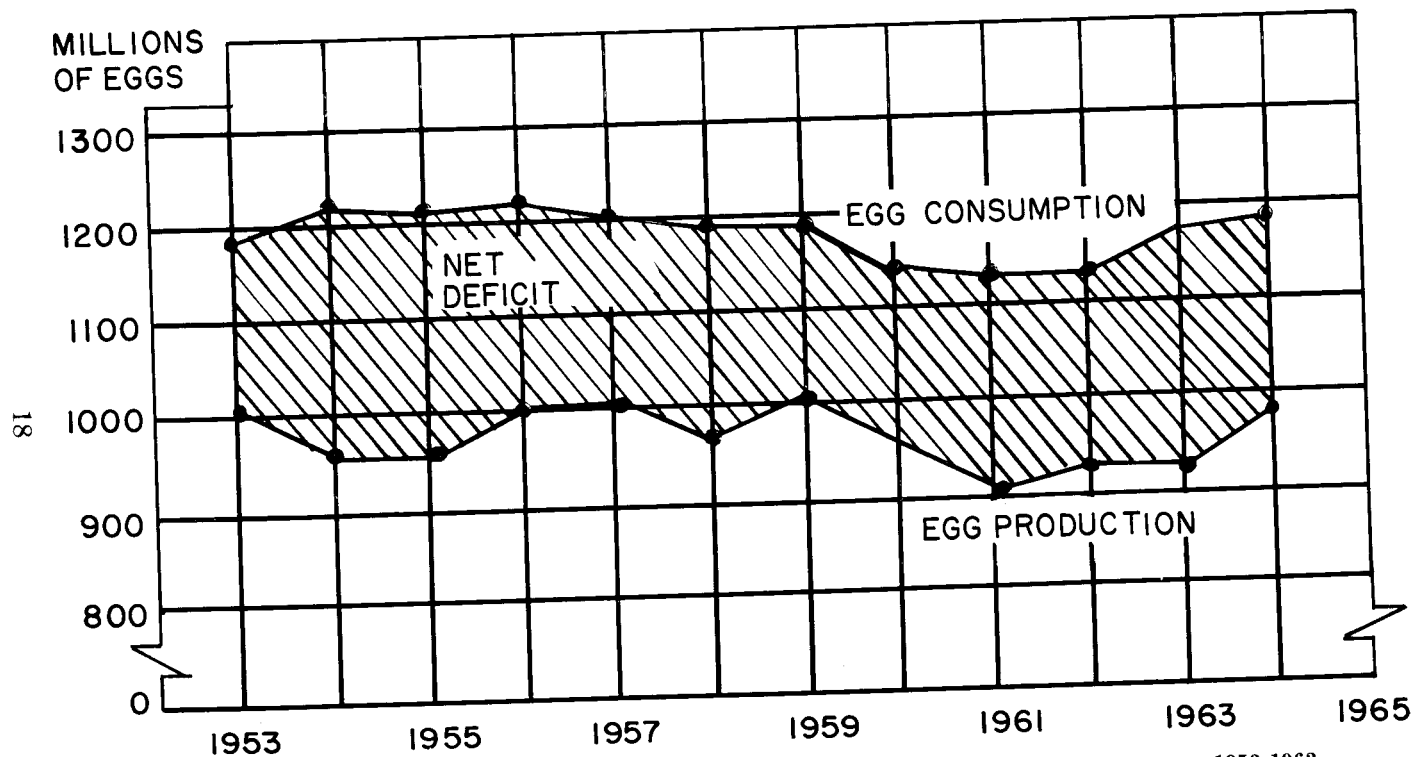


Figure 5. Production, consumption, and estimated net deficit in commercial eggs, Tennessee, 1953-1962.

TRANSFER TIME AND COST ESTIMATES FOR EGGS

In this study transfer costs for eggs are expressed in cents per case. Transfer-cost functions normally contain components that remain constant regardless of the length-of-haul and components that vary with distance.

Fixed cost components. Fixed costs remain constant regardless of length of haul, and include terminal costs, docking charges, time depreciation of equipment, insurance, taxes, licenses, and specialized labor. Some of these fixed cost elements may become variable under vehicle leasing arrangements.

Variable cost components. Variable costs or line-haul costs include all trucking costs that vary with the length of haul. Costs falling into this category include driver's wages, fuel, lubricants, vehicle maintenance, tires and tubes, certain taxes,¹¹ and wear depreciation. The proportion of variable costs to total costs varies considerably within the trucking industry, but present evidence indicates that it is lower than in other common modes of land transportation. The prime effect of the Interstate Highway System on total per unit trucking costs will be made through decreases in certain of these variable cost components. While these costs vary with length of haul, they are inelastic with respect to the size of the payload.

OTHER FACTORS AFFECTING TRANSPORTATION COST FOR EGGS

Several other factors influence the cost of transporting eggs. Two of the most important of these are whether eggs comprise the forward or back-haul for the vehicle and the number of unladen miles traveled by the vehicle. Rates for back-hauls are normally less than forward haul rates because most of the vehicular costs will be incurred whether the truck returns laden or unladen. A rational operator would, therefore, carry a back-haul as long as receipts covered the out-of-pocket costs incurred in moving it and contribute something to the other costs of returning the vehicle.

Table 4 shows the tonnage and direction of haul for poultry

¹¹Ton-mile taxes and gasoline taxes.

and eggs in 1960. There is considerable variation in the percentages of poultry and egg movements when classified by direction of haul. The South Central states have the largest volume of outbound traffic, comprising 95.9 percent, and the Western states have the smallest proportion at 44.5 percent.

