April 2006

Poultry Slaughter and Processing Sector Facility-Level Model

Final Report

Contract No. 53-3A94-03-12, Delivery Order 10

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*RTI International is a trade name of Research Triangle Institute.

Contents

Section **Page**

1. Introduction **1-1**

1.1 Background 1-2

1.2 Project Objective 1-2

1.3 Organization of the Report 1-3

2. Poultry Slaughter Industry Profile **2-1**

2.1 Supply Characterization of the Poultry Slaughter Industry 2-1

2.1.1 Stages of Production 2-2

2.1.2 Production Inputs for Poultry Slaughter Plants 2-3

2.1.3 Production Output for Poultry Slaughter Plants 2-6

2.1.4 Supply Elasticities 2-11

2.2 Demand Characterization of the Poultry Slaughter Industry 2-12

2.2.1 Consumption 2-12

2.2.2 Demand Elasticities 2-13

2.3 Industry Organization 2-15

2.3.1 Company Specialization 2-15

2.3.2 Number of Plants and Companies 2-16

2.3.3 Poultry Slaughter Plant Characteristics Based on Survey Results 2-16

2.3.4 Market Power 2-20

2.4 Market-Level Data 2-20

2.4.1 Prices 2-21

2.4.2 Poultry Trade 2-23

2.4.3 Model Baseline Year 2-27

3. Methodology for Economic Impact Analysis 3-1

3.1 Economic Impact Analysis Methodology Overview 3-1

3.2 Conceptual Approach 3-5

3.2.1 Characterization of Affected Markets 3-5

3.2.2 Supply Relationships in the Poultry Model 3-10

3.2.3 Demand Relationships in the Poultry Model 3-12

3.2.4 Baseline and With-Regulation Market Equilibrium 3-12

3.2.5 Social Costs 3-14

3.3 Operational Model 3-15

3.3.1 Domestic Supply of Poultry Products 3-19

3.3.2 Foreign Supply of Poultry 3-23

3.3.3 Domestic Demand for Poultry 3-24

3.3.4 Export Demand for Poultry 3-25

3.3.5 Baseline Scenario 3-26

3.3.6 Model Calibration 3-29

3.3.7 Incorporation of Compliance Costs 3-29

3.3.8 Solving for Market Equilibrium With Regulation 3-30

3.3.9 Postregulatory Impact Estimates 3-32

3.4 Sensitivity Analysis 3-34

4. Instructions for Using the Poultry Slaughter and Processing Facility-Level Model 4-1

4.1 An Operational Overview of the Model 4-1

4.2 Running the Model 4-3

4.3 Entering Cost Differences to Simulate an Adjusted 2004 Baseline 4-7

4.4 Model Results 4-8

5. References 5-1

Appendices

A Supply Elasticity Estimates A-1

B Demand Elasticity Estimates B-1

Figures

Number		Page
2-1	Process Flow Diagram: Young Chicken Slaughter	2-4
2-2	Per Capita Meat and Poultry Consumption, 1990–2003 (lbs)	2-13
2-3	HHI Values for Slaughter Facilities, 1997–2003	2-21
2-4	Nominal Meat and Poultry Retail Prices, 1998–2004 ($/lb)	2-22
2-5	Nominal Wholesale Meat and Poultry Prices, 1998–2004 ($/lb)	2-23
2-6	Nominal Livestock and Poultry Farm Prices, 1998–2004 ($/lb)	2-24
2-7	Volume of Chicken Trade, 2000–2004 (1,000 lbs)	2-25
2-8	Value of Chicken Trade, 2000–2004 ($1,000)	2-25
2-9	Volume of Turkey Trade, 2000–2004 (1,000 lbs)	2-28
2-10	Value of Turkey Trade, 2000–2004 ($1,000)	2-28
3-1	Overview of Facility-Level Economic Impact Analysis Model	3-3
3-2	Market Linkages in Poultry Production	3-7
3-3	Market Equilibrium Without and With Regulation	3-13
3-4	Economic Welfare Changes for a Regulation that Increases the Cost of Production: Consumer and Producer Surplus Changes	3-15
3-5	Theoretical Supply Function for Product j at Facility i	3-22
4-1	The Interface Screen for the Poultry Slaughter Facility-Level Model	4-4
4-2	The Choose Baseline Pop-Up Screen	4-4
4-3	The Adjusted 2004 Baseline Pop-Up Screen	4-5

Tables

Number		Page
2-1	Average Weight of Poultry at Federal Plants, 2004	2-3
2-2	Input Factor Shares at Poultry Slaughter Plants	2-5
2-3	Live Bird Prices by State, 2004	2-7
2-4	Labor and Energy Rates and Respective Indices and Poultry Cost Indices by State, 2004	2-9
2-5	Supply Elasticities for Poultry	2-11
2-6	Demand Elasticities for Poultry	2-14
2-7	Plant Inventories and Slaughter Volumes for Federal Plants that Slaughtered Poultry in FY 2004	2-17
2-8	Known Companies Owning Multiple Poultry Slaughter Plants	2-18
2-9	Nominal Retail Prices for Meat and Poultry, Based on Scanner Data ($/lb)	2-24
2-10	Volume of Chicken Trade by HTS-6 Code, 2000–2004 (1,000 lbs)	2-26
2-11	Volume of Turkey Trade by HTS-6 Code, 2000–2004 (1,000 lbs)	2-29
3-1	Variables Used in Market Model	3-18
3-2	Market-Level Data for the Poultry Facility-Level Model, 2004 Baseline	3-27
4-1	Baseline Characterization of U.S. Poultry Market: 2004	4-10
4-2	Summary of Market-Level Impacts of Regulation: 2004	4-10
4-3	Summary of National-Level Industry Impacts of Regulation: 2004	4-11
4-4	Distribution of Social Costs Associated with Regulation: 2004	4-11

4-5 Capacity and Compliance Costs Comparisons for Small and Large Companies: 2004 4-12
4-6 Capacity and Compliance Costs Comparisons for Very Small, Small, and Large Plants: 2004 4-13
4-7 Summary of Small Business Impacts of Regulation: 2004 4-13
4-8 Summary of HACCP Size Impacts of Regulation: 2004 4-14

1 Introduction

The poultry slaughter and processing facility-level model provides a tool for FSIS to estimate in a consistent and rigorous manner the economic effects of regulations affecting the industry.

In August 2004, the U.S. Department of Agriculture's Food Safety and Inspection Service (USDA, FSIS) contracted with RTI International (RTI) to develop a poultry slaughter and processing facility-level model with a proper user interface, product market characterization, and documentation for use by FSIS in regulatory impact analysis. The model uses data for fiscal year 2004; thus, analyses using the model will be based on a 2004 baseline. Using this model, analysts can input estimates of the costs of complying with a regulation and obtain estimates of the facility, market, and economic welfare effects of the regulation.

RTI developed the model using data characterizing the following poultry market categories:

- young chickens,
- other chickens (includes capons, light fowl, and heavy fowl),
- turkeys (includes roaster, young, breeder, and old breeder turkeys), and
- other poultry (includes ducks, geese, and other types).

The data used to develop the model were obtained from the 2005 update of the Enhanced Facilities Database, a database of meat, poultry, and egg facilities operating in the United States; the results of a survey of the poultry slaughter industry fielded by FSIS in late 2004; and market-level data available from published sources. The model is designed so that FSIS can use it to estimate the economic effects of regulations affecting poultry plants. For example, estimates of the costs (or cost savings) associated with fully implementing Hazard Analysis and Critical Control Points (HACCP) in young chicken establishments can be incorporated into the model to estimate the economic impacts once the regulatory requirements have been identified and the costs of compliance have been estimated by an analyst.

1.1 BACKGROUND

FSIS is proposing to implement a new system of slaughter inspection that will improve the efficiency of inspection while at least maintaining current levels of food safety as measured by statistical verification assessments, including testing, that FSIS inspection personnel perform. The major structural changes in inspection resulting from this proposed rulemaking will also give industry and FSIS flexibility in how they use resources and could result in a significantly lower cost of product to the consumer. The new system of slaughter inspection will be evaluated in terms of its effects on industry, consumers, and international trade for all classes of poultry and red meat that are slaughtered and processed in federally inspected establishments.

The modeling approach is consistent with the modeling approach that was used in developing the beef slaughter and processing facility-level model and will be used in developing the pork slaughter and processing facility-level model.

FSIS is also considering other regulations that affect the poultry slaughter and processing sectors. These regulations include alternatives to gauge the process-control activities of poultry establishments and to provide greater flexibility in adapting poultry processing activities to processing and technological changes (e.g., poultry chilling and product labeling).

FSIS has had existing contracts with RTI to develop analytical models that will be used in regulatory impact analysis. A facility-level model of the beef slaughter industry and a beef processing industry market model have been completed. In addition to a poultry-sector facility-level model, a pork-sector facility-level model is also being developed. This set of tools will allow FSIS to estimate the economic effects of regulations affecting industries under its authority as needs arise.

1.2 PROJECT OBJECTIVE

The objective of this delivery order is to develop a poultry-sector facility-level model that will allow FSIS to conduct regulatory impact analyses of the new inspection system in poultry and other regulatory initiatives. The model allows FSIS to enter estimated costs of regulations and obtain estimates of the direct and indirect economic impacts on both the poultry slaughter and processing sectors. The facility-level model identifies price, production, and consumer impacts for a limited number of aggregate product and plant categories for the poultry industry.

1.3 ORGANIZATION OF THE REPORT

This report is organized as follows. Section 2 provides a brief profile of the poultry slaughter industry and describes baseline conditions in the industry and data used to characterize the baseline in the model. Section 3 describes the methodology used to develop the model. Section 4 provides instructions for operating the model, including inputting cost estimates, altering default values in the model, and generating results tables to be used in a regulatory impact analysis. References follow in Section 5.

Elasticity estimates for the poultry industry are provided in Appendices A and B. These estimates were used to develop the default values in the model and provide a resource for FSIS to obtain other plausible values for conducting sensitivity analyses.

2 Poultry Slaughter Industry Profile

A profile of the industry provides useful information for analyzing market-level effects of proposed regulations.

This section of the report provides an overview of the poultry slaughter industry as background information for modeling the poultry industry. First, we describe the poultry industry supply chain, followed by a brief explanation of consumer-level demand. We then discuss the organization of the industry and conclude with a presentation of market-level data used in developing the model.

2.1 SUPPLY CHARACTERIZATION OF THE POULTRY SLAUGHTER INDUSTRY

Based on FSIS's needs, poultry species were divided into four market categories for the facility-level model:

- **Young Chickens**—broilers or meat-type chickens
- **Other Chickens**—any chicken not considered a young chicken, typically spent hens (includes capons, light fowl, and heavy fowl)
- **Turkeys**—all breeds and types of turkeys (includes roasters, young turkeys, young breeding turkeys, and old breeding turkeys)
- **Other Poultry**—all other types of poultry (includes ducks, geese, and other poultry)

Establishments that slaughter any poultry species are classified in North American Industry Classification System (NAICS) code 311615 Poultry Processing (formerly Standard Industrial Code [SIC] 2015).

In this section, we describe the production of the four types of poultry through all stages of production.

2.1.1 Stages of Production

Chickens, turkeys, ducks, and other types of poultry are all produced using similar methods. The process typically begins with layers that are inseminated, either naturally or artificially, to produce fertile eggs. The eggs are then collected and placed in incubators that simulate a natural brooding process. From the incubator, eggs are moved to a hatcher where they are housed until the chicks, poults, or ducklings begin to emerge.

The time required to hatch a bird varies by species and breed. The incubation period for chickens is approximately 21 days. Turkeys and common ducks require about 28 days. Other varieties of ducks may take 35 days to hatch.

The growout phase is the final stage of live poultry production. This stage starts with day-old birds placed on specialized feed rations in a closely monitored environment. As birds grow, their feed rations are changed to meet their dietary needs. Environmental conditions are also customized to maximize weight gain. Chickens complete the growout phase in 4 to 6 weeks, turkeys take up to 18 weeks to reach market weight depending on sex, and ducks take approximately 7 weeks.

The live weight of poultry ready for slaughter also varies significantly depending on the species. Table 2-1 shows the average live weight of broilers (young chickens) is 5.27 pounds, and mature chickens weigh 5.66 pounds. The growout period for turkeys, which is longer than that for chickens, results in market weights of 26.84 to 27.12 depending on age. The average weight for ducks is 6.71 pounds.

Mature birds are transported to slaughter facilities where they undergo an ante-mortem inspection to ensure they are healthful and sound or otherwise unadulterated. Approved birds are slaughtered, and carcasses are inspected for any conditions that would cause them to be unfit for consumption. The carcasses are then packaged for shipment as whole birds, cut into parts and pieces, ground, or further processed. Further processing may be conducted on site or at a separate facility. Figure 2-1 shows the process a typical poultry slaughter facility follows.

