7. Turkey Slaughter Cost Estimation

Structural changes in the turkey slaughter industry were remarkably similar to those in the chicken slaughter industry. During the 25 years prior to 1992, total turkey production more than tripled and an average turkey plant's share of output from further-processed turkey products more than quadrupled to about 18 percent (Census estimates).

In this chapter, a translog cost model is used to examine scale economies in turkey slaughter. The data include all plants with more than 50 percent of their output from turkey slaughter products that reported turkey slaughter product shipments in the Census of Manufactures for 1967, 1972, 1977, 1982, 1987, and 1992—a total of 314 plants.

Model Selection

The procedures and table formats that were used in chapter 6 are also employed in this chapter. Table 7-1 contains the model description, the G-J statistic, and the number of parameters estimated for eight variations of the cost model. Table 7-2 includes information used to evaluate model fit.

Models are rejected or not rejected based on the manner in which they affect model fit and their consistency with economic theory. As shown in table 7-2, Model II has a better fit than Model I, and Model III has the best fit of the data. Thus, bulk output share, seasonality, and whole-bird output share significantly affect plant costs, but single-plant firm status and turkey meat input mix do not. Although seasonality does not meet the rejection threshold of a 99-percent level of confidence, it does meet the less restrictive criterion of a 95-percent level. It is retained in order to illustrate that more balanced production schedules do affect plant costs, although only in a small way.

Table 7-1: Goodness- of-fit statistics for the turkey slaughter cost function models

Model	Description	G-J statistic	Parameters estimated
I	Translog, factor prices and output only	1133	15
II	Adds plant bulk output share and seasonality to I	1100	28
III	Adds whole-bird output share to II	1076	33
IV	Adds poultry meat input mix to III	1086	41
V	Adds single establishment to III	1071	38
VI	Removes seasonality from III	1092	26
VII	Removes plant bulk output share from III	1111	26
VIII	Adds time to model II	1051	53
IIIH	Imposes homotheticity on III by removing factor price and output interaction terms	1096	30

Notes: There are 314 observations in the 1967, 1972, 1977, 1982, 1987, and 1992 Censuses.

Model VIII was rejected for reasons similar to those given for chicken slaughter, i.e., results suggest regressive technical change. If time-shift variables are included in the model, the whole-bird output share variable must be excluded because it and the time-shift variables are constant across plants in any given year, resulting in insufficient model variance and model collapse. However, if whole-bird output share is excluded, the temporal shift in production from whole birds to cut-up and deboned turkey over the 1967-92 period (table 4-4) is not accounted for and estimated production costs rise. We discuss this in more detail below.

The homotheticity assumption, i.e., factor shares do not vary with plant output, is imposed on Model III by removing the interactions between output and the three relevant factor prices from the model. Results of Model III versus Model IIIH suggest that the standard translog model is not homothetic, meaning that large and small plants use different proportions of labor, capital, and materials in their production technologies.

Summary of the Best Model

Tables 7-3 and 7-4 show the estimated coefficients of Model III and are organized like tables 6-3 and 6-4 for chicken. First-order coefficients can be interpreted as factor shares at the sample mean. Accounting for 66 percent of turkey slaughter costs in 1992, turkey meat inputs (PMEAT) dominate total plant costs and are similar, but somewhat smaller than chicken meat inputs. Turkey slaughter has a substantially higher share of other materials and modestly lower shares of labor and capital than chicken slaughter. These differences may be due to the relatively higher level of further processing in turkey slaughter (table 4-4).

The skewed distribution of factor shares gives rise to monotonicity violations. The estimated capital share was negative for about 6 percent of the plants, and the

Table 7-2: Hypothesis tests for the turkey slaughter cost model

Maintained hypothesis	Tested hypothesis	Parameter restrictions	Chi-square @ .99	Chi-square statistic	Status of tested model
Model II	Model I	13	27.7	33	Reject
Model III	Model II	5	15.1	24	Reject
Model IV	Model III	8	20.1	-10	Not Reject
Model V	Model III	5	15.1	5	Not Reject
Model III	Model VI	7	18.5	16	Reject[1]
Model III	Model VII	7	18.5	35	Reject
Model VIII	Model II	25	44.3	49	Reject[2]
Model III	Model IIIH	3	11.3	20	Reject

[1] Test hypothesis was rejected at the 95% level of confidence.
[2] Model VIII was rejected because it does not account for the shift to more cut-up and deboned turkey and less whole-bird production over the 1967-92 period, and very likely gives misleading results.
Notes: There are 314 observations in the 1967, 1972, 1977, 1982, 1987, and 1992 Censuses. Chi-square statistic is G-J statistic of tested hypothesis minus G-J statistic of maintained hypothesis.