Even though the proportion of unladen miles also contributes to the total cost of moving eggs by truck, all costs of operating

Table 4. Tonnage and percentage of poultry and eggs hauled by truckers in the continental United States by region of home office and direction of haul, 1960

Regions of home office and direction of haul	Tons	Percent
North Atlantic		
Outbound	18,373	48.3
Homebound	20,185	51.7
Total	39,058	100.0
East North Central		
Outbound	45,087	91.1
Homebound	4,420	8.9
Total	49,507	100.0
West North Central		
Outbound	142,019	79.5
Homebound	36,599	20.5
Total	178,618	100.0
South Atlantic		
Outbound	115,466	90.0
Homebound	12,766	10.0
Total	128,232	100.0
South Central		
Outbound	58,136	95.9
Homebound	2,493	4.1
Total	60,629	100.00
Western		
Outbound	1,722	44.5
Homebound	2,146	55.5
Total	3,868	100.0
United States		
Outbound	381,303	82.9
Homebound	78,609	17.1
Total	459,912	100.0

Source: Economic Research Service, Marketing Economics Division, U. S. Department of Agriculture, *For Hire Motor Carriers Hauling Exempt Agricultural Commodities, Nature and Extent of Operations*, Marketing Research Report No. 585 (Washington: Government Printing Office, 1963), p. 33.

the vehicle must be charged against the payload it carries. Any time a vehicle operates empty for considerable distances, there must be a corresponding adjustment in tariffs for the commodity handled. The average miles traveled by loaded and empty trucks, by regions of the continental United States in 1960, are shown in Table 5.

Truckers in the South carrying eggs on regular weekly or semi-weekly schedules tend to specialize in moving eggs and generally return to the South unladen or hauling empty cartons or cases. This could be explained by the time factor. These specialized egg-marketing firms operate on a very tight schedule; therefore they do not have time to wait for a profitable back-haul or to trip-lease their vehicles to some other trucking firm for the return trip.

PRE-INTERSTATE HIGHWAY SYSTEM TRANSFER COST ESTIMATES

An estimating equation was used to relate transfer costs to distance traveled for the several routes because of the lack of uniform data on the cost of moving eggs over the various routes in the egg-trading system. This technique required several simplifying assumptions about the egg economy:

- 1) Equivalent charges were made for similar distances traveled regardless of point of origin, destination, or direction of haul.¹²
- 2) Charges included a fixed docking charge plus a variable or line-haul component.
- 3) Per-mile charges decreased with increases in the length-of-haul.

¹²Highway distance estimates between origins and destinations were obtained from the **Rand McNally Commercial and Marketing Atlas** in the following manner: estimates of air distance between shipping and receiving points were obtained by applying the scale of miles in the map legend; the resulting air mileages were converted to highway mileages by the following relationship.

$$D_r = 1.19 D_a^*$$

where

D_r = highway miles

D_a = air miles

*Source: Gene A. Mathia and R. A. King, **Planning Data for the Sweet Potato Industry, Part 3, Selection of the Optimum Number, Size and Location of Processing Plants in Eastern North Carolina**, Agricultural Economics Information Series No. 97 (Raleigh: North Carolina State University, 1962), p. 18.

Table 5. Number of trucks, miles traveled laden and empty, average miles per vehicle, and percentage of miles laden per vehicle by region of trucker's home office, United States, 1960

Region of home office	Total tractors and straight trucks	Laden Miles	Average per vehicle	Unladen Miles	Average per vehicle	Total Miles	Average per vehicle	Per-cent laden
North Atlantic	502	14,133,901	28,155	7,348,280	14,638	21,482,181	42,793	65.8
East North Central	775	21,141,767	27,280	11,918,054	15,378	33,059,821	42,658	64.0
West North Central	1,414	47,965,830	33,922	22,312,009	15,779	70,277,839	49,701	68.3
South Atlantic	1,070	43,869,257	40,999	17,571,441	16,422	61,440,698	57,421	71.4
South Central	718	36,881,519	51,367	14,323,553	19,949	51,025,072	71,316	72.0
Western	651	30,371,713	46,654	9,937,429	15,265	40,309,142	61,919	75.3
Total	5,130	194,363,987	37,888	83,410,766	16,529	227,774,753	54,147	70.0

Source: Economic Research Service, Marketing Economics Division, United States Department of Agriculture, **For Hire Motor Carriers Hauling Exempt Agricultural Commodities, Nature and Extent of Operations,**

Marketing Research Report No. 585 (Washington: Government Printing Office, 1963), p. 39.

The basic transfer cost function chosen was obtained from a North Carolina study.¹³ The equation took the following form:

$$Y = 70.2242 + .0214202679X - .0000030829X^2$$

where Y = transportation rate in cents per case and

X = estimated highway distances between the various origins and destinations.

This second-degree transfer-cost function yielded a correlation coefficient of 90.3 in that study.

The possibility of adjusting the cost function to take account of price increases in the economy since 1959 was examined and rejected because the wholesale price index remained relatively constant over this period.¹⁴

TRANSIT TIME REQUIREMENTS FOR EGGS

The time required to transport eggs from a specified point of origin to a given destination is a function of the distance traveled and the rate of vehicular speed. An investigation was made to determine the effects of the Interstate Highway System on the transfer time requirements for eggs. This study consisted of two parts: the effects of the new highways on the alignment of principal routes among important cities in the continental United States, and the effects of the new highways on the average rates of speed of various types of private and commercial vehicles.