Table 2-1. Average Weight of Poultry at Federal Plants, 2004
The dressing percentage averages more than 73 percent across all poultry species. Within each species the dressing percentage decreases with age.

Poultry Type	Average Live Weight (lbs)	Average Dressed Weight (lbs)[a]
Chickens		
Young	5.27	3.89
Mature	5.66	3.52
All Chickens	5.27	3.89
Turkeys		
Young	27.12	21.46
Old	26.84	20.02
All Turkeys	27.12	21.45
Ducks	6.71	4.93

[a]Dressed weight means ready-to-cook weight.

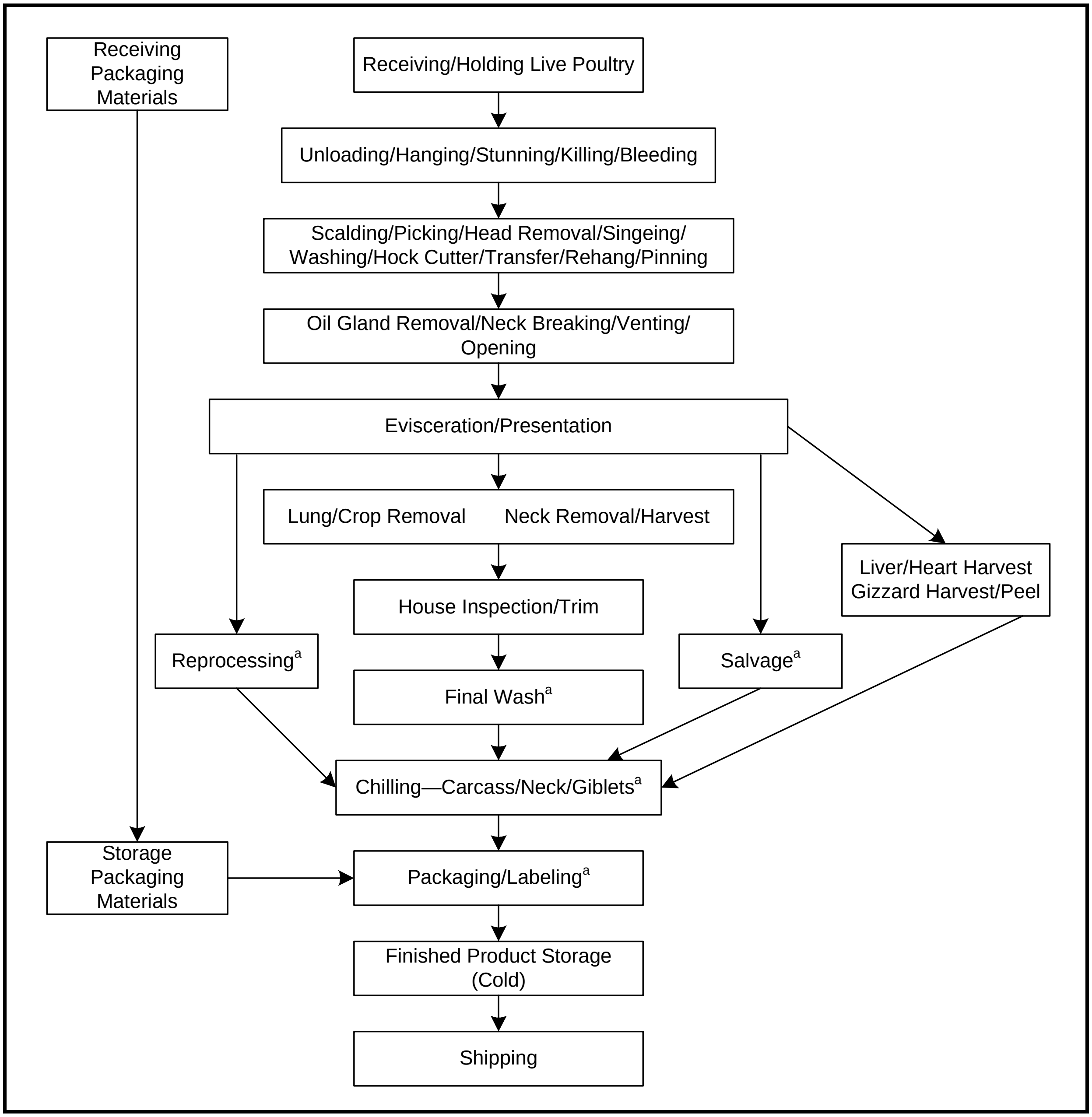
Source: U.S. Department of Agriculture (USDA), Agricultural Statistics Board, National Agricultural Statistics Service (NASS). February 28, 2005. *Poultry Slaughter 2004 Annual Summary*. Washington, DC: USDA.

Poultry production is primarily concentrated in the eastern half of the United States. The largest chicken-producing states are located in a band from Delaware to Texas. Turkey production is slightly more dispersed, with leading states located in two areas—between Minnesota and Missouri and between Pennsylvania and South Carolina. Wisconsin and Indiana are the primary duck-producing states. California is a notable exception as a top producer of both chickens and turkeys outside of these regions.

2.1.2 Production Inputs for Poultry Slaughter Plants

The cost of live animals is the primary input cost for poultry slaughter plants. As Figure 2-1 shows, live poultry and packaging materials are the primary inputs to poultry processing; however, to transform those inputs into finished goods, companies employ equipment, labor, and other materials. The cost for each of these additional factor inputs is broken down in Table 2-2. Live birds represent over 65 percent of the total production cost for both chicken and turkey slaughter plants (Ollinger, MacDonald, and Madison, 2000). Labor and materials each account for 11 to 19 percent. Capital equipment constitutes less than 3 percent of plant production costs.

Figure 2-1. Process Flow Diagram: Young Chicken Slaughter



[a]Steps in the process where nonmeat ingredients (e.g., antimicrobials) are added to or come in contact with product.

Source: U.S. Department of Agriculture (USDA), Food Safety and Inspection Service. September 1999. "Generic HACCP Model for Poultry Slaughter." HACCP-5. Washington, DC: USDA FSIS.

Table 2-2. Input Factor Shares at Poultry Slaughter Plants
Over 65 percent of the total production cost for chicken and turkey slaughter plants comes from the cost of live birds.

	Factor Share[a]	
Cost Category	**Chicken**	**Turkey**
Labor	0.150	0.131
Meat (live animal)	0.733	0.662
Materials	0.112	0.191
Capital equipment	0.025	0.016

[a]Total may not add to 1.0 due to rounding.

Source: Ollinger, M., J. MacDonald, and M. Madison. September 2000. "Structural Change in U.S. Chicken and Turkey Slaughter." USDA/ERS Agricultural Economic Report No. 787. Washington, DC: USDA. Table 6-5 (pg. 28) and Table 7-5 (pg. 36)

The hourly wage estimates represent wages for production workers. The annual salary survey conducted by *Meat and Poultry* magazine provides a breakdown of wage estimates for managerial employees. In 2004, the survey results were obtained from large companies with annual sales of $100 million or more (Troxel-Hellmer and Nunes, 2004). Assuming 2,200 hours per year,[1] the average annual and hourly wage estimates (not including benefits) for 2004 are

- $95,000 per year ($43.18 per hour) for plant/general managers,
- $63,300 per year ($28.77 per hour) for food safety/HACCP managers, and
- $59,000 per year ($26.18 per hour) for quality assurance managers.

In 2005, the survey focused on small to midsize companies with annual sales of less than $100 million (Nunes and Troxel-Hellmer, 2005). Results from the 2005 survey indicated average annual wage estimates of $52,000 for plant/general managers, $40,000 for food safety/HACCP managers, and $59,700 for quality assurance managers. Although the average reported wages for plant/general managers and food safety/HACCP managers was substantially lower than for large companies, average reported wages for quality assurance managers was slightly higher.

[1]The number of hours per year is calculated as 8 hours per day times 5.5 days per week times 50 weeks per year=2,200 hours per year.

The facility-level model described in Section 3 incorporates production costs at the state level. Table 2-3 shows the 2004 state-level prices for young chickens, other chickens, turkeys, and other poultry birds. Prices for young chickens, other chickens, and turkeys were obtained directly from USDA's National Agricultural Statistics Service, but prices for other poultry birds were not available and thus were constructed using available information (see footnote d in Table 2-3). In cases in which state-level prices were not reported, values were constructed by taking an average of adjacent states.

Table 2-4 shows the state-level wage and electricity rates that were used to construct production cost indexes. The index values for wages and electricity rates reflect each state's rate relative to the national average. These indices are combined into a production cost index for each species by multiplying each index by its associated percentage of production costs.[2] Electricity rates are used as a proxy for material costs.

2.1.3 Production Output for Poultry Slaughter Plants

The variety of poultry products produced by slaughter plants has changed substantially since the 1970s. Poultry was traditionally sold as whole birds that had to be cooked whole or cut up after they were purchased by the final consumer. Now, in addition to whole chickens and turkeys, slaughter plants offer bone-in and boneless cuts as well as many other processed and ready-to-eat products.

The Census Bureau (2004) identifies the range of output from poultry slaughter plants as follows:

- young chickens, whole or parts
  - broilers and fryers
  - tray pack (consumer packaged) broilers and fryers
  - roasters and capons
- hens and/or fowl, whole or parts

[2]For example, Alabama's chicken production cost index (excluding the costs of the live bird) is (93.44•0.57252)+(77.01•0.42748)=86.42, where 0.57252 and 0.42748 are the associated proportions of production costs for labor and materials calculated from values in Table 2-2.

Table 2-3. Live Bird Prices by State, 2004

	Young Chickens[a]	Other Chickens[b]	Turkeys[c]	Other Poultry[d]
AK	0.473	0.004	1.770	1.080
AL	0.440	0.097	0.105	1.010
AR	0.440	0.096	0.430	1.010
AZ	0.460	0.004	0.310	1.050
CA	0.473	0.008	0.410	1.080
CO	0.449	0.034	0.420	1.030
CT	0.450	0.002	1.350	1.030
DE	0.460	0.004	0.420	1.050
FL	0.450	0.029	0.170	1.030
GA	0.440	0.080	0.240	1.010
HI	0.473	0.199	1.770	1.080
IA	0.473	0.002	0.420	1.080
ID	0.473	0.010	0.190	1.080
IL	0.462	0.010	0.420	1.060
IN	0.473	0.008	0.420	1.080
KS	0.454	0.004	0.420	1.040
KY	0.440	0.094	0.300	1.010
LA	0.460	0.090	0.340	1.050
MA	0.450	0.004	1.590	1.030
MD	0.460	0.010	0.430	1.050
ME	0.450	0.003	1.770	1.030
MI	0.473	0.001	0.370	1.080
MN	0.440	0.001	0.420	1.010
MO	0.473	0.050	0.420	1.080
MS	0.440	0.087	0.170	1.010
MT	0.458	0.006	0.310	1.050
NC	0.450	0.090	0.420	1.030
ND	0.447	0.004	0.400	1.020
NE	0.450	0.001	0.420	1.030
NH	0.450	0.020	1.770	1.030
NJ	0.455	0.001	0.870	1.040
NM	0.446	0.004	0.400	1.020

(continued)

Table 2-3. Live Bird Prices by State, 2004 (continued)

	Young Chickens[a]	Other Chickens[b]	Turkeys[c]	Other Poultry[d]
NV	0.473	0.004	0.290	1.080
NY	0.450	0.001	0.430	1.030
OH	0.450	0.001	0.420	1.030
OK	0.440	0.090	0.420	1.010
OR	0.473	0.001	0.420	1.080
PA	0.460	0.009	0.480	1.050
RI	0.450	0.004	1.470	1.030
SC	0.440	0.078	0.400	1.010
SD	0.454	0.001	0.380	1.040
TN	0.440	0.099	0.250	1.010
TX	0.450	0.049	0.420	1.030
UT	0.460	0.010	0.420	1.050
VA	0.440	0.063	0.420	1.010
VT	0.450	0.011	0.420	1.030
WA	0.473	0.001	0.310	1.080
WI	0.450	0.025	0.420	1.030
WV	0.440	0.091	0.410	1.010
WY	0.459	0.001	0.270	1.050
Average	0.455	0.030	0.554	1.041

Source: U.S. Department of Agriculture (USDA), National Agricultural Statistics Service. April 2005c. "Poultry: Production and Value 2004 Summary." Pou 3-1 (05). Washington, DC: USDA.

[a]Values for missing states for young chickens (AK, AL, AR, AZ, CA, CO, CT, ID, IL, KS, MA, MD, ME, MT, ND, NH, NJ, NM, NV, RI, SD, UT, VT, WY) were constructed by averaging the values for adjacent states (AK and HI were set to the highest state price).