Table 7-3: Turkey slaughter cost function parameter estimates: First-order terms and factor price interaction terms

	Interacted with				
Variable	1st order	PLAB	PMEAT	PMAT	PCAP
	Coefficients and standard errors				
Intercept	-0.208***	-	-	-	-
	(.018)				
PLAB	.131***	.053***	-.061***	-.008**	.017**
	(.005)	(.012)	(.010)	(.004)	(.007)
PMEAT	.662***		.161***	-.089***	-.011
	(.007)		(.013)	(.005)	(.007)
PMAT	.191***			.103***	-.006
	(.004)			(.003)	(.0035)
PCAP	.016***				-.0002[1]
	(.005)				
BULK	-.029				
	(.033)				
SEASON	.021				
	(.017)				
Q (lbs)	.919***				
	(.025)				
WHOLE	-.128**				
	(.050)				

* significant at 90% level;
** significant at 95% level;
*** significant at 99% level.
[1] Standard error could not be estimated.
Note: Translog cost function estimation for turkey slaughter, 1967-1992. There are 314 observations. Since all variables are standardized at their means, first-order coefficients can be interpreted as elasticities at the sample means.

Table 7-4: Turkey slaughter cost function parameter estimates: First-order terms and bulk output share,seasonality, output, and whole-bird output share interaction terms

	Interacted with				
Variable	1st order	B	S	Q	W
	Coefficients and standard errors				
Intercept	-0.208***	-	-	-	-
	(.018)				
PLAB	.131***	-.0082***	.0023	-.015***	.002
	(.005)	(.0026)	(.002)	(.005)	(.016)
PMEAT	.662***	.0081***	-.0061**	.0178***	.018
	(.007)	(.003)	(.003)	(.006)	(.019)
PMAT	.191***	-.0067***	.002	.0042	.004
	(.004)	(.002)	(.002)	(.004)	(.011)
PCAP	.016***	.0068***	.0018	-.007	-.022
	(.005)	(.002)	(.002)	(.005)	(.014)
BULK	-.029	-.002	-.004	-.002	-
	(.033)	(.008)	(.003)	(.007)	
SEASON	.021		.005	-.0015	-
	(.017)		(.005)	(.008)	
Q (lbs)	.919***			-.025	-.039
	(.025)			(.027)	(.056)
WHOLE	-.128**	-			
	(.050)				

* significant at 90% level;
** significant at 95% level;
*** significant at 99% level.
Note: Results of estimation of translog cost function for turkey slaughter plants, 1967-92. Since all variables are standardized at their means, first-order coefficients can be interpreted as elasticities at the sample means. Quadratic (on diagonal) and interaction terms from estimation of translog cost function.

estimated other materials share was negative for about 7 percent of the plants. Estimated labor and turkey meat input factor shares were never negative.

The interaction terms show how estimated elasticities (and factor shares) vary with movement away from sample means. Since bulk products require less labor and packaging materials than further-processed products, the coefficients on the interactions of plant bulk output share (BULK) with the prices of labor (PLAB) and other materials (PMAT)—mainly packaging materials—should have negative signs, and turkey meat inputs (PMEAT), positive signs. Results (table 7-4) are consistent with these hypotheses.

The coefficients for the interactions of output (Q) and factor prices (table 7-4) show how prices vary with plant size. For example, since the coefficient of the labor and output interaction term is negative, plants use relatively less labor as output grows, but there is less of a labor reduction for turkeys than for chickens. Interpreting results in this manner suggests that the labor share declines and the turkey meat factor share rises about 0.15 percent for each 10-percent increase in output. Results also suggest that the labor share of costs drops and the turkey meat factor cost share rises as industry whole-bird share of output rises.