Effects of the interstate system on route alignment. No appreciable change in route alignment could be attributed to the Interstate Highway System. Straight line air distances in statute miles were used as indices of optimum alignment. Sample conventional and interstate routes were compared with direct airline routes to estimate the alignment of the two systems.

Comparison of direct airline distances and similar routes using

¹³A. P. Stemberger, *North Carolina Eggs in Interregional Competition*, Agricultural Economics Information Series No. 73 (Raleigh: North Carolina State University, 1960), p. 34.

¹⁴The wholesale price index is a continuous statistical series published by the Bureau of Labor Statistics and is designed to measure average changes in prices of commodities sold in primary markets in the United States. The index had a value of 100.6 in both 1959 and 1962 (1957-59 = 100).*

*Source: United States Department of Commerce, *Statistical Abstract of the United States*, 1963 (Washington: Government Printing Office, 1963).

the Interstate Highway System yielded the following relationship:¹⁵

$$D_i = 1.196 D_a$$

where D_i = interstate highway miles, and
 D_a = direct airline miles

On the basis of these relationships, it may be assumed that any decreases in transit time requirements brought about by the new highway network are due primarily to increased vehicle speed.¹⁶

Effects of the interstate system on vehicle speeds. The Interstate Highway System should increase vehicular speeds through reductions in traffic congestion, signal stops, traffic slowdowns, maximum grade specifications, and sharp curves. Eliminating intersections at grade, limiting access points, and improving roadway surfaces also affect vehicular movements. In order to arrive at a plausible estimate of the time savings due to the construction of the new system, weighted averages of the speeds of trucks over conventional and interstate system routes were obtained from U. S. Department of Commerce data (Table 6).¹⁷ The

¹⁵From a sample of 250 paired observations. The equation was statistically adjusted to force it through the origin. The resulting correlation coefficient was .990.

¹⁶The above equation was compared with the conventional road equation presented in footnote 12. There was no significant difference in the coefficients of these two equations at the 1% significance level.

¹⁷The weightings consisted of the proportions of the total national highway network falling into each category listed in Table 6.

Table 6. Average speeds of common motor vehicles by type of highway, 1963

Type of highway	Av. vehicular speed in miles per hour	All vehicles	Passenger cars	Trucks Buses
Rural interstate completed	59.5	60.8	53.9	60.7
Rural interstate not completed	54.2	55.5	49.6	54.7
Urban interstate completed	51.6	52.6	48.0	52.9
Urban interstate not completed	43.6	44.4	41.1	42.8
Suburban interstate completed	50.2	50.4	49.7	56.7
Main rural	55.6	56.9	51.1	57.7
Rural secondary	48.2	49.0	45.4	44.6
Urban primary	47.9	48.6	45.0	47.9
Urban secondary	35.1	35.7	35.8	31.2
Suburban primary	46.3	47.0	45.0	56.7
Suburban secondary	43.2	43.5	42.5	38.2

Source: United States Department of Commerce, *Traffic Speed Trends* (Washington: Government Printing Office, March, 1964), p. 4.

weighted averages yielded mean speeds of 47.2 miles per hour for trucks moving over conventional roads and 53.1 miles per hour over interstate highways. This speed differential of 5.9 miles per hour was used in the estimating equation relating time consumption over the interstate system to the time consumption for similar trips over the conventional road network.¹⁸

The most important factors determining the impact of the new highway system on the distribution of shipments in the national egg trading system are the decrease in required transit time and the accompanying reduction in the transfer costs for eggs. Table 7 shows the estimated value of a one minute reduction in the required travel time for different motor vehicles. These value data can be combined with the equations in order to estimate the value of the respective time decreases.¹⁹

EFFECTS OF THE INTERSTATE HIGHWAY SYSTEM ON TRANSFER COSTS

The next phase in deriving the transfer cost function for moving commercial eggs from surplus to deficit areas over the Interstate Highway System consisted of combining the estimated value of the proportionate decrease in transit time with the original transfer cost function. It was necessary, however, to convert these functions to a similar base before combining them. The simplest method of conversion consisted of multiplying the original cost function by the average number of cases per truckload.²⁰ Since

¹⁸The basic relationship is expressed in simple functional form below. (Time functions for other vehicles may be constructed in similar manner.)

$$T_i = .875 T_r$$

where T_i is the mean time requirement for a truck moving over an Interstate Highway System route, and

T_r is the mean time requirement for a truck moving over a corresponding conventional route.

¹⁹For a tractor semi-trailer combination, the value of time saved function assumes the form indicated below:

$$V_{ti} = 6.08 (.125 T_r)$$

which reduces to

$$V_{ti} = .760 T_r$$

This estimate is derived by multiplying the value of a minute saved in transit time by the proportionate time saving that can be attributed to the Interstate Highway System.

²⁰The average number of cases, 672 cases of eggs per load, was determined from firms in the Knoxville, Tennessee, area. The range, however, extended from 600 cases to 756 cases. The resulting equation is:

$$Y = 47191 + 14.39442003X - .00207171X^2$$

where

Y = transfer cost in cents per truckload

X = highway distance in miles.