[b]Values for missing states for other chickens (AK, AZ, DE, KS, ND, NM, NV, RI) were constructed by averaging the values for adjacent states (AK and HI were set to the highest state price).

[c]Values for missing states for turkeys (AK, AL, AZ, FL, GA, HI, ID, KY, LA, ME, MS, MT, NM, NV, RI, TN, WA, WV, WY) were constructed by averaging the values for adjacent states (AK and HI were set to the highest state price).

[d]Values for other poultry were calculated by multiplying the average farm price of ducks in 2004 from Clauer (n.d.) by the average price index for young chickens in each state.

Table 2-4. Labor and Energy Rates and Respective Indices and Poultry Cost Indices by State, 2004

The input shares used to calculate the cost index were derived from estimates in Table 2-2 from Ollinger, MacDonald, and Madison (2000).

State	Hourly Wages ($/hour)[a,b]	Hourly Wage Index (Average = 100)	Electricity Revenue (Cents/kWh)	Electricity Revenue Index (Average = 100)	Chicken Production Cost Index	Turkey Production Cost Index	Other Poultry Production Cost Index[c]
AL	13.86	93.44	4.21	77.01	86.42	83.69	85.06
AK	17.87	120.47	8.10	148.17	132.31	136.90	134.61
AZ	12.90	86.96	5.50	100.61	92.80	95.06	93.93
AR	13.18	88.85	4.19	76.65	83.63	81.61	82.62
CA	13.99	94.31	8.53	156.04	120.70	130.93	125.82
CO	15.75	106.18	5.32	97.32	102.39	100.92	101.66
CT	16.95	114.27	8.16	149.27	129.23	135.03	132.13
DE	14.69	99.03	4.99	91.28	95.72	94.43	95.08
FL	13.68	92.22	5.86	107.20	98.62	101.10	99.86
GA	13.33	89.86	4.45	81.40	86.25	84.85	85.55
HI	17.87	120.47	13.36	244.39	173.44	193.98	183.71
ID	15.25	102.81	3.83	70.06	88.81	83.38	86.10
IL	14.93	100.65	4.73	86.53	94.61	92.27	93.44
IN	15.65	105.50	4.14	75.73	92.78	87.84	90.31
IA	16.87	113.73	4.39	80.31	99.44	93.90	96.67
KS	15.60	105.17	4.59	83.96	96.10	92.59	94.35
KY	14.83	99.98	3.30	60.37	83.04	76.48	79.76
LA	13.36	90.09	5.82	106.46	97.09	99.80	98.45
ME	17.17	115.75	3.56	65.12	94.11	85.72	89.92
MD	14.49	97.68	4.51	82.50	91.19	88.68	89.94
MA	15.84	106.78	8.49	155.31	127.53	135.57	131.55
MI	15.02	101.26	4.91	89.82	96.37	94.47	95.42
MN	15.35	103.48	4.70	85.98	96.00	93.10	94.55
MS	12.08	81.44	4.80	87.81	84.16	85.21	84.69
MO	14.82	99.91	4.39	80.31	91.53	88.28	89.91
MT	16.39	110.49	4.14	75.73	95.63	89.87	92.75
NE	15.46	104.22	4.25	77.74	92.90	88.52	90.71
NV	14.38	96.94	7.25	132.62	112.19	118.11	115.15
NH	15.54	104.76	10.04	183.66	138.49	151.56	145.03
NJ	14.76	99.50	8.67	158.60	124.77	134.56	129.67
NM	13.76	92.76	5.10	93.29	92.99	93.08	93.04

(continued)

Table 2-4. Labor and Energy Rates and Respective Indices and Poultry Cost Indices, by State, 2004 (continued)

State	Hourly Wages ($/hour)[a,b]	Hourly Wage Index (Average = 100)	Electricity Revenue (Cents/ kWh)	Electricity Revenue Index (Average = 100)	Chicken Production Cost Index	Turkey Production Cost Index	Other Poultry Production Cost Index[c]
NY	15.18	102.33	6.23	113.96	107.31	109.23	108.27
NC	13.56	91.41	4.89	89.45	90.58	90.25	90.42
ND	14.10	95.05	4.20	76.83	87.26	84.24	85.75
OH	14.56	98.16	4.74	86.71	93.26	91.37	92.32
OK	11.56	77.93	4.72	86.34	81.53	82.92	82.23
OR	14.98	100.99	4.25	77.74	91.05	87.20	89.13
PA	14.63	98.63	5.86	107.20	102.29	103.71	103.00
RI	13.02	87.77	8.58	156.95	117.35	128.81	123.08
SC	13.78	92.90	4.14	75.73	85.56	82.72	84.14
SD	15.45	104.12	4.60	84.15	95.58	92.27	93.93
TN	13.89	93.64	4.48	81.95	88.64	86.71	87.68
TX	14.83	99.98	5.57	101.89	100.79	101.11	100.95
UT	14.34	96.69	4.07	74.45	87.19	83.50	85.35
VT	13.40	90.34	7.93	145.06	113.73	122.80	118.27
VA	15.10	101.80	4.30	78.66	91.91	88.07	89.99
WA	15.12	101.90	3.85	70.43	88.44	83.23	85.84
WV	17.87	120.47	3.83	70.06	98.92	90.57	94.75
WI	14.83	99.98	4.91	89.82	95.63	93.95	94.79
WY	15.87	106.96	3.90	71.34	91.74	85.83	88.79
Average	14.83	100.00	5.47	100.00	100.00	100.00	100.00

[a]The following states did not have wage data: ID, LA, NM, SD, UT, WA, and WY. We calculated wage rates for these states using the average of neighboring states.

[b]Wages for Alaska and Hawaii were not available; we used the highest figure among the other 48 states for AK and HI.

[c]Other poultry production cost index is equal to the average young chicken and turkey index for the respective state.

Hourly wages source: U.S. Bureau of Labor Statistics. http://data.bls.gov/cgi-bin/dsrv?sm.

Electricity source: U.S. Energy Information Administration. March 2005. *Electric Power Monthly*. DOE/EIA-0226 (2005/03). Available from http://tonto.eia.doe.gov/ftproot/electricity/epm/02260503.pdf.

- turkeys, whole or parts
  - fryer-roaster turkeys (under 16 weeks of age)
  - young turkeys (4 to 7 months of age)
  - whole old turkeys (over 12 months of age)
- other poultry and small game, whole or parts
- processed poultry and small game containing 20 percent or more poultry or meat

Poultry slaughter plants also produce poultry by-products such as chicken wingtips, paws, and giblets; turkey gizzards; and duck and goose livers. Many of these by-products are considered delicacies both domestically and abroad; however, because of the low volume produced per bird, it was determined to be impractical to include their value in the poultry slaughter economic model.

2.1.4 Supply Elasticities

Supply elasticities measure the sensitivity of the quantity of a product supplied in response to changes in input and output prices. In modeling the effects of regulations on the poultry industry, the own-price elasticity of supply and the import supply elasticity for each type of poultry are required. Available empirical estimates of supply elasticities were used to approximate the values for each of the four markets (see Tables A-1 and A-2 in Appendix A for the list of available sources) as indicated in Table 2-5.

Table 2-5. Supply Elasticities for Poultry
Elasticities of supply for poultry are fairly inelastic.

Elasticity Type	Young Chickens	Other Chickens	Turkeys	Other Poultry
Own-price supply elasticities	0.22	0.22	0.26	0.26
Import supply elasticities	0.62	—	0.52	0.52

Note: The list of sources is provided in Tables A-1 and A-2.

For chickens and young chickens, we used the estimate of 0.22, which is an average of five supply elasticity estimates for broilers. For turkeys and other poultry, we used an estimate of 0.26, which is an average of three supply elasticity estimates for turkey. Because no estimates of import supply elasticities are available from the literature, we assumed that import supply is twice as elastic as domestic supply. However, no value was included for other chicken imports because we assumed this product is not imported. Users have the option of modifying any of the default elasticity estimates in the model if more accurate estimates are available from other sources. In addition, users may input different estimates of the supply elasticities for very small, small, and large plants to represent potential differences in responsiveness to price changes depending on plant size.

2.2 DEMAND CHARACTERIZATION OF THE POULTRY SLAUGHTER INDUSTRY

Poultry demand has dramatically changed over the last few decades. Poultry consumption has evolved from a by-product of egg production and holiday fare to a staple of consumers' diets. This transformation has been attributed to improved products offered at lower costs, increased consumer health concerns, increased numbers of convenience products, and introduction to the fast-food market (Haley, 2001).

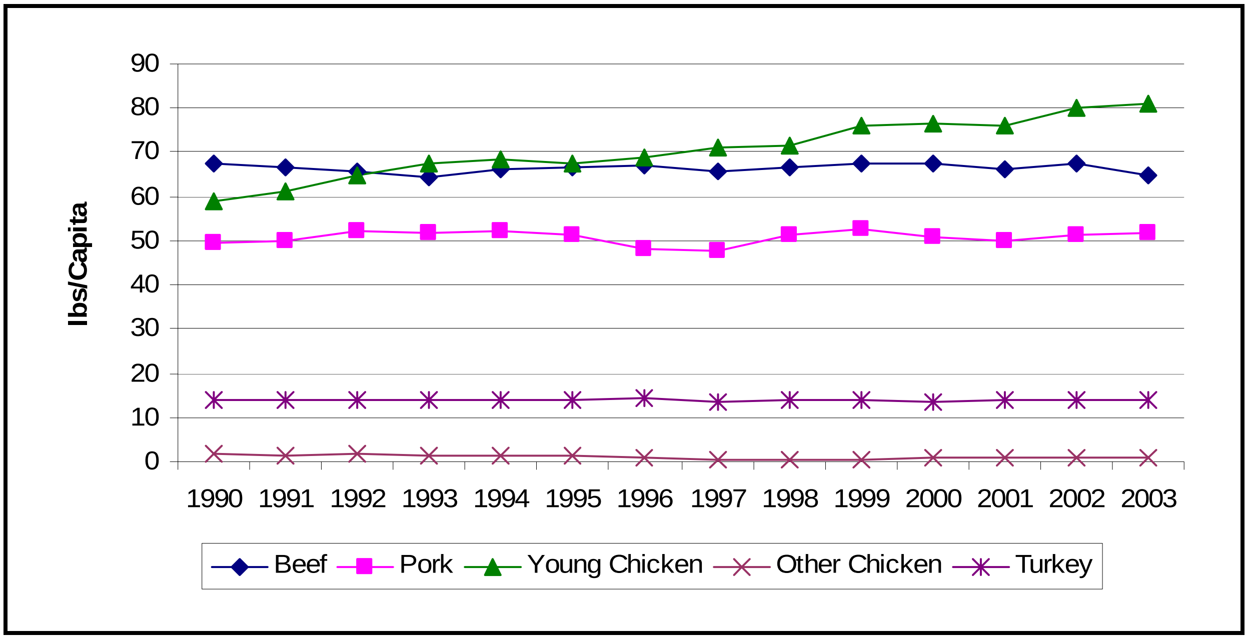
In this section, we describe consumption of poultry products and elasticities of demand for poultry products.

2.2.1 Consumption

Consumption of young chickens dominates both meat and poultry consumption. Figure 2-2 shows that broiler consumption per capita has increased since 1990, surpassing beef in 1992 and averaging over 80 pounds in 2003. Other chicken consumption, which is primarily chicken used in further processing, is low at approximately 5 pounds per person annually. Annual turkey consumption has remained relatively constant at approximately 15 pounds per person. Data on consumption of other types of poultry are not available.

As mentioned, chicken from broilers displaced beef as the single largest animal protein consumed in the United States in 1992. This change in consumption from meat to poultry had been culminating for many years. Broiler consumption has steadily increased from less than 35 pounds in the late 1960s, while beef consumption has declined from a high of 94 pounds per capita in 1976 to current levels of approximately 65 pounds

Figure 2-2. Per Capita Meat and Poultry Consumption, 1990–2003 (lbs)



[a]Boneless weight was used, retail weight was not available.

Source: U.S. Department of Agriculture (USDA), Economic Research Service. May 2005a. "Food Availability: Spreadsheets." <http://www.ers.usda.gov/data/FoodConsumption/FoodAvailSpreadsheets.htm>.

per capita. Broiler consumption surpassed pork in 1986 despite increases in pork consumption from 45 pounds in the mid-1970s to almost 52 pounds per person currently.

2.2.2 Demand Elasticities

Demand elasticities measure the sensitivity of the quantity of a product purchased in response to changes in the price of a product and its closest substitutes. In modeling the effects of regulations on the poultry industry, the following demand elasticities are required:

- own-price demand elasticities for each poultry type,
- cross-price demand elasticities between different types of poultry, and
- export demand elasticities for each poultry type.