The cost of birds as a share of total input costs is much higher than for other factors in turkey slaughter, and with the same implications as in the chicken slaughter industry. First, if total costs are dominated by meat purchase expenses, then substantial scale economies in slaughter and processing translate into small scale economies calculated on total costs. Second, wage changes will lead to small retail-price changes because wages are a small share of total costs. Finally, wage changes that are not passed through as product price changes can lead to large changes in returns on invested capital because the labor share of costs is six times larger than the capital share.

Own-Factor Price and Allen Elasticities

Cost function coefficients are used to calculate own- and Allen price elasticities (table 7-5). Own-price elasticities indicate how factor demand changes with prices, holding output constant. For example, own-price elasticities for labor (table 7-5) show that a 10-percent increase in the price of labor leads to a 4.6-percent decline in the demand for labor. The demand for labor is more sensitive to factor prices and demand for capital is less sensitive in turkey slaughter relative to chicken slaughter. Like chicken, the factor demand curves have downward slopes (all elasticities are negative), but the own-price elasticity for turkey meat is more inelastic, i.e., a change in price leads to smaller changes in quantity demanded. Compared with cattle and hog slaughter, own-price elasticities for turkey slaughter are much less inelastic. These differences may be due to differences in turkey-growing technologies compared with animal-growing operations for chickens, cattle, and hogs. Of the four industries, chicken slaughter plants have the greatest ability to control the relationship between meat factor prices and purchase decisions because they can directly influence purchase price through contractual specification of a growing technology. Turkey plants have less influence because more growers are independent, and cattle slaughter plants have the least control because slaughter plants must purchase animals at market prices. Thus, if chicken-growing technology changes, then chicken meat factor prices change for one plant, but if cattle-raising technology changes, all cattle slaughter plants are affected.

Positive Allen elasticities indicate substitutes, and negative elasticities indicate complements. The reported elasticity of 0.293 for labor and turkey meat inputs and 0.671 for labor and materials (table 7-5) means that 1-percent increases in each of these factors, holding output constant, results in 0.3- and 0.7-percent decreases in the demand for turkey meat inputs. All other Allen elasticities, except for capital and turkey meat inputs and capital and other materials, are substitutes—an outcome similar to that in the chicken industry.

Table 7-5: 1992 own-factor price and Allen elasticities evaluated at the sample mean for turkey slaughter

	Factor price variables			
	PLAB	PMEAT	PMAT	PCAP
Estimated factor shares	.131	.662	.191	.016
ϵ_{ii} (own-factor price)	-0.464	-0.094	-.269	-0.998
σ_{ij} (Allen)				
PLAB	-3.548	0.293	0.671	8.922
PMEAT		-0.143	0.294	-0.020
PMAT			-1.408	-0.813
PCAP				-62.86

Note: All values are evaluated at the sample mean using parameters from table 7-3. The own-price input demand elasticities (ϵ_{ii}) are calculated holding output and other factors constant, while the elasticities of substitution (σ_{ij}) are calculated using Allen's formula.

Scale Economies

The cost elasticity is estimated with equation 5-4 using the coefficients of the first-order output term and the second-order output term (table 7-4). Interactions between output and other model variables are ignored because competitive forces drive factor prices to similar levels and the other variables have very small coefficients.

The cost elasticity at sample mean prices and output is 0.919 (the first-order coefficient for Q in table 7-4). Holding all firm characteristics constant at their sample means, a 1-percent increase in output leads to a 0.919-percent increase in total costs.

Cost elasticities, an average cost index, and processing costs for various plant sizes are reported in table 7-6. The third column illustrates very sharp growth in mean turkey plant size, increasing by about 600 percent from 1967 to 1992. However, the mean turkey plant size was still only about 80 percent as large as the mean chicken plant size in 1992.

The final three columns of table 7-6 give cost elasticity, average cost index, and processing costs as a share of total costs for various plant sizes. As with chicken slaughter, increasing returns to scale exist throughout the size range examined, and also grow in magnitude, dropping from 0.936 for a plant that is half the sample mean plant size to 0.884 for a plant that is four times larger than the sample mean plant size. These strong scale economies result in a 17-percent cost advantage for the largest plants relative to sample mean plants and in a continuous decline in the processing share of total costs. The cost differentials are consistent with the near-disappearance of small plants and likely contributed to the increase in mean plant size over the 1967-92 period.