Table 7. Estimates of the value of a reduction in time consumption to users of highway vehicles, 1961

Type of vehicle	Value of a reduction in time consumption per vehicle in cents per minute
Passenger cars	2.37
Buses:	5.77
Local and suburban	7.52
Intercity	
Single unit trucks:	4.75
2-axle, 4 tire	5.02
2-axle, 6 tire	5.78
3-axle	
Tractor-semi-trailer combination: ^a	5.53
2-S1	6.08
2-S2	6.50
3-S2	
Truck, full-trailer combinations:	5.52
2-1	6.52
2-2	6.67
2-3	6.75
3-2	6.87
6 axles or more	
Tractor-semi-trailer and full trailer combinations, all units	7.13

a. The combined numerical and letter designation refers to the number of axles the vehicle possesses. For example, 2-S1 refers to a tractor with two axles and a semi-trailer with one axle. Likewise the designation 2-1 refers to a tractor with two axles and a full trailer with one axle.

Source: United States Department of Commerce, **Final Report of the Highway Cost Allocation Study** (Washington: Government Printing Office, 1961), p. 209.

the Interstate Highway System is expected to make its greatest contribution to transfer cost reduction by lowering line-haul costs, the original cost function was partitioned into a fixed cost component and two cost coefficients that varied with distance.²¹

²¹Since the original transfer cost function was derived by regression techniques from a mail questionnaire (Stemberger, *op. cit.*, p. 34) on actual rates charged by firms rather than budgeting the various costs of hauling eggs by truck, it was not feasible to quantitatively estimate the effects of the interstate system on the fixed costs of hauling eggs by truck. It is known, however, that the interstate system contributes to longer useful lives of vehicles, so the fixed costs would be influenced.

The effects of this cost reduction on over-the-road costs can be estimated by multiplying the variable components of the original transfer cost function by the cost-savings factor as follows (Data are in cents per case.):

$$Y_1 = 47191. + .760 (14.39442008X - .002071717171X^2)$$

which simplifies to

$$Y_1 = 47191. + 10.93975922X - .0015744996X^2$$

and converting to cents per case

$$Y_1 = 70.2242 + .0162794036X - .0000023430X^2$$

where

Y_1 = the transfer cost in cents per case utilizing the Interstate Highway System and

X = highway distance in miles.

This cost function was used to estimate projected changes in optimum flows of commercial eggs and the associated equilibrium price differentials.

OPTIMUM ROUTING OF COMMERCIAL EGG SHIPMENTS

In this study only the role of transportation and its associated costs were considered.²² The perfect market was used as a standard by which to evaluate the pricing efficiency of the commercial egg industry. In a perfect market, location and distance affect prices in both consuming centers and producing areas through transfer costs.

A system of egg shipments was considered optimum when no alternative shipping pattern would yield a reduction in the total transfer charges under the existing conditions. Accompanying the optimum shipping patterns were sets of equilibrium price differentials which the several markets tended to approximate because of the profit motive of entrepreneurs and competition between them. The strengths of the forces affecting changes in the system under different conditions could be approximated by the opportunity costs of non-optimum actions.

Comparison of Optimum Commercial Egg Shipping Patterns Before and After the Interstate System

The least-cost shipping pattern for commercial eggs over the conventional highway net yielded the flows represented in Figure 6. The two largest suppliers of the Northern and Northeastern deficit areas were the South and the Midwest.

The least-cost shipping pattern for commercial eggs utilizing the interstate highway network is indicated by the flow diagram in Figure 7. These new equilibrium flows represent only a slight departure from the conventional highway shipping pattern. The two largest supply regions for the northeastern markets remained the South and the Midwest. The proportion of shipments from the respective origins to the several destinations remained relatively constant.

An example of the moderate changes in routing of shipments which did occur is illustrated by the fact that the Little Rock, Arkansas area diverted commercial egg shipments which had previously gone to the New York City area and the Dallas-Fort Worth,

²²Commercial egg marketing spreads were considered to be similar throughout the national egg-trading system.