Poultry demand elasticity estimates were identified from the economics literature for use in the facility-level poultry model. Available empirical estimates of supply elasticities were used to approximate the values for each of the four markets (see Tables B-1, B-2, and B-3 in Appendix B for the list of available sources) as indicated in Table 2-6.

Table 2-6. Demand Elasticities for Poultry
Elasticities of demand for poultry are inelastic. The upper diagonal cross-price elasticities of demand were adjusted by the relative expenditure shares for each pair of products.

Elasticity Type	Young Chickens	Other Chickens	Turkeys	Other Poultry
Own-Price Demand	–0.43	–0.62	–0.58	–0.62
Cross-Price Demand				
Young chickens	—	0.000	0.023	0.001
Other chickens	0.01	—	0.214	0.012
Turkeys	0.15	0.01	—	0.009
Other poultry	0.15	0.01	0.15	—
Export Demand	–1.44	–1.44	–1.44	–1.44

Note: The list of sources is provided in Tables B-1 through B-5.

For young chickens, we used an estimate of –0.43, which is an average of 20 demand elasticity estimates for chicken. We used –0.58 for turkeys, which is an average of 10 demand elasticity estimates for turkey. We used –0.62 for other chickens and other poultry, which is an average of 12 demand elasticity estimates for all poultry. For export demand, we used –1.44 for all poultry types based on an average of nine estimates available for poultry exports to various countries.[3]

For cross-price demand elasticities among the different types of poultry, only one estimate was available for the cross-price elasticity between poultry products. This estimate represented the cross-price elasticity of demand between chicken and turkey and had a value of 0.33. Because this was the only value available between poultry products, we aggregated all available cross-price elasticities of demand between chicken or poultry and other meat products that had the correct (positive) sign. Thus, we used a value of 0.15, which is an average of 19 cross-price elasticity estimates between chicken or poultry and beef or pork, as a default value for the cross-price elasticity of demand among poultry products with the exception of the cross-price elasticities of demand with other chicken.[4] Because substitution by consumers between other chicken, which is generally used in processed products, and the other poultry types is very limited, we assumed a value of 0.01 for the cross-

[3]One export demand elasticity with the wrong sign was excluded from the calculation of the average value.
[4]Ten cross-price elasticity estimates with the wrong sign were excluded from the calculation of the average value.

price elasticities of demand for other chicken. The cross-price elasticity of demand represents the percentage change in, for example, the quantity of young chicken purchases in response to a 1 percent change in the price of turkey. To generate the corresponding values for substitution in the opposite direction (e.g., the percentage change in the quantity of turkey purchases in response to a 1 percent change in the price of young chickens), we adjusted the cross-price elasticities based on relative expenditure shares.[5]

2.3 INDUSTRY ORGANIZATION

The poultry industry has become a model of efficiency in production and marketing. It has dominated competition during the past 30 years, expanding its market share as efficiency improved (Vukina, 2001). The poultry industry's adoption of different business structures has allowed it to reap the benefits of advancements in methods of production from feed milling and genetic improvements to slaughter and further processing.

In this section, we describe some of the unique features of the organizational structure in the poultry industry.

2.3.1 Company Specialization

Poultry producers and processors typically specialize in one species. Focusing on one or a few species allows companies to standardize equipment and increase the speed of production. Ollinger, MacDonald, and Madison (2000) reported that by the 1960s the majority of birds procured by poultry slaughter facilities were from a single species. By 1992, live chickens accounted for 99 percent of the meat inputs for chicken facilities. Turkey facilities appeared to exclusively handle live turkeys because they represented 100 percent of the industry's meat inputs in 1992.

Plant specialization has been facilitated by vertical integration within the industry. Integration allows processors to ensure

[5]When using Marshallian welfare measures (i.e., consumer and producer surplus), symmetry conditions require $\eta_{ij} = \frac{\gamma_j}{\gamma_i}\eta_{ji}$, where $\frac{\gamma_j}{\gamma_i}$ is the ratio of expenditure shares (equal to the ratio of the revenue shares for the slaughter and processing sector) and η_{ij} and η_{ji} are the cross-price elasticities of demand between products (Zhao, Mullen, and Griffith, 2005).

their supply of poultry by managing all phases of the production process. Broiler integrators typically own feed mills, breeding stock, hatcheries, and slaughter plants, but almost all contract with independent growers to raise their birds. Integration in the turkey industry is less uniform; companies are less apt to own hatcheries but more likely to have company-owned farms (Vukina, 2001). Integrator-owned and contracted birds represented 99 percent of all chickens and 88 percent of all turkeys slaughtered in 1994 (Ollinger, MacDonald, and Madison, 2000).

2.3.2 Number of Plants and Companies

A total of 297 federally inspected plants slaughter poultry in 2004. More plants slaughter broilers than any other poultry type, but many plants slaughter multiple types of poultry. Specifically, 218 federally inspected plants slaughtered over 8 billion young chickens, 39 plants slaughtered approximately 140 million other chickens, 70 plants slaughtered over 250 million turkeys, and 50 plants slaughtered approximately 27 million other poultry (see Table 2-7). In addition, at least 87 state-inspected plants (85 very small and 2 small plants) slaughtered some poultry species in FY 2004. However, not all states provide information on whether plants slaughter meat or poultry species; thus, the total number of state-inspected plants that slaughter poultry species is likely greater than 87. States that indicate which plants slaughter poultry species do not provide data on which poultry species is slaughtered or the total volume slaughtered. However, the total volume of slaughter for state-inspected plants is extremely small compared with the volume of slaughter for federally inspected plants (less than an estimated 0.1 percent).

Table 2-8 shows all of the companies included in the poultry model that own more than one plant. Multiple-plant companies own over 50 percent of all the plants included in the model. The 10 companies that own five or more plants each represent over 40 percent of plants in the model.

2.3.3 Poultry Slaughter Plant Characteristics Based on Survey Results

In 2004, FSIS completed a survey of meat and poultry slaughter and processing plants to obtain information on food safety practices (Cates et al., 2005). As part of the survey, additional information was obtained regarding the

Table 2-7. Plant Inventories and Slaughter Volumes for Federal Plants that Slaughtered Poultry in FY 2004
Although many of the 297 federally inspect poultry slaughter establishments slaughter only one poultry species, some slaughter multiple species.

Size	Young Chicken		Other Chicken		Turkey		Other Poultry	
	Number of Plants	Volume	Number of Plants	Volume	Number of Plants	Volume	Number of Plants	Volume
Very small	32	5,541,165	6	81,925	20	100,384	30	635,637
Small	60	1,292,214,385	21	98,166,727	25	57,657,363	19	26,142,858
Large	126	7,088,916,052	12	41,250,511	25	194,030,037	1	2,600
Total	218	8,386,671,602	39	139,499,163	70	251,787,784	50	26,781,095

Source: RTI International. 2005. Enhanced Facilities Database. Research Triangle Park, NC: RTI.

Table 2-8. Known Companies Owning Multiple Poultry Slaughter Plants
Three of the companies listed are classified as small companies by the Small Business Administration (SBA).

Name	Number of Poultry Plants	Small Business Administration Classification	Employment[a]
Tyson Foods, Inc.	41	No	114,000
Pilgrim's Pride Corp.	23	No	40,300
Gold Kist Holdings Inc.	11	No	17,000
Perdue Farms Inc.	11	No	18,000
Contigroup Companies, Inc.	8	No	15,500
ConAgra Foods, Inc.	6	No	39,000
Foster Farms, Inc.	6	No	11,000
Sanderson Farms, Inc.	6	No	8,300
Cargill Inc.	5	No	101,000
House of Raeford Farms, Inc.	5	No	5,000
Hormel Foods Corporation	4	No	15,600
Peco Foods, Inc.	4	No	3,200
Allen Family Foods, Inc.	3	No	2,400
Cagle's Inc.	3	No	2,010
Case Foods, Inc.	3	No	1,800
George's Inc.	3	No	3,700
Mountaire Farms, Inc.	3	No	3,310
Simmons Foods, Inc.	3	Yes	468
Fieldale Farms Corp.	2	Yes	150
JFC Inc.	2	No	1,600
Keystone Foods Corp.	2	No	6,500
Maple Leaf Foods, Inc.	2	No	22,784
Marshall Durbin Poultry Co.	2	No	1,450
OK Foods, Inc.	2	No	2,700
Townsends, Inc.	2	No	2,600
Booth Creek Management Corp.	2	No	745
Koch Foods, LLC	2	Yes	350

[a]Employment figures represent company-wide employment, including facilities that do not slaughter poultry.

Source: RTI International. 2005. Enhanced Facilities Database. Research Triangle Park, NC: RTI.

characteristics of poultry slaughter plants, including sources of inputs, production processes, and age and different measures of the size of plants. The information from the survey is useful in characterizing establishments to develop the economic model for estimating the effects of regulation on the industry.

Based on the results of the survey, almost all live birds slaughtered in U.S. poultry slaughter plants are from domestic sources. An estimated 95 percent of plants do not slaughter any imported birds. In addition, 93 percent of poultry slaughter plants that receive raw poultry inputs do not receive any raw poultry inputs from foreign sources. However, most poultry slaughter plants (78 percent) receive or purchase some portion of their raw poultry inputs from other U.S. plants. The remaining plants only process raw poultry produced from birds that are slaughtered within the plant.

In addition to slaughtering, an estimated 56 percent of plants grind or further process poultry. Of those plants that further process, 87 percent produce not ready-to-eat (NRTE) products, 24 percent produce RTE products, and 61 percent produce inputs for further processing by other plants. The volume produced by poultry slaughter plants tends to be large, with 50 percent of plants producing more than 100 million pounds of raw, not ground poultry products annually. The mean annual production volume is estimated at 149.8 million pounds. In addition to raw, not ground poultry products,

- 61 plants produced raw, ground poultry (average 27.4 million pounds annually);
- 25 plants produced fully cooked, shelf-stable poultry (average 28.2 pounds annually);
- 17 plants produced heat-treated, but not fully cooked, not shelf-stable poultry (average 44.8 million pounds); and
- between one and four plants produced the remaining types of poultry, such as commercially sterile and not heat-treated, shelf-stable poultry.

The survey results also indicate several measures of plant size in addition to production volume. The average production space in a poultry slaughter plant is 111,600 square feet, but 79 percent of the plants are between 10,000 and 999,999 square feet. The average number of employees is 645 with 54 percent of plants having 500 or more and 31.4 percent having 10 to

499 employees. The sales range category with the highest percentage of plants (26.5 percent) is $100.0 million to $249.9 million in annual sales with the remaining plants distributed relatively evenly across the other sales categories. However, five poultry slaughter plants have annual sales of $500 million or more. Because these five plants represent such a large volume of output, the average values for all measures of size are higher than is likely representative of a typical plant in the poultry slaughter industry.

The range of ages of poultry slaughter plants is large. In addition, any one plant might have production areas that were built at different times. An average poultry slaughter plant was built or most recently renovated in 1987, and 61.5 percent of plants were built or renovated since 1990. An estimated 46.5 percent of the square footage is 20 years old or more.