The sign on the coefficient of output interaction with output (table 7-4) is negative, suggesting that increasing returns become stronger with size and that plant size will continue to increase. Possible constraints on plant size that are not captured by the cost function include a lack of a suitable number of growers and laborers and environmental issues. However, no hard data are available to examine the issue empirically.

Turkey slaughter is much less automated than chicken slaughter because turkeys are less likely to be of uniform size; thus, there is not so great a need to have plants specialize by turkey size and end use. Environmental issues are important and become an issue in regions with susceptible watersheds. However, appropriate site selection can permit slaughter plants to avoid environmental degradation. For example, turkey slaughter plants have not been located in the Delmarva Peninsula, but are concentrated in the North and South Central regions.

Alice Johnson of the National Turkey Federation (interviewed May 10, 1999) suggested that a lack of turkey growers and low-cost labor may limit plant size. She asserted that the financial risks of raising turkeys are greater than for chickens because turkeys are much more susceptible to disease and heat stress due to their longer grow-out period and greater size. She also claimed that turkey growers need greater financial resources than chicken growers because (1) turkeys require larger housing facilities and greater environmental controls; (2) turkeys generate more variable cash flows because flock sizes must shrink during the summer months in order to reduce the threat of heat stress, and then be expanded rapidly to meet market demands for the holiday season; and (3) turkey growers must carry excess capacity during much of the year because of varying flock size. This greater financial risk of turkey growing relative to chicken growing requires turkey slaughter plants to bear greater financial risks by owning a greater share of bird-growing operations than chicken slaughter plants do, but would seem to have little effect on plant size.

Labor shortages may play a larger role than the nature of grower contracting in limiting turkey plant size. Turkey plants must locate in rural areas that are not environmentally fragile in order to have access to turkey meat inputs and to avoid high environmental

Table 7-6: Estimated cost elasticity and average cost index by plant size for turkeys

Plant size	Plant size to sample mean	Plant size to 1967 mean	Plant size to 1992 mean	Elasticity	Avg. cost index*	Process cost
Million lbs.		*Ratio*				*Percent*
21.9	0.50	1.37	0.19	0.936	1.05	35.0
43.7	1.00	2.74	0.38	0.919	1.00	33.8
87.4	2.00	5.48	0.75	0.902	0.89	32.6
174.8	4.00	10.96	1.51	0.884	0.83	31.3

Notes: Values are based on sample mean values. Only the scale of the operation changes.

control costs. These rural areas tend to have a limited labor supply. Johnson argued that since plants cannot raise wages for new hires without raising the wages for all employees, the marginal cost of hiring additional workers is very high. Although this phenomenon may also exist in chicken slaughter, its impact is likely more severe with turkeys because of the turkey industry's greater reliance on manual labor.

A large share of turkey products are sold as branded or further-processed products, requiring turkey breeds with different qualities. Since some of these turkey breeds vary substantially in size, managers must match turkey breeds with specialized plants that are able to slaughter them. This need for specialization and a limited market may result in plant sizes with a substantial degree of increasing returns to scale.

Consider how much labor and turkey meat factor costs would have to rise to offset the cost savings resulting from scale economies. Suppose that the largest turkey plants produce at a level of eight times the sample mean plant size (this is about three times greater than the 1992 mean plant size). Assuming that model coefficients do not change as plant size exceeds the limit of the dataset, a doubling of plant size leads to a decline in the average cost index to 0.759 or about an 8-percent decrease in costs from a plant that is four times the sample mean plant size. Given that the turkey meat factor share of costs is about 66 percent and the labor share of costs is about 13 percent, this means that turkey meat factor prices would have to rise by about 13 percent, or labor costs would have to rise about 64 percent to offset the gains accruing to scale economies. If the limiting factor is the size of final product market—either because the product is branded or otherwise limited—then cost savings in production would be offset by higher marketing costs.

Table 7-7 shows a comparison of cost elasticities and a cost index for four animal slaughter categories. The cost elasticity valued at the sample mean for turkeys

Table 7-7: Cost elasticities and cost index comparisons for four slaughter industries

Comparison type	Chicken	Turkey	Cattle	Hogs
Cost elasticity (sample mean)	.901	.919	.932	.926
Cost elasticity (4 times mean)	.852	.884	.947	.960
Average cost index*	.850	.828	.929	.946

* Four times mean plant size relative to sample mean plant size.