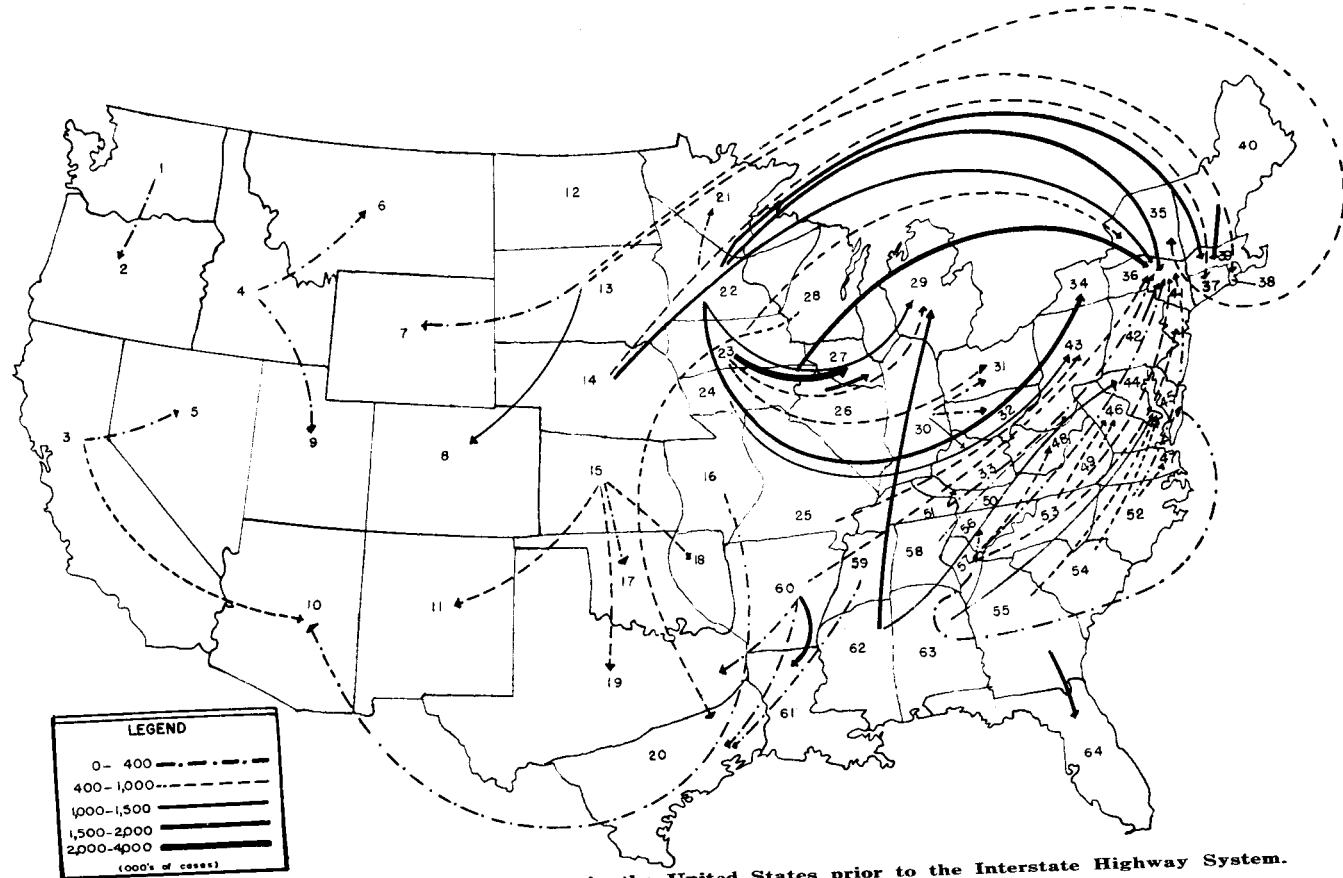


Figure 6. Optimum flows of commercial eggs in the United States prior to the Interstate Highway System.

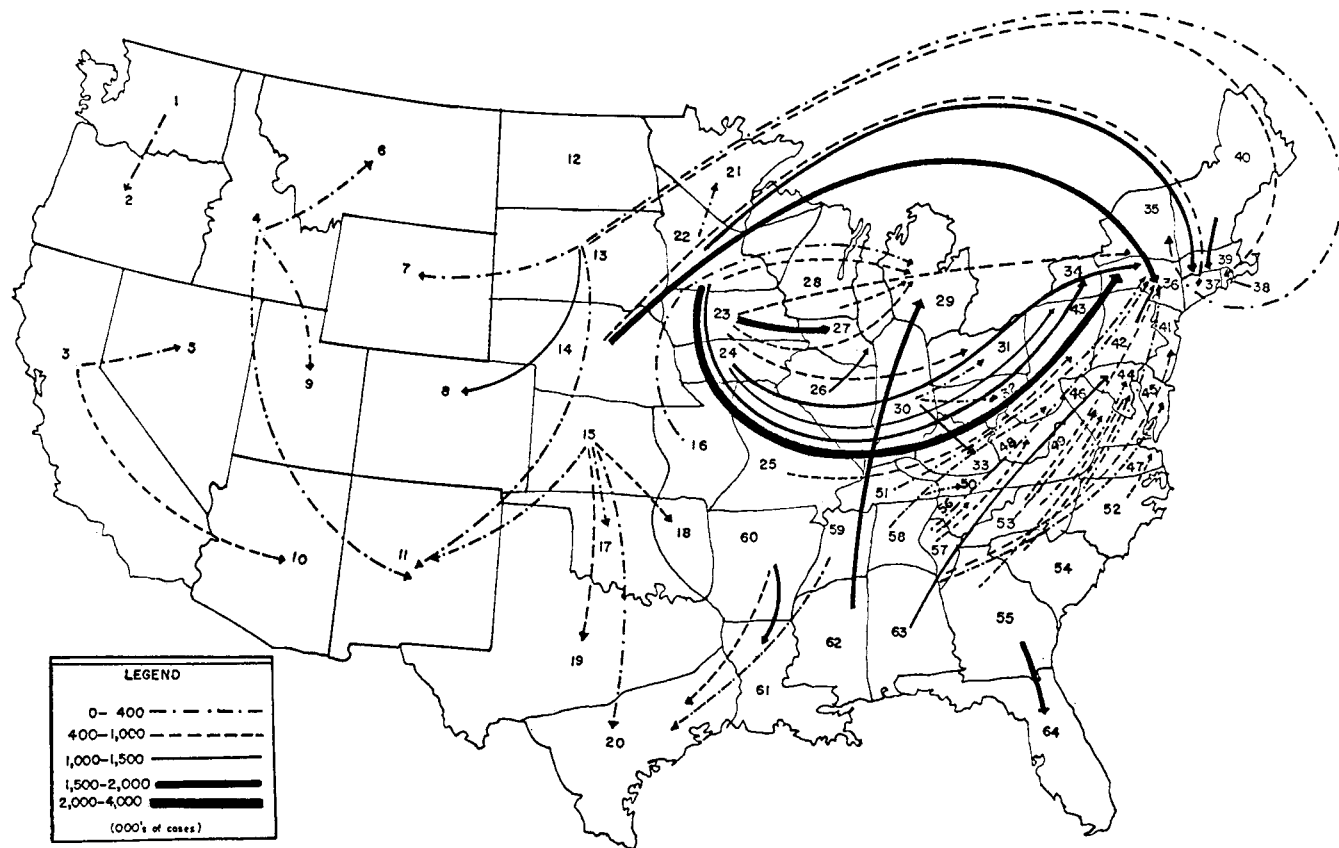


Figure 7. Optimum flows of commercial eggs in the United States with the Interstate Highway System completed.