2.3.4 Market Power

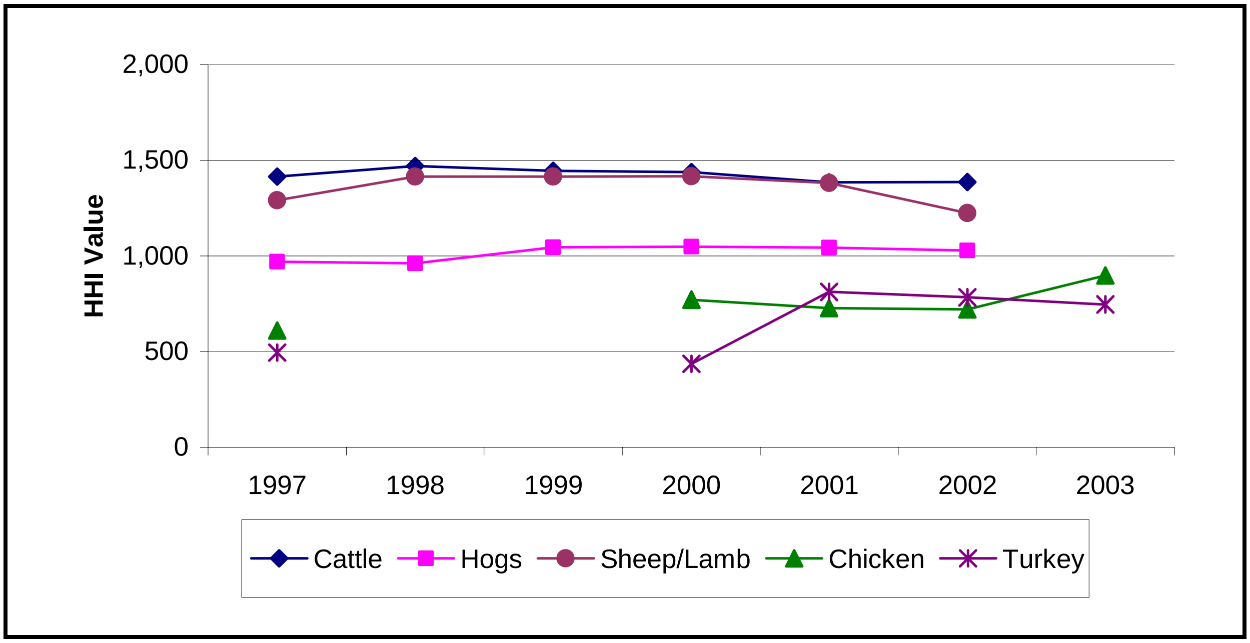
Measures of market concentration for chicken slaughter and turkey slaughter indicate values are similar for both industries. Figure 2-3 shows the chicken and turkey industries both have Herfindahl-Hirschman Indexes (HHI) lower than any of the meat industries (beef, pork, and lamb). The HHI is a measure of industry concentration that is calculated as the sum of each firm’s squared percentage of total commercial slaughter and can vary from close to 0 to 10,000. Industries with an HHI below 1,000 are considered “competitive” industries by the U.S. Department of Justice. Based on this criterion, the chicken and turkey slaughter industries would be categorized as competitive.

Turkey industry concentration, like all of the meat industries, appears to have peaked and begun to decline in recent years. The chicken industry, however, saw its largest concentration increase between 2002 and 2003.

2.4 MARKET-LEVEL DATA

The integrated nature of the poultry industry alters the way market data are reported. Other livestock industries provide more transparent information as animals are transferred between different owners throughout the supply chain. However, integrated poultry slaughter companies internalize this information; subsequently, many of the reported values for

Figure 2-3. HHI Values for Slaughter Facilities, 1997–2003



HHI = Herfindahl-Hirschman Index

Sources: U.S. Department of Agriculture (USDA), Grain Inspection, Packers and Stockyards Administration. 2004a. "Assessment of the Cattle, Hog, Poultry, and Sheep Industries: 2003 Report." <http://151.121.3.117/pubs/packers/assessment02-03.pdf>.

U.S. Department of Agriculture (USDA), Grain Inspection, Packers and Stockyards Administration. 2004b. "Packers and Stockyards Statistical Report: 2002 Reporting Year." SR-04-01. Washington, DC: GIPSA.

upstream markets rely on information derived from retail markets.

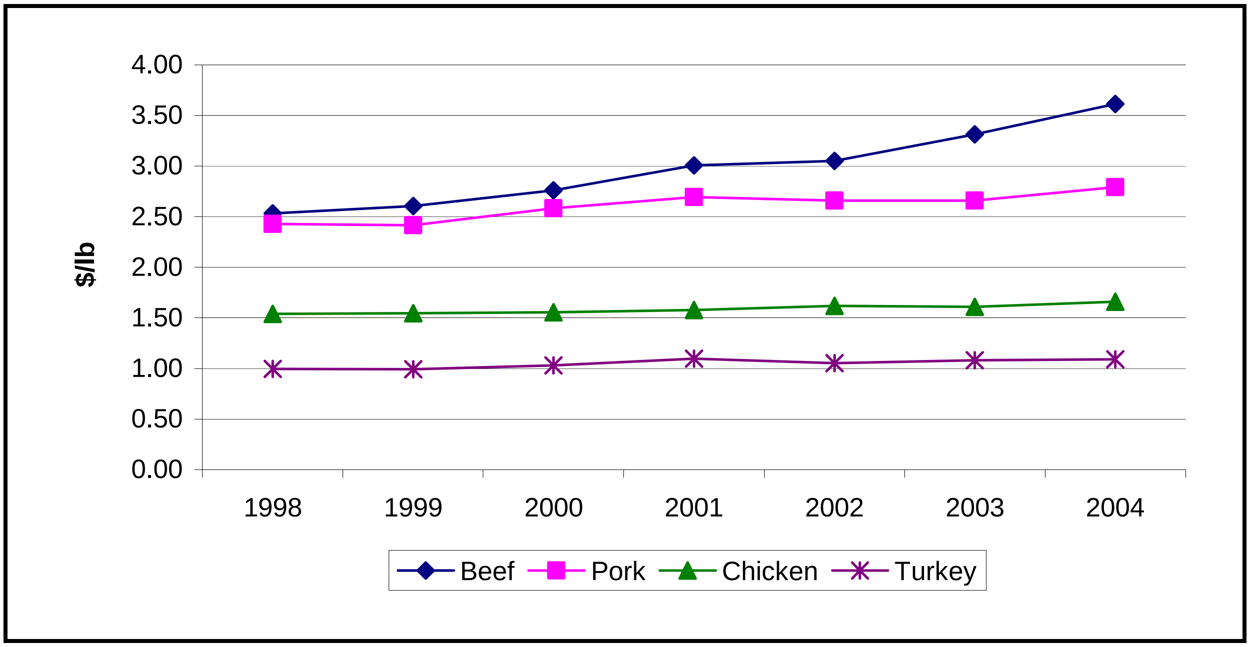
In this section, we describe the current state of the poultry market by examining reported domestic prices and international trade values.

2.4.1 Prices

Poultry products are low-cost protein sources for consumers. Figure 2-4 shows that average nominal retail prices for both chicken and turkey have remained stable at approximately $1.50 and $1.00 per pound, respectively, from 1998 to 2004. Adjusting the prices in Figure 2-4 for inflation indicates that real retail prices for chicken and turkey have declined. In contrast, the relatively stable trend of poultry prices did not occur for red meat prices. Specifically, retail beef prices increased by more than 40 percent from 1998 to 2004, and retail pork prices increased by almost 15 percent during the same time period.

Figures 2-5 and 2-6 display input prices for the meat and poultry industries. The wholesale prices in Figure 2-5 are the

Figure 2-4. Nominal Meat and Poultry Retail Prices, 1998–2004 ($/lb)



Sources: U.S. Department of Agriculture (USDA), Economic Research Service. August 2004b. *Poultry Yearbook.* Washington, DC: USDA. <http://usda.mannlib.cornell.edu/data-sets/livestock/89007/>.

U.S. Department of Agriculture (USDA), Economic Research Service. 2004c. *Red Meat Yearbook*. Stock #94006. Washington, DC: USDA, ERS. <http://usda.mannlib.cornell.edu/data-sets/livestock/94006/>.

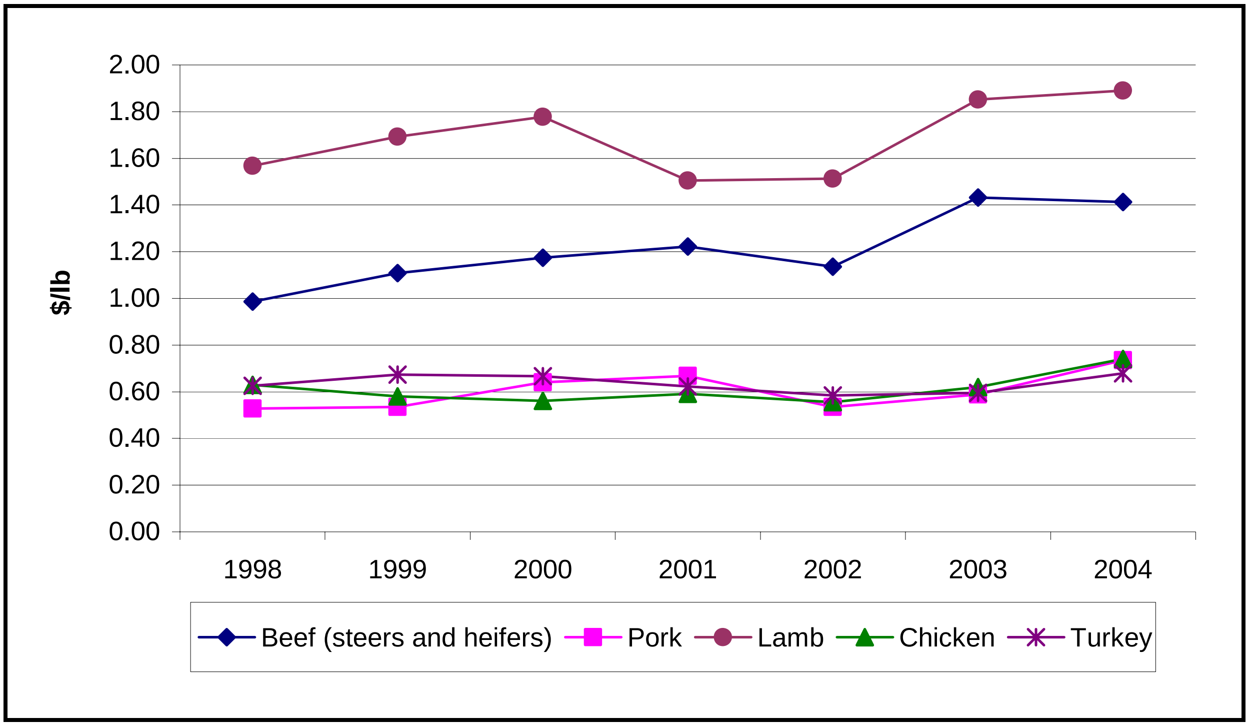
U.S. Department of Agriculture (USDA), Economic Research Service. 2005b. *Livestock, Dairy, & Poultry Outlook.* Washington, DC: USDA, ERS. <http://www.ers.usda.gov/publications/ldp/>.

prices paid by retailers and food service providers for meat and poultry products. The wholesale prices resemble retail prices in that chicken and turkey commodities are lower cost relative to beef; however, pork is much more cost competitive at the wholesale level. Lamb is considered a niche market product and receives higher prices at wholesale.

Figure 2-6 depicts the prices paid to producers by slaughter plants for live animal inputs. The parallels between farm prices and wholesale prices are evident. Prices for broilers, turkeys, and hogs are consistently lower than prices for cattle and lamb. Juxtaposing retail, wholesale, and farm-level prices reveals patterns in marketing margins within the industries.

Table 2-9 provides retail prices on the same meat and poultry commodities discussed above, with the addition of lamb and veal. These prices, reported by supermarkets around the country, show the same categories presented in Figures 2-4 through 2-6. Chicken and turkey are the lowest-cost commodities followed by pork and then beef. Veal and lamb, both niche products, receive the highest prices.

Figure 2-5. Nominal Wholesale Meat and Poultry Prices, 1998–2004 ($/lb)



Sources: U.S. Department of Agriculture (USDA), Economic Research Service. 2005b. *Livestock, Dairy, & Poultry Outlook.* Washington, DC. <http://www.ers.usda.gov/publications/ldp/>.

Supplemented with:

2000–2004 veal prices from Urner Barry Pricebook Collection. 2005. Pork, Lamb, and Veal Price Book, Northeast Carcass Veal.

2001 beef (cows and bulls) prices from U.S. Department of Agriculture (USDA), Agricultural Marketing Service. 2002 National Carlot Meat Trade Review. <http://www.ams.usda.gov/lsmnpubs/meattrade/NCMTR2002.pdf>.