(0.919) is higher than for chickens (0.901), but lower than for cattle slaughter (0.953) and hog slaughter (0.926). Thus, scale economies are greater for turkeys than for either cattle or hogs but less than for chickens. Cost elasticities grow dramatically for chicken and turkey relative to cattle and hogs as plant size increases; thus, large chicken and turkey plants have much lower costs relative to their sample mean plants than is the case for cattle and hog slaughter plants.

Bulk Output Share, Whole-Bird Output Share, and Other Plant Characteristics

Plant characteristics important to turkey production costs include bulk output share (BULK), whole-bird output share (WHOLE), and seasonality of production (SEASON). Bulk output share is defined as one minus the share of further-processed turkey products. Bulk products include whole turkeys, cut-up and deboned turkey, and miscellaneous byproducts.[22] Products not defined as bulk include frankfurters and other sausages, luncheon meats, and other cooked products. The production of bulk products requires fewer inputs to convert a pound of turkey into a finished product; thus, plant production costs and the labor share of total costs should decline as the bulk output share rises. The coefficients on the bulk output share and the interactions of the bulk output share with PLAB, PMEAT, PMAT, and PCAP are consistent with these hypotheses. They show that (1) production costs decline as the bulk output share rises and, (2) a plant that produces mainly bulk products has lower labor and materials shares of costs and greater turkey meat and capital factor shares of costs than a plant that produces mainly luncheon meats and other further-processed turkey products.

Equation 5.5 is used to see how much average costs change as the bulk output share changes. The elasticity of costs with respect to bulk output share at sample mean prices and output ($\in_{CM}$) is -0.029 (table 7-8), meaning that a 1-percent increase in the bulk output share leads to a 0.029-percent decline in turkey slaughter plant operating costs. To see how average costs change as the bulk output share varies, average costs at sample mean prices and output for plants having bulk output shares of 20, 50, and 80 percent of the sample mean bulk output share are evaluated (table 7-8). Plants with sample mean output and factor prices, which produce about 80 percent of the sample mean

[22] Plant-level data for turkey parts are available only from the 1987 and 1992 Censuses and, thus, cannot be used in the analysis.

bulk product share of output, have 0.5-percent higher production costs than identical plants with a bulk share at the sample mean. Plants with 20 percent of the sample mean bulk product share have about 3-percent higher costs than plants with sample mean bulk output share. These changes in bulk output share may cause substantially lower cost increases than for chicken slaughtering, perhaps because turkey slaughter already requires more labor per bird for slaughtering than does chicken and, thus, proportionately less additional labor for further processing. As with chicken slaughter, processing costs drop as bulk output share rises.

One explanation for larger plants' having a greater share of output from turkey parts and further-processed products than smaller plants (table 4.5) is the existence of economies of scope. However, since the interaction of the bulk output share with output (next to last column of table 7-4) is negative and insignificant, there is no such evidence (it would have to be positive and significant).

The negative coefficient for whole-bird output share (table 7-4) shows that a rise in the whole-bird share of output leads to a downward shift of the total cost function. There are also small but insignificant increases in the shares of labor and meat costs. Coefficients on the interactions of whole-bird output share with factor prices suggest that the capital share of costs drops, and the labor, turkey meat factor, and materials shares increase as the whole-bird output share rises.

To see how much average costs change as the whole-bird output share varies, we evaluated average costs at the sample mean for plants having whole-bird shares that are 20, 50, 80, and 120 percent of the sample mean whole-bird share (table 7-9). Plants with 120 percent of the sample mean whole-bird share have 0.5-percent lower average production costs and a 0.3-percent higher processing cost share than do plants at the sample mean plant size.

Now consider the bias caused by ignoring bulk output share and whole-bird output share effects. If both plant bulk output share and whole-bird output share are omitted (Model I, table 7-1), the coefficient on the output term (cost elasticity at sample mean prices and output) is 0.977, but if bulk output share and whole-bird output share are included, the coefficient drops to 0.919. If the last pound of turkey cost $0.50 to produce, these scale economy estimates mean that the estimated costs of producing the next pound of turkey would be $0.488 without a control for bulk output share and whole-bird output share or $0.459 with controls. This $0.029-per-pound estimation bias strongly affects plant profitability when considered in the context of a plant producing 200 million pounds of turkey each year.