Texas area into San Antonio, Texas. This was the only significant shift in egg flows that affected the southeastern egg-producing region. The shipping patterns for Chattanooga, Memphis, Knoxville, and Nashville, Tennessee were unchanged by the new road net.

The estimated price differentials associated with the two solutions of the transportation model are shown in Tables 8 and 9.

Table 8. Comparison of estimated price differentials among commercial egg markets with optimum routing of shipments and New York City as a base

and New York City as a base				
Market	Conventional highways alone	Interstate Highway System	Signed difference	
			Positive	Negative
Dollars per case				
Portland, Ore.	a	a		a
Carson City, Nev.	a	a		a
Helena, Mont.	a	— .146		a
Cheyenne, Wyo.	— .186	— .141		— .045
Denver, Colo.	— .165	— .125		— .040
Salt Lake City, Utah	a	— .144		a
Phoenix, Ariz.	a	a		a
Santa Fe, New Mexico	— .117	— .086		— .031
Oklahoma City, Okla.	— .198	— .147		— .051
Tulsa, Okla.	— .202	— .150		— .052
Dallas, Texas	— .152	— .112		— .040
San Antonio, Texas	— .105	— .073		— .032
Duluth, Minn.	— .181	— .137		— .044
Chicago, Ill.	— .143	— .107		— .036
Detroit, Mich.	— .090	— .068		— .022
Cleveland, Ohio	— .076	— .057		— .019
Columbus, Ohio	— .097	— .073		— .024
Cincinnati, Ohio	— .111	— .084		— .027
Rochester, N. Y.	— .039	— .029		— .010
Utica, N. Y.	— .014	— .011		— .003
Hartford, Conn.	+ .009	+ .007	+ .002	
Providence, R. I.	+ .017	+ .013	+ .004	
Boston, Mass.	+ .017	+ .013	+ .004	
Newark, N. J.	— .005	— .003		— .002
Pittsburgh, Pa.	— .056	— .042		— .014
Baltimore, Md.	— .035	— .027		— .008
Wilmington, Del.	— .023	— .017		— .006
Washington, D. C.	— .044	— .033		— .011
Richmond, Va.	— .066	— .050		— .016
Charleston, W. Va.	— .096	— .073		— .023
Louisville, Ky.	— .133	— .101		— .032
Knoxville, Tenn.	— .144	— .109		— .035
Baton Rouge, La.	— .150	— .107		— .043
Tampa, Fla.	— .082	— .062		— .020
New York, N. Y.	.000	.000		.000

a. Data were not available for computing values.

These tables may be read as follows: Table 8 indicates that prior to the Interstate Highway System, the equilibrium price of eggs in the Knoxville, Tennessee market would be 14.4 cents per case lower than the price in New York, and that after the new highways are completed the price would be 10.7 cents lower due to location alone.

According to Table 9, the equilibrium price of eggs at the Macon, Georgia shipping point would be 87.7 cents per case below the New York price using conventional highways and 83.5 cents

Table 9. Comparison of estimated price differentials among designated commercial egg shipping points with optimum routing of shipments and New York City as a base

Shipping point Observations	Before interstate system	After interstate system	Signed difference	
			Positive	Negative
Dollars per case				
1. Seattle, Wash.	a	a		a
3. Sacramento, Calif.	a	a		a
4. Boise, Idaho	a	.903		a
12. Bismark, N. D.	a	a		a
13. Pierre, S. D.	—.969	—.905		—.064
14. Lincoln, Neb.	—.947	—.888		—.059
15. Wichita, Kan.	—.938	—.878		—.060
16. Kansas City, Kan., Mo.,	a	—.851		a
22. Minneapolis-St. Paul, Minn.	a	a		a
	—.917	—.865		—.052
23. Mason City, Iowa	—.915	—.864		—.051
24. Des Moines, Iowa	—.918	—.866		—.052
25. St. Louis, Mo.	—.887	—.842		—.045
26. Peoria, Ill.	—.879	—.835		—.044
28. Milwaukee, Wis.	—.741	—.818	+.077	a
30. Indianapolis, Ind.	—.841	—.807		—.034
40. Lewiston, Maine	—.718	—.714		—.004
42. Philadelphia, Pa.	—.724	—.718		—.006
49. Roanoke, Va.	—.793	—.771		—.022
51. Paducah, Ky.	—.880	—.837		—.043
52. Raleigh, N. C.	—.803	—.779		—.024
53. Charlotte, N. C.	—.826	—.796		—.030
54. Columbia, S. C.	—.843	—.810		—.033
55. Macon, Ga.	—.877	—.835		—.042
57. Chattanooga, Tenn.	—.871	—.830		—.041
58. Nashville, Tenn.	—.868	—.828		—.040
59. Memphis, Tenn.	—.849	—.807		—.042
60. Little Rock, Ark.	—.927	—.866		—.061
62. Jackson, Miss.	—.871	—.830		—.041
63. Montgomery, Ala.	—.822	—.794		—.028

a. The data were not available for computing values.

per case utilizing the Interstate Highway System because of their locations.