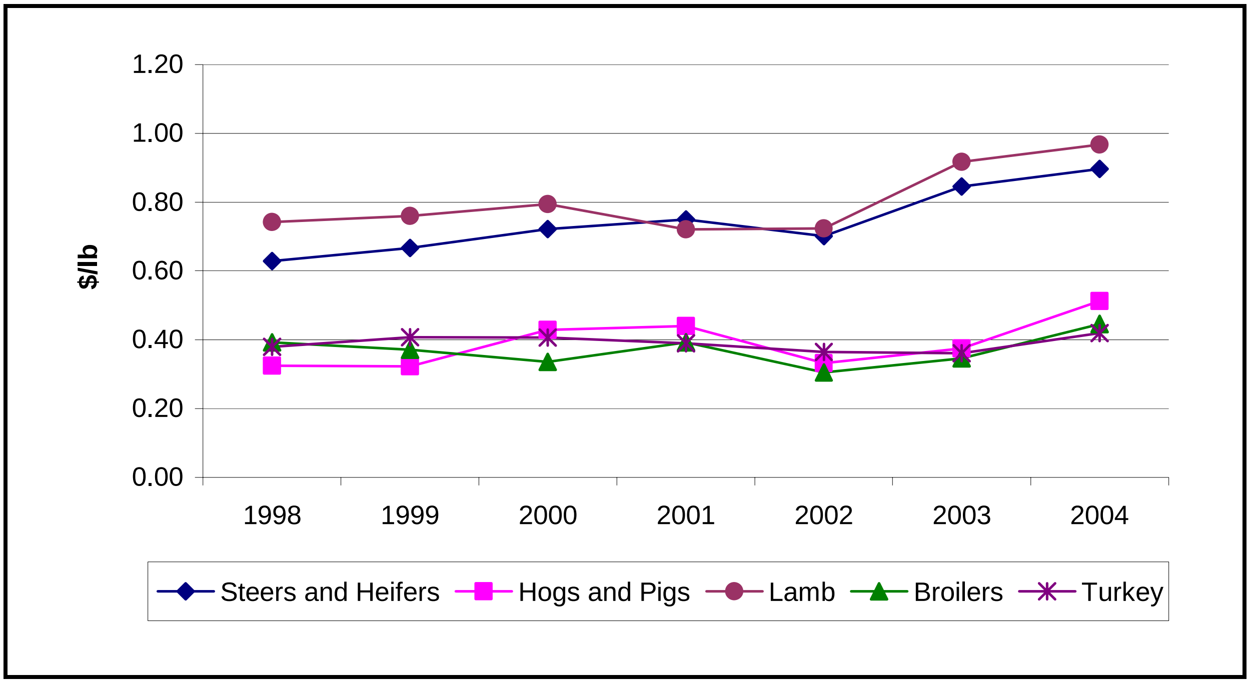
2002–2003 beef (cows and bulls) prices from U.S. Department of Agriculture (USDA), Agricultural Marketing Service. 2003 Annual Meat Trade Review. <http://www.ams.usda.gov/lsmnpubs/meattrade/NCMTR2003.pdf>.

2004 beef (cows and bulls) prices from U.S. Department of Agriculture (USDA), Agricultural Marketing Service. 2004 Annual Meat Trade Review. <http://www.ams.usda.gov/lsmnpubs/meattrade/NCMTR2004.pdf>.

2.4.2 Poultry Trade

The United States is the world's largest exporter of chicken (USDA, ERS, 2004a). Chicken exports have ranged from over 5 billion pounds to just over 6 billion pounds since 2000 (see Figure 2-7). In 2004, chicken exports were valued at almost $1.8 billion (see Figure 2-8). Most of the chicken exports are frozen cuts and pieces (see Table 2-10). Chicken imports, which are at very low levels, have recently also been dominated by frozen cuts and pieces.

Figure 2-6. Nominal Livestock and Poultry Farm Prices, 1998–2004 ($/lb)



Sources: U.S. Department of Agriculture (USDA), National Agricultural Statistics Service. 2005a. Prices Received by Farmers, Cattle. <http://www.usda.gov/nass/graphics/data/priceca.txt>.

U.S. Department of Agriculture (USDA), National Agricultural Statistics Service. 2005b. Prices Received by Farmers, Hogs. <http://www.usda.gov/nass/graphics/data/pricehg.txt>.

U.S. Department of Agriculture (USDA), Economic Research Service. 2004c. *Red Meat Yearbook*. Stock #94006. Washington, DC: USDA, ERS. <http://usda.mannlib.cornell.edu/data-sets/livestock/94006/>.

U.S. Department of Agriculture (USDA), Economic Research Service. 2005b. *Livestock, Dairy, & Poultry Outlook.* Washington, DC: USDA, ERS. <http://www.ers.usda.gov/publications/ldp/>.

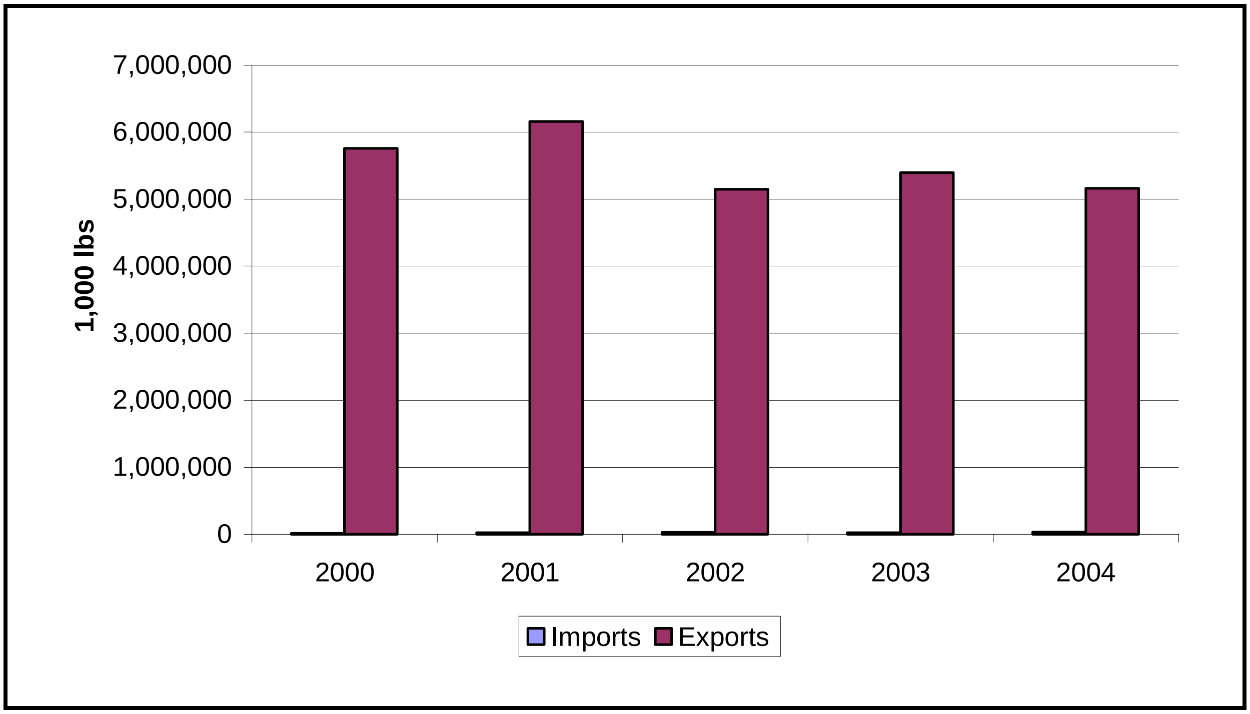
U.S. Department of Agriculture (USDA), National Agricultural Statistics Service. 1999–2005 Poultry: Production and Value-Supplement, April edition. <http://usda.mannlib.cornell.edu/reports/nassr/poultry/pbh-bbp/>.

Table 2-9. Nominal Retail Prices for Meat and Poultry, Based on Scanner Data ($/lb)
USDA began to report prices using meat scanner data in January 2001.

Product	2001	2002	2003	2004
Beef	$3.02	$2.96	$3.28	$3.36
Veal	$4.94	$5.12	$5.30	$4.67
Pork	$2.65	$2.56	$2.61	$2.46
Lamb	$4.26	$4.23	$4.62	$5.09
Chicken	$1.69	$1.70	$1.77	$1.67
Turkey	$1.53	$1.48	$1.46	$1.38

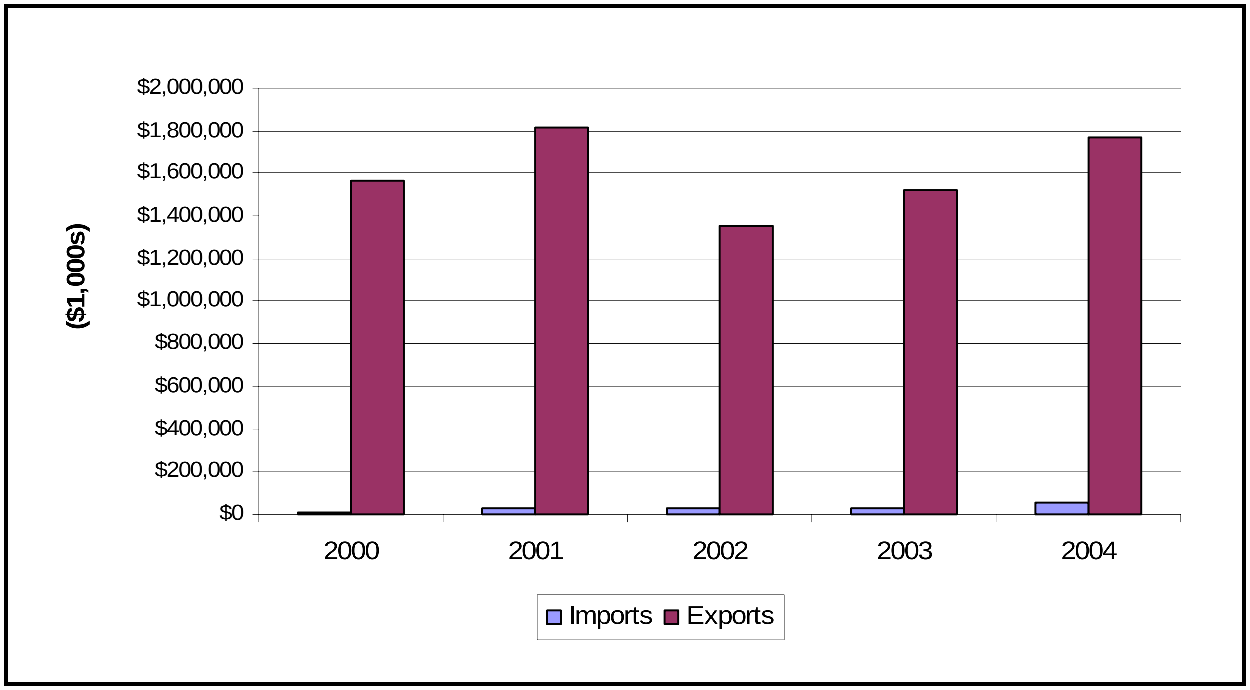
Source: U.S. Department of Agriculture (USDA), Economic Research Service. 2005c. Livestock Marketing Information Center. <http://www.lmic.info/meatscanner/ meatscanner.shtml>.

Figure 2-7. Volume of Chicken Trade, 2000–2004 (1,000 lbs)



Source: U.S. International Trade Commission. Interactive Tariff and Trade DataWeb. <http://dataweb.usitc.gov/>. Accessed June 2005.

Figure 2-8. Value of Chicken Trade, 2000–2004 ($1,000)



Source: U.S. International Trade Commission. Interactive Tariff and Trade DataWeb. <http://dataweb.usitc.gov/>. Accessed June 2005.

Table 2-10. Volume of Chicken Trade by HTS-6 Code, 2000–2004 (1,000 lbs)

HTS-6 Code	Description	Imports					Exports				
		2000	**2001**	**2002**	**2003**	**2004**	**2000**	**2001**	**2002**	**2003**	**2004**
20711	Meat and edible offal of chickens, not cut in pieces, fresh or chilled	4,942	10,296	9,042	7,367	6,072	170,380	70,053	80,506	63,501	114,958
20712	Meat and edible offal of chickens, not cut in pieces, frozen	607	1,100	1,538	1,692	774	83,029	135,013	60,324	43,514	108,891
20713	Chicken cuts and edible offal (including livers), fresh or chilled	7,247	7,530	12,198	11,007	7,748	321,843	279,703	300,496	355,513	447,837
20714	Chicken cuts and edible offal (including livers), frozen	2,543	5,535	4,618	5,997	21,638	5,186,796	5,676,473	4,708,411	4,936,166	4,494,198

Source: U.S. International Trade Commission. Interactive Tariff and Trade DataWeb. <http://dataweb.usitc.gov/>. Accessed June 2005.