The greater degree to which chicken and turkey slaughter plants process bird carcasses into finished

Table 7-8: Estimated turkey cost elasticity and the associated cost index for selected bulk shares at industry mean values

Bulk share	Bulk share to sample mean	Bulk share to 1972 mean	Bulk share to 1992 mean	Elasticity	Cost index*	Process cost
Percent	————	*Ratio*	————			*Percent*
17.9	0.20	0.18	0.21	-0.026	1.030	35.1
44.8	0.50	0.45	0.54	-0.028	1.014	34.4
71.6	0.80	0.72	0.87	-0.029	1.005	34.0
89.5	1.00	0.90	0.10	-0.029	1.000	33.8

* Index based on sample mean values with only bulk output share changing.

Table 7-9: Estimated cost elasticity and the associated cost index for selected whole-bird shares using industry mean values

Whole-bird share	Whole-bird share to sample mean	Whole-bird share	Whole-bird share to 1972 mean	Elasticity to 1992 mean	Cost index*	Process cost
Percent	————	*Ratio*	————			*Percent*
15.5	0.20	0.17	0.34	-0.128	1.048	36.7
38.8	0.50	0.41	0.86	-0.128	1.020	35.0
62.0	0.80	0.66	1.38	-0.128	1.006	34.2
77.5	1.00	0.82	1.73	-0.128	1.000	33.8
96.9	120.0	1.03	2.16	-0.128	0.995	33.5

* Values are based on sample mean values. Only whole-bird share of output changes.

and semi-finished products suggests that controlling for bulk output share and whole-bird output share is more important to these industries than it is for cattle and hog slaughter (table 7-10). The cost elasticities for chickens and turkeys drop by about 5.5 percent after including both bulk output share controls, while the cost elasticities for cattle and hogs decline by only about 1.5 percent. These comparisons suggest that ignoring product mix significantly biases the results of all models, but the bias is much greater in chicken and turkey than in cattle and hogs.

Turkey slaughter plants have traditionally had stronger demand during the end-of-the-year holiday season than during other seasons. This seasonality of demand can impose a cost of either carrying excess capacity or of paying high variable costs during peak demand periods. Turkey plants reduced seasonality over the 1967-92 period (table 4-2), suggesting that lower costs may have resulted. However, production seasonality was found to have a very modest impact on model fit (tables 7-2, 7-4), and is retained only to illustrate its modest impact.

Other plant characteristics were also examined but did not improve model fit. These include single-plant firm status, and liveweight turkey input mix. The insignificance of single-plant firm status suggests that plant technology is similar regardless of firm type. Turkey meat input mix may not have contributed to model fit because live turkeys accounted for most inputs throughout the study period (table 4-2). Alternative specifications for the bulk output share variables were also tried, but none improved on bulk output share.

Implications of the results of product mix effects are important and similar to chicken. The effects of change in product mix must be separated from the effects of plant size because turkey plants increased turkey processing while simultaneously increasing plant size. Simple cost functions that do not account for product mix will confuse product mix effects with size-related effects and likely understate scale economies.

Table 7-10: Cost elasticities for four slaughter industries at the sample mean for models with and without controls for bulk share and whole-bird shares

Cost elasticity comparison	Chicken	Turkey	Cattle	Hogs
Cost elasticity with control for product mix (bulk output share for chicken and turkey)	.901	.919	.932	.926
Cost elasticity without control for product mix (bulk output share for chicken and turkey)	.953	.977	.959	.980
Difference	.052	.058	.027	.054

Technological Change

Technological change over the 1967-92 period consisted of changes in product mix and materials- and labor-saving innovations. The model controls for changes in product mix with the bulk output share and whole-bird output share terms. It also controls for size-related technological change with the output term and accounts for some labor and material efficiency gains through coefficients on wages and chicken meat factor prices. However, the model does not directly account for other disembodied technological change.

A model employing technology variables (time-shift variables), but no whole-bird output share term (Model VIII, table 7-2), was found to improve model fit over a model consisting of factor prices, plant output, seasonality, and factor and bulk output share (Model II, table 7-2). However, this model was rejected because, as with the chicken model, most interaction terms are statistically insignificant; the model is barely statistically significant; and, worse, there is no way to control for whole-bird output share because both it and the time-shift variables are constant across plants, causing insufficient model variance and model collapse. Since the change in cut-up and deboned turkey as a share of output rose from less than 10 to over 50 percent in the 1967-92 period and since processing cut-up and deboned turkey is more labor intensive than whole-bird production, excluding whole-bird output share likely leads to serious specification errors.