The average market price differential which can be attributed to location is 1.8 cents per case less under the Interstate System than under the conventional road net. The average producer price differential observed was 82.8 cents, or 3.1 cents less in the second solution.

The highest cost indicated for using a non-optimum route excluding the Interstate highways was 49.1 cents per case or 1.64 cents per dozen eggs. In most cases the opportunity costs were less than one-half cent per dozen. Table 10 shows the estimated opportunity costs of choosing selected routes.

Table 11 indicates the opportunity costs of shipping between the same origins and destinations over the Interstate Highway System. In this instance the highest cost of utilizing a non-optimum route was estimated to be 39.4 cents per case or 1.32 cents per dozen eggs. Thus, moderate economic pressure exists to force egg producers to utilize the optimum routes.

COMPARISON OF THE EQUILIBRIUM PRICE DIFFERENTIALS BEFORE AND AFTER INITIATION OF THE INTERSTATE SYSTEM

It is possible under certain circumstances for price effects to be present when the effects on shipping patterns are absent. To determine if the projected changes in transfer costs had a significant effect on price differentials, the sign test was chosen.²³

In Table 8 positive signs occurred in three instances out of a total of 30 observations, indicating a significant difference at the 99 percent level. The sign test of producers price differentials

²³Since the data allow little grounds for assuming a normal distribution of observations, to be consistent with statistical theory, a non-parametric technique is required. See Dixon and Massey, *Introduction to Statistical Analysis*, pp. 247-254. This technique pairs the estimated price differentials before and after the Interstate Highway System and the researcher can note the positive or negative signs obtained. The sign occurring less frequently was designated by the letter r. The total value of r was determined and referred to an appropriate statistical table containing critical values of r for various significance levels and sample sizes. No computations of sample means or variances were required.

Table 10. Estimated added cost of hauling over non-optimum routes rather than over-optimum routes, representative commercial egg markets in the United States utilizing the conventional highway net^a

Importing region	Tampa, Fla.	Denver, Colo.	Ft. Worth- Dallas, Texas	Cheyenne, Wyo.	Chicago, Ill.	Cleve- land, Ohio	New York, N.Y.	Balti- more, Md.	Washing- ton, D.C.	Knox- ville, Tenn.
Pierre, S. D.	.106	.000	.070	.000	.025	.017	.005	.002	.032	.098
Lincoln, Neb.	.086	.025	.040	.042	.013	.007	.000	.017	.024	.078
Wichita, Kan.	.079	.033	.000	.060	.045	.034	.022	.035	.041	.077
Minneapolis-St. Paul, Minn.	.134	.109	.124	.117	.013	.005	.000	.026	.029	.104
Mason City, Iowa	.120	.098	.108	.114	.000	.000	.004	.022	.034	.092
Des Moines, Iowa	.105	.086	.080	.101	.002	.002	.000	.018	.021	.076
St. Louis, Mo.	.088	.156	.094	.179	.021	.006	.005	.017	.018	.052
Peoria, Ill.	.118	.169	.132	.185	.000	.029	.003	.017	.022	.075
Milwaukee, Wis.	.277	.325	.307	.356	.127	.121	.130	.146	.155	.234
Indianapolis, Ind.	.137	.243	.189	.258	.046	.000	.014	.021	.026	.078
Lewiston, Maine	.329	.472	.442	.491	.325	.203	.054	.132	.151	.329
Philadelphia, Pa.	.265	.449	.388	.453	.270	.140	.000	.038	.053	.249
Roanoke, Va.	.137	.346	.281	.365	.175	.058	.009	.001	.000	.112
Paducah, Ky.	.073	.185	.107	.204	.035	.015	.000	.012	.014	.034
Raleigh, N. C.	.121	.347	.271	.368	.188	.076	.000	.000	.001	.115
Charlotte, N. C.	.083	.310	.228	.332	.154	.055	.000	.000	.000	.065
Columbia, S. C.	.047	.298	.216	.319	.153	.059	.005	.000	.003	.058
Macon, Ga.	.000	.250	.153	.273	.119	.043	.081	.000	.002	.026
Chattanooga, Tenn.	.038	.232	.140	.253	.093	.024	.000	.000	.001	.000
Nashville, Tenn.	.062	.216	.128	.238	.074	.018	.003	.010	.009	.018
Memphis, Tenn.	.092	.214	.115	.242	.115	.078	.066	.068	.073	.086
Little Rock, Ark.	.028	.112	.000	.143	.045	.016	.000	.011	.012	.032
Jackson, Miss.	.046	.206	.083	.234	.129	.085	.092	.072	.067	.083
Montgomery, Ala.	.057	.285	.178	.314	.176	.111	.080	.000	.083	.094

a. These values were obtained by subtracting the equilibrium transfer costs from the actual transfer costs between the various surplus and deficit areas. Values in bold type indicate routes which appeared in the

optimum solution of the transportation model. Other zero entries indicate alternate routes which could have been utilized without increasing the total transfer costs for the system.