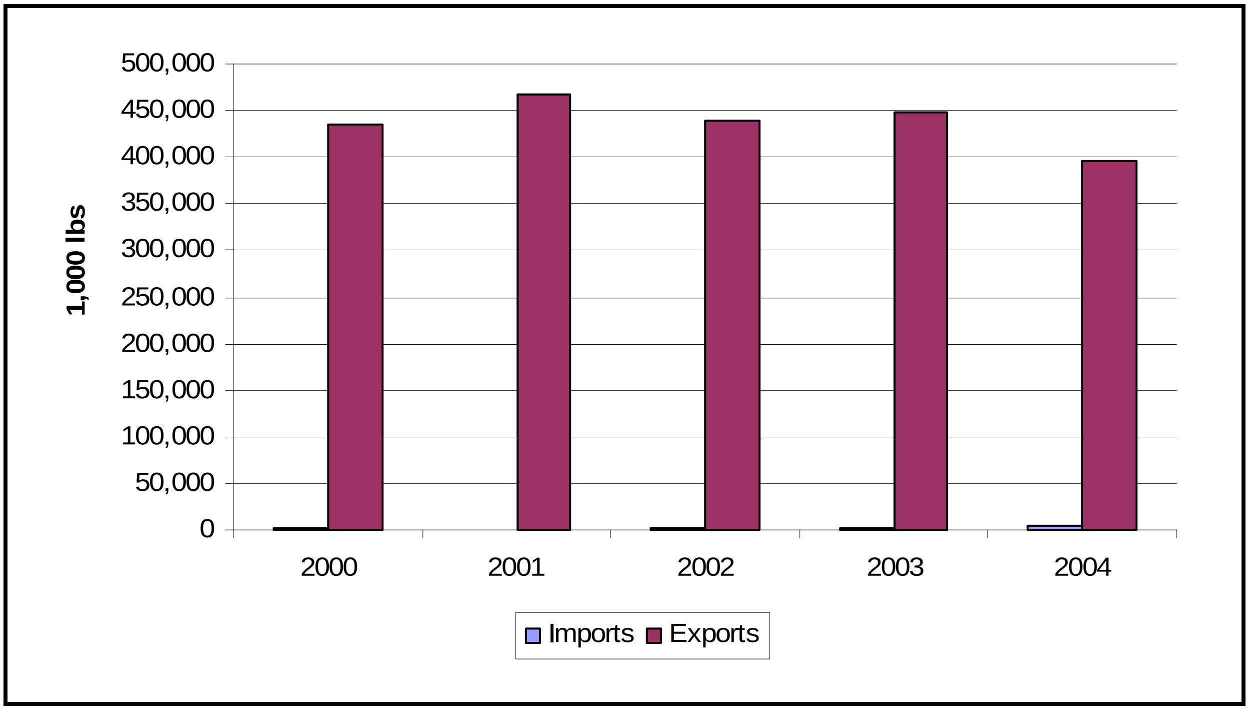
The United States is also the world's largest exporter of turkey (USDA, ERS, 2004a). Just under 400 million pounds of turkey were exported in 2004, which was the lowest level of turkey exports since 2000 (see Figure 2-9). Despite the low level of exports in 2004, the value of exports was greater than $250 million (see Figure 2-10). As with chicken exports, turkey is predominately exported as cuts; however, the proportions of fresh and frozen cuts are much closer for turkey (see Table 2-11). Some turkey is imported, but the volumes of different products vary considerably.

The United States is a net exporter of other poultry but the volumes are very small. The volume of other poultry exports has varied from approximately 7.5 million pounds in 2001 to a low of approximately 4.5 million pounds in 2004. Frozen cuts are the largest type of other poultry exports.

2.4.3 Model Baseline Year

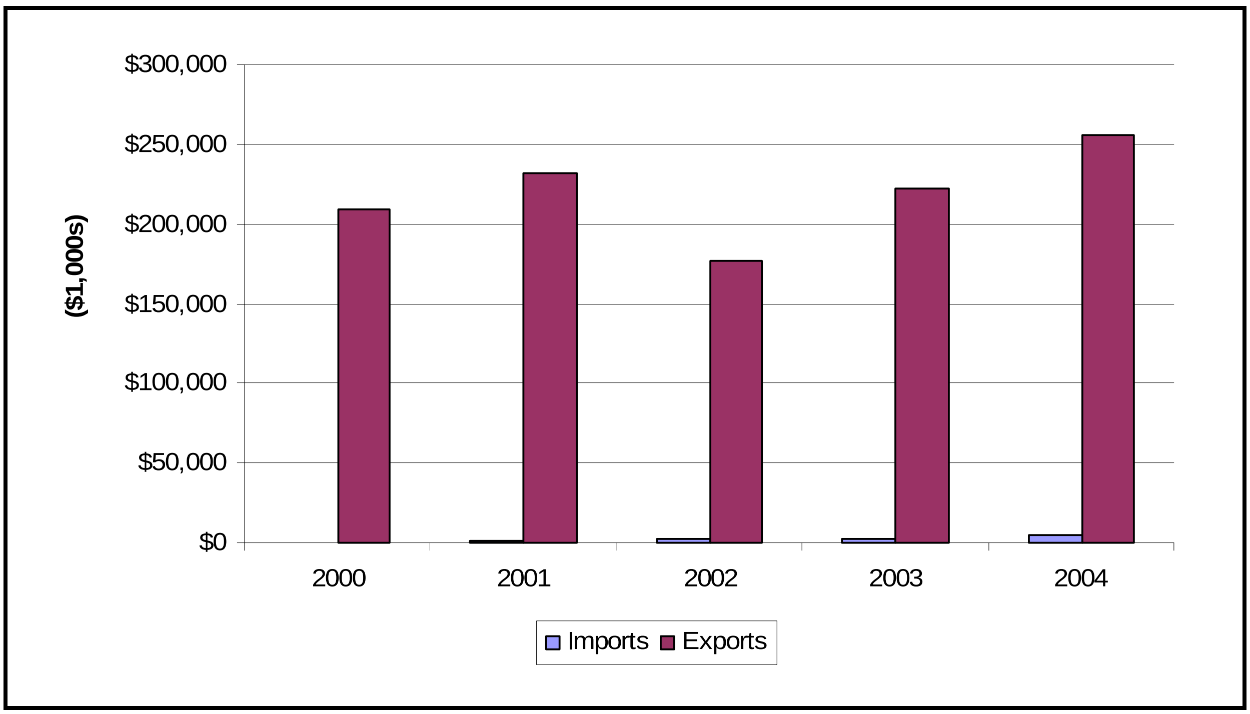
The baseline year for the poultry model is 2004. Using 2004 as the baseline allowed us to incorporate current and complete annual data from most market sources. In addition, we were able to use the most recent facility data available from the updated Enhanced Facilities Database.

Figure 2-9. Volume of Turkey Trade, 2000–2004 (1,000 lbs)



Source: U.S. International Trade Commission. Interactive Tariff and Trade DataWeb. <http://dataweb.usitc.gov/>. Accessed June 2005.

Figure 2-10. Value of Turkey Trade, 2000–2004 ($1,000)



Source: U.S. International Trade Commission. Interactive Tariff and Trade DataWeb. <http://dataweb.usitc.gov/>. Accessed June 2005.

Table 2-11. Volume of Turkey Trade by HTS-6 Code, 2000–2004 (1,000 lbs)

HTS-6 Code	Description	Imports					Exports				
		2000	2001	2002	2003	2004	2000	2001	2002	2003	2004
20724	Turkeys, not cut in pieces, fresh or chilled	10	131	173	50	1,118	5,189	5,672	3,510	9,275	6,404
20725	Turkeys, not cut in pieces, frozen	15	45	59	199	2	28,363	14,658	11,760	17,279	16,899
20726	Turkey cuts and edible offal (including livers), fresh or chilled	97	182	491	358	177	92,913	121,983	150,801	169,199	173,182
20727	Turkey cuts and edible offal (including livers), frozen	963	568	777	1,717	3,633	308,160	325,792	274,338	252,390	198,816

Source: U.S. International Trade Commission. Interactive Tariff and Trade DataWeb. <http://dataweb.usitc.gov/>. Accessed June 2005.

3 Methodology for Economic Impact Analysis

> The economic impact analysis methodology incorporates market-level data, facility-level data, and compliance cost estimates into a modeling framework based on microeconomic theory.

Poultry slaughter and processing facilities that are directly affected by FSIS's regulations are likely to respond to this change in the market environment by modifying their production rate and/or altering their input mix. The impacts of these adjustments on equilibrium prices and quantities will result in the compliance costs being at least partially transmitted to other entities through market relationships. To develop estimates of the social costs of the rules and their distribution, we constructed a facility-level behavioral model that simulates producer and consumer responses to changing market conditions. This section of the report describes the quantitative model and the underlying economic theory.

3.1 ECONOMIC IMPACT ANALYSIS METHODOLOGY OVERVIEW

Executive Order (EO) 12866 requires regulatory agencies to conduct a comprehensive analysis of the economic benefits and costs of significant regulatory actions.[1] In addition, the Regulatory Flexibility Act (RFA) and Small Business Regulatory Enforcement and Fairness Act (SBREFA) require regulatory agencies to consider the economic impacts of regulatory actions on small entities. The methodology used for this analysis is consistent with standard microeconomic theory and was designed to comply, to the extent possible given data and

[1]Office of Management and Budget (OMB) guidance under EO 12866 stipulates that a full benefit-cost analysis is required when a regulatory action is expected to have an annual effect on the economy of $100 million or above.

resource limitations, with OMB's most recent guidelines for regulatory impact analysis (OMB, 2003).

We developed a facility-level model that uses a behavioral approach to analyze the responses of producers and consumers in a market setting (see Figure 3-1). Specifically, this approach explicitly recognizes that the owners of the affected plants can and will make adjustments such as changing production rates or altering input mixes that will affect the market environment in which they operate. As producers change their production levels in response to regulation, consumers are typically faced with changes in prices that lead them to alter their consumption levels. Producers and consumers face incentives to adjust production and consumption until reaching a new market equilibrium at prices where quantity supplied and demanded are equal in all markets.

Users of the poultry slaughter and processing facility-level model enter estimates of cost changes associated with regulations and indicate which plants are affected by the changes.

The model is designed to allow users flexibility in conducting analyses of different types of regulations. Users of the model

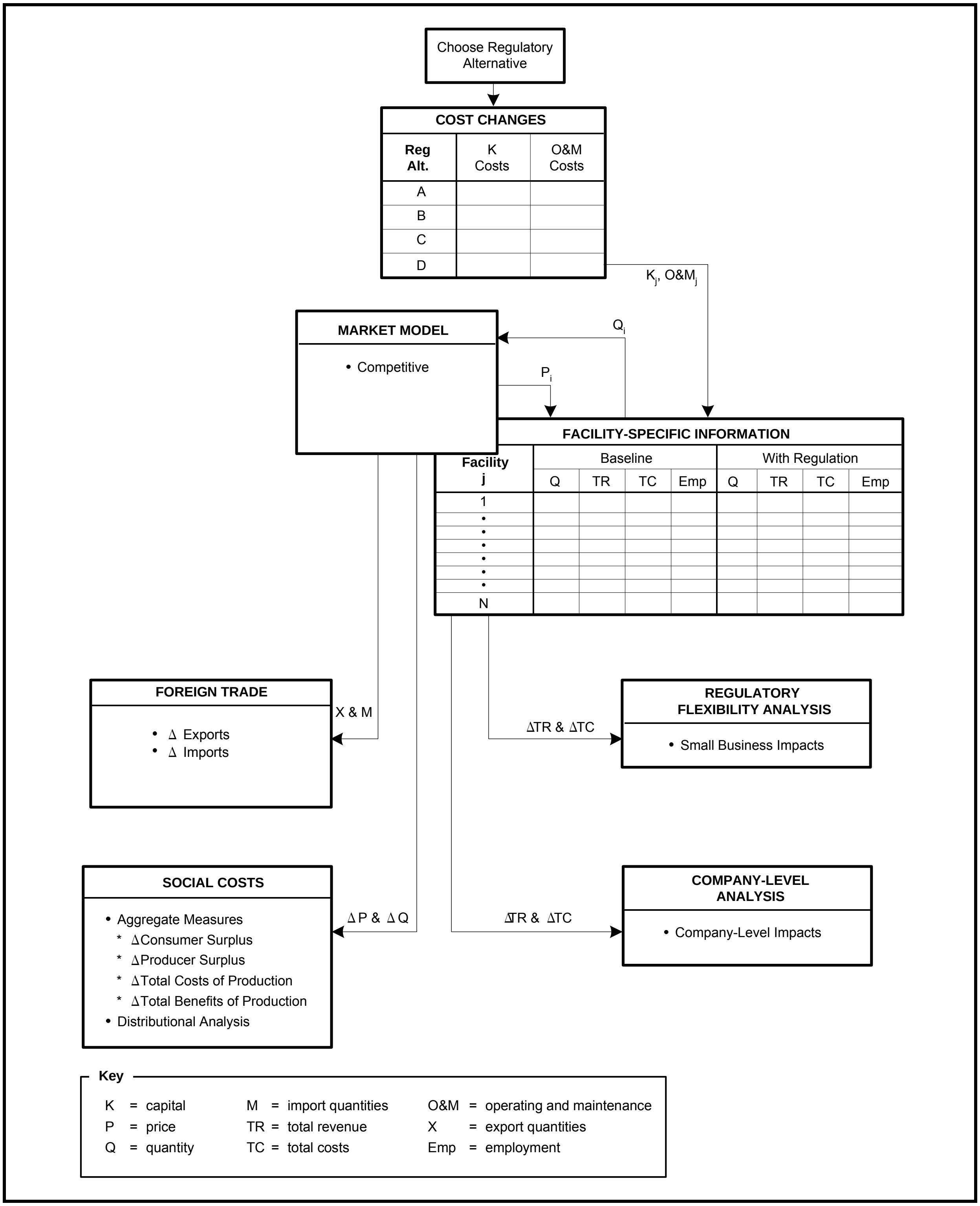
- enter estimates of capital and other one-time costs by size of plant and type of poultry slaughtered,
- enter estimates of ongoing costs by size of plant and type of poultry slaughtered, and
- designate "affected" plants (for some or all types of poultry slaughtered) that are either required to implement changes due to the regulation or assumed to volunteer to implement changes.

Because users can designate affected plants, the model can accommodate an analysis of the full implementation of HACCP in poultry slaughter plants. If plants that volunteer are expected to achieve ongoing cost savings, the user can insert negative values for ongoing costs associated with the regulation. This would occur, for example, if additional labor costs are offset by cost savings associated with operating at higher line speeds.

The economic impact analysis model incorporates the regulatory cost estimates into a market framework to evaluate equilibrium facility- and company-level production impacts and market-level changes in equilibrium prices and output.

The economic impact analysis model incorporates the regulatory cost estimates into a market framework to evaluate equilibrium facility- and company-level production impacts and market-level changes in equilibrium prices and output. The changes in price and production from the market-level impacts are used to estimate the distribution of social costs between consumers and producers associated with the regulations

Figure 3-1. Overview of Facility-Level Economic Impact Analysis Model
This figure summarizes the types of linkages included in the economic impact analysis model.



affecting poultry slaughter and processing. In essence, this approach models the expected reallocation of society's resources in response to a regulation.

An economic impact analysis of a regulatory action should assess the effects of regulatory alternatives at the facility, company, market, and societal levels to provide a comprehensive examination of the expected impacts. The model provides an integrated, conceptually coherent economic framework that generates the following key outputs for each of these levels:

- **Facility Effects.** The model predicts changes in production, revenue, compliance costs, production costs, and employment resulting from the FSIS regulations based on a model of profit-maximizing behavior. These changes are calculated for all facilities included in the model. The model also reports estimates of the number of facility closures resulting from a regulation.
- **Company Effects.** The model computes company-level effects by identifying the ownership of each plant and aggregating the financial effects at each plant up to the company level. Key company-level variables reported by the model include the compliance cost burden, impacts on profitability, and impacts on the financial viability of affected companies. To address the requirements of the RFA and SBREFA, it is necessary to estimate changes in costs, revenues, profitability, employment, and business closures separately for large and small businesses to aid in determining the relative burden on small businesses. Thus, the model provides summary statistics for company-level impacts for all companies, as well as broken down by company size.
- **Market Effects.** The model simulates changes in the market equilibrium prices and quantities, including estimates of changes in production by supply source (i.e., different types of domestic slaughter establishments, imports) and changes in consumption by demanders (i.e., domestic use, exports). Market-level results are presented by HACCP size category (very small, small, and large plants) and by size of business (small and large), where applicable. Estimates of effects on imports and exports are based on assumed or estimated elasticities of export demand and import supply. The model translates simulated changes in product prices as a result of a regulation into changes in import and export quantities using these trade elasticities.

- **Societal Effects.** The model calculates social costs for use in a benefit-cost analysis of the regulations. The social costs component of the model uses the market adjustments in price and quantity to calculate the aggregate change in welfare and the distribution of the social costs of the regulation using applied welfare economics principles. The aggregate measures of social cost include consumer and producer surplus changes.

3.2 CONCEPTUAL APPROACH

Most economic impact analyses focus on regulations that increase the costs of production, but the facility-level model can also accommodate analyses of regulations that result in net decreases in production costs.

As noted earlier, regulations on poultry slaughter will affect the costs of production in the industry. These costs will vary across facilities depending on the inputs and production processes used prior to the regulations. Most economic impact analyses focus on regulations that increase the costs of production, but the facility-level model can also accommodate analyses of regulations that result in net decreases in production costs. In particular, capital equipment or other one-time costs might increase, while ongoing annual costs decrease with the net effect being either net cost increases or decreases. In either case, facility-level production responses to these changes in production costs, in combination with consumer responses, will determine the market impacts of the regulations.

This section describes the basic economic theory underlying the development of supply and demand curves for affected products and the influence the regulations have on production and consumption decisions.

3.2.1 Characterization of Affected Markets

In the broadest sense, all markets in the economy are directly or indirectly linked. Thus, a regulation will affect all commodities and markets to some extent. However, that does not imply that all market linkages need to be modeled to examine the impacts of a rule. The appropriate level of market interactions to be included in an economic impact analysis is determined by the total cost of the regulation, the number of industries directly affected by the regulatory requirements, the importance of directly affected industries as suppliers of inputs to other industries, and the ability of affected firms to pass along regulatory costs in the form of higher prices. The larger and more widespread the impacts are expected to be, the more markets that should be included in the analysis.

Because the scope of the regulatory action being analyzed is sector specific and is not expected to substantially affect overall economic activity in the United States, we used a multimarket partial equilibrium model to estimate the impacts.

Alternative approaches for modeling interactions between economic sectors can generally be divided into three groups: partial equilibrium models, general equilibrium models, and multimarket models. Because the scope of the regulatory actions typically analyzed by FSIS is sector specific and is not expected to substantially affect overall economic activity in the United States, a multimarket partial equilibrium model is appropriate for estimating the impacts.[2] This approach represents an intermediate step between a simple, single-market partial equilibrium approach and a full general equilibrium approach. This technique has most recently been referred to in the literature as "partial equilibrium analysis of multiple markets" (Berck and Hoffmann, 2002). Determining the specific markets to be included in the model requires identifying the products most affected by the regulations and characterizing the directly affected industry, as provided in Section 2. This information is used to identify key market linkages and select the appropriate level of aggregation based on characteristics of the products, markets, and regulations, subject to data availability.

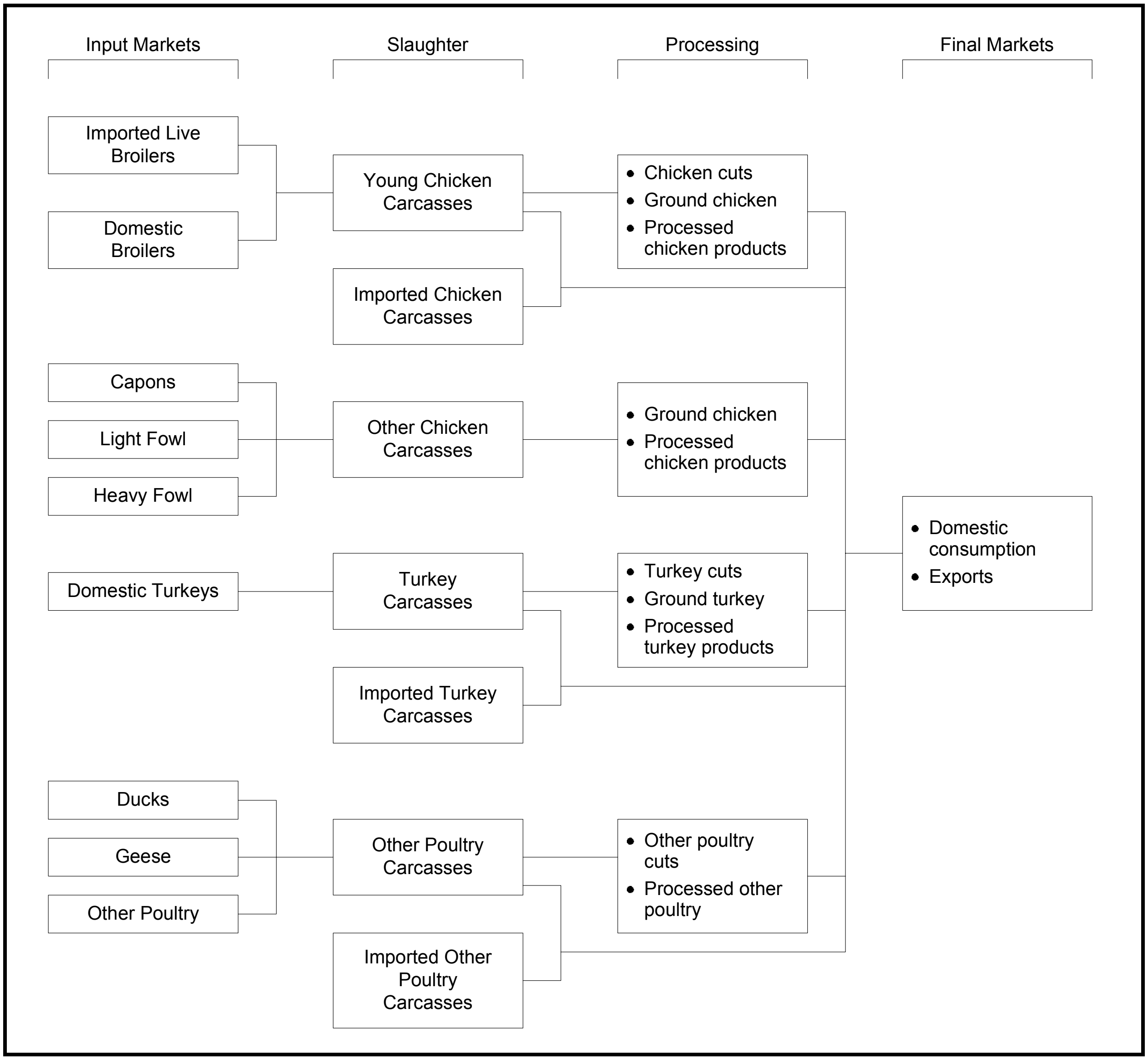
For the purposes of the model, the primary products of the poultry slaughter and processing industry were divided into four markets:

- processed young chickens (broilers),
- processed other chickens (capons, light fowl, and heavy fowl),
- processed turkeys (roasters, young, breeder, and old breeder), and
- processed other poultry (ducks, geese, and other poultry).

[2]The alternative approach would be to develop a general equilibrium model in which all sectors of the economy are modeled together. General equilibrium models operationalize neoclassical microeconomic theory by modeling not only the direct effects of regulatory costs but also potential input substitution effects, changes in production levels associated with changes in market prices across all sectors, and the associated changes in welfare. Although general equilibrium models offer more comprehensive estimates of economy-wide impacts, they generally do so at the expense of providing detailed results for individual sectors of the economy. In addition, these models require substantial time and resources to develop.

As described in Section 2, there are important differences among these markets. Thus, disaggregating the output of the industry in the market model enables more accurate simulation of regulatory impacts on the industry. Figure 3-2 shows the market linkages between live poultry inputs and poultry product consumption. The model focuses on production of carcasses as the primary output, as an intermediate or final output, of poultry slaughter establishments.

Figure 3-2. Market Linkages in Poultry Production
Poultry production is divided into four separate markets in the modeling approach (processed young chickens, processed other chickens, processed turkey, and processed other poultry).



While the markets for each type of poultry product are assumed to be different, poultry products within each of these markets are assumed to be homogenous because of limited data availability at a more disaggregated level. In addition, markets for poultry products are assumed to be national in scope (as opposed to regional markets). Thus, each of the submarkets included in the model has a single national equilibrium price for that market.

Because there is substitution between poultry products on the demand side, the prices of all the products were included in the demand functions for each individual product. This enabled us to capture substitution between poultry products by buyers in response to relative price changes.

Although all four poultry product markets have their own equilibrium price and quantity in the model, there are linkages between them. Because there is substitution between poultry products on the demand side, the prices of all the products were included in the demand functions for each individual product. This enabled us to capture substitution between poultry products by buyers in response to relative price changes, which is important for addressing net impacts on the poultry slaughter and processing industry.

There may also be some consumer substitution of other products (e.g., beef, pork, seafood) for poultry products. The benefits to producers of these alternative protein sources would partially offset costs to the poultry industry in terms of net welfare changes associated with regulations on the poultry industry. In addition, increasing demand for poultry substitutes would increase prices in those markets and would have feedback effects on the demand for poultry. However, these substitution effects have not been included in the current model because the focus of this task order is development of a facility-level model for analyzing regulatory and policy impacts on the poultry slaughter and processing industry. All facilities included in the model are poultry slaughter and processing plants. Substitution between products could potentially be modeled at the aggregate-market level, but inclusion of these substitution effects would likely have little effect on estimated regulatory impacts on poultry markets for most regulations while substantially complicating the model. Thus, project resources were devoted to other areas of model development and documentation. However, for future analyses of major regulations expected to have large impacts on poultry prices, it may be necessary to consider modifying the model to capture substitution between poultry and other products.

Substitution on the supply side could theoretically be included as well (i.e., plants could