Table 7-11 shows that Model VIII cost estimates are 7 percent higher than the preferred model (Model III) at a size that is twice the sample mean (about 75 percent of the 1992 mean size). Estimates from Model I (basic model) and Model II (controlling for bulk output share and seasonality only), at twice the size of the sample mean plant, were 8.5 and 6 percent higher than estimates from Model III.

A comparison of estimates from Model VIII for various Census periods (table 7-12) shows that intercept terms shift upward over time and scale economies are completely exhausted by 1992 (the coefficient on Q is about 1.04). Additionally, estimates at twice the sample mean plant size suggest that it was about 21 percent less costly to produce turkey in 1967 than in 1992 and that average costs rose from 1967 to 1982 and then stabilized thereafter—never falling to the same cost level as what existed in 1967. These results are inconsistent with other data that show that plant size increased by over 600 percent over the 1967-92 period; such inconsistencies lead one to conclude that Model VIII suffers from severe specification error.

In summary, Model VIII was rejected because (1) it is only marginally significant (table 7-2) and (2) comparisons with other models and the existence of regressive technological change suggest that serious specification errors exist. This finding does not imply that technological change did not occur. Quite to the contrary, technological change has had a profound effect on shaping the turkey slaughter industry. However, technological change has been captured through variables other than time. The model accounts for changes in product mix with the bulk output share and whole-bird output share terms, size-related change with the output term, and labor and poultry production changes with labor and meat costs.

Conclusion

The main purpose of this chapter is to assess the role of scale economies and product mix on turkey slaughter plant production costs. Results suggest a cost structure similar to that of chicken slaughter plants in that substantial scale economies exist and product mix, i.e., bulk output share and whole-bird output share, significantly affects plant production costs. Plants that are four times larger than the sample mean plant size realized a 17-percent reduction in costs, and plants twice as large as the sample mean plant size had a 10-percent reduction. Higher transportation costs, environmental and labor constraints, and plant specialization by bird type may inhibit additional plant size growth, but this is uncertain because there is no hard evidence to support any of these hypotheses. Thus, the question of the extent of scale economies will require further research.

Model fit might be improved with additional data. Turkey slaughter plants produce three main product classes: consumer-ready whole birds, parts, and further-processed products; cut-up and deboned turkey packed in bulk containers; and whole birds packed in bulk containers. Plant-specific data were available only for the further-processed products. Industry-level data were used to account for temporal changes in cut-up and deboned turkey, but these data cannot account for some plant-level differences.

The use of whole-bird output share as a control for product mix effects prevented the use of time-shift variables to account for disembodied technological change because the model collapses if both time shifters and industry-level whole-bird output share variables are included in the same model. Whole-bird output share rather than time-shift variables was used because cost estimates were consistent with economic theory, whereas, the time-shift model provided perverse results suggesting regressive technological change. Results from a model containing control variables for bulk share of output, whole-bird output share, and seasonality but no time shifters show large scale economies that likely led to the 600-percent increase in turkey plant size from 1967 to 1992.

Table 7-11: Turkey cost and elasticity ratios of models I, II, and VIII relative to model III at sample mean and twice sample mean values for 1992

Model	Model cost estimate relative to Model III at sample mean	Model cost estimate relative to model III at twice sample mean	Elasticity
	Ratio	*Ratio*	
I	1.030	1.085	0.977
II	1.023	1.060	0.958
III	1.000	1.000	0.919
VIII	0.992	1.070	1.048

Table 7-12: 1972-87 turkey cost and elasticity ratios of model VIII for 1967-87 relative to model VIII for 1992, evaluated at sample mean and twice sample mean values

Census year	Model VIII costs at sample mean for 1967-87 relative to model VIII costs for 1992	Model VIII costs at twice sample mean for 1967-87 relative to model VIII costs for 1992	Model VIII elasticity at sample mean for 1967-87 relative to model VIII elasticity for 1992
1967	0.916	0.788	0.795
1972	0.971	0.872	0.851
1977	1.026	0.934	0.870
1982	1.050	1.010	0.947
1987	1.150	1.004	0.952
1992	1.000	1.000	1.000