Table 11. Estimated added cost of hauling over non-optimum routes rather than over optimum routes, representative commercial egg markets in the United States utilizing the Interstate Highway System

Importing region	Tampa, Fla.	Denver, Colo.	Ft. Worth- Dallas, Texas	Cheyenne, Wyo.	Chicago, Ill.	Cleve- land, Ohio	New York, N.Y.	Balti- more, Md.	Washing- ton, D.C.	Knox- ville, Tenn.
Pierre, S. D.	.080	.000	.050	.000	.018	.012	.003	.017	.024	.080
Lincoln, Neb.	.066	.019	.027	.032	.008	.005	.000	.014	.018	.059
Wichita, Kan.	.063	.028	.000	.049	.036	.029	.020	.030	.034	.040
Minneapolis-St. Paul, Minn.	.102	.083	.091	.089	.009	.003	.000	.021	.022	.079
Mason City, Iowa	.091	.074	.078	.086	.000	.000	.003	.017	.025	.069
Des Moines, Iowa	.080	.066	.057	.077	.000	.001	.000	.014	.016	.057
St. Louis, Mo.	.067	.119	.069	.136	.015	.004	.004	.014	.014	.040
Peoria, Ill.	.091	.130	.099	.142	.000	.023	.004	.015	.018	.058
Milwaukee, Wis.	.124	.160	.144	.184	.008	.005	.012	.025	.031	.091
Indianapolis, Ind.	.105	.185	.141	.197	.034	.000	.012	.017	.020	.059
Lewiston, Maine	.250	.359	.333	.373	.245	.153	.042	.101	.115	.250
Philadelphia, Pa.	.202	.342	.292	.345	.205	.107	.000	.030	.041	.190
Roanoke, Va.	.104	.262	.210	.277	.132	.043	.007	.001	.000	.085
Paducah, Ky.	.055	.140	.078	.155	.025	.011	.000	.010	.010	.026
Raleigh, N. C.	.091	.263	.202	.279	.141	.057	.000	.000	.000	.087
Charlotte, N. C.	.063	.235	.170	.252	.116	.041	.000	.000	.000	.049
Columbia, S. C.	.035	.225	.160	.241	.114	.043	.003	.000	.001	.043
Macon, Ga.	.000	.190	.113	.207	.089	.032	.062	.000	.001	.019
Chattanooga, Tenn.	.029	.176	.104	.192	.069	.018	.000	.000	.001	.000
Nashville, Tenn.	.047	.164	.094	.181	.053	.013	.002	.008	.007	.013
Memphis, Tenn.	.007	.169	.091	.190	.092	.066	.057	.059	.062	.071
Little Rock, Ark.	.028	.092	.003	.115	.040	.019	.007	.016	.015	.031
Jackson, Miss.	.035	.157	.060	.178	.097	.064	.070	.056	.051	.063
Montgomery, Ala.	.042	.216	.131	.237	.132	.083	.060	.000	.062	.071

(Table 9) yielded only one positive sign out of 24 observations. This was also significant at the 99 percent level.

The largest observed difference in market prices relative to New York City which can be attributed to the Interstate Highway System occurred in Tulsa (Table 8). However, this amounted to only 5.2 cents per case. Pierre, South Dakota, showed the largest price difference of any of the shipping points for which data were available (Table 9). There were technical limitations to calculating the equilibrium price differentials for certain western cities which theoretically could have yielded greater differences. These price differences, however, are not expected to exceed 10 cents per case under the present assumptions regarding transfer costs.

CONCLUSIONS

Since World War II, Tennessee has been deficit in egg production, and this condition is expected to continue. The ready availability of eggs from the surplus states to the East, South, and West of Tennessee will tend to prevent any significant increase in the farm prices of Tennessee eggs above the prices in surrounding areas. Any shifts in the concentration of egg production in the State will possibly be due to local changes in the profitability of egg production relative to alternative farm enterprises.

The primary effect of the Interstate Highway System on the transit time requirements of vehicles was found to be due to speed rather than distance. No significant change in route alignment could be attributed to the interstate highway net. A speed differential of 5.9 miles per hour was obtained for tractor-semi-trailer combinations moving over the interstate system as compared to the conventional road net.

The effects of the Interstate Highway System on the optimal routing of commercial egg shipments was found to be slight. Using 1962 data, the total interregional transportation bill for commercial eggs under the conventional road net was \$38,046,656. Use of the Interstate Highway System for moving the same quantity of eggs resulted in a transportation bill of \$36,811,755, or a saving of \$1,234,900. There were no data on a nationwide scale with which to compare the optimal shipping patterns. This lack of actual data required the use of indirect methods for comparing shipments over non-optimum routes with the least cost shipping patterns.

Equilibrium price differentials were estimated under both situations with New York City as a base for the several markets and shipping points. The Interstate Highway System was found to have significantly reduced the price differentials in these geographically separated markets. It was also found that the highest cost of utilizing a non-optimum route was 49.1 cents per case under the conventional road net and 39.6 cents per case under the interstate system.

It was found that while statistically significant differences in transfer cost did occur, these differences were not great and may be easily dissipated by inefficiencies in other areas of the

egg-marketing process. Attention should also be called to the fact that any economies of transfer due to the Interstate Highway System will accrue gradually over time as more of the routes become operational. Marketing firms will, therefore, have several years in which to make any necessary adjustments in their shipping practices.

The conclusions drawn from this study are conservative ones based on theoretical considerations and should be used only to indicate the direction of commodity and price movements, not the magnitudes of such movements. Additional research should be carried out in the area of trucking cost determination through engineering analysis and personal survey of truckers primarily engaged in the transportation of agricultural commodities. This would be necessary before the quantitative effects of the Interstate Highway System on an area can be estimated with reasonable certainty.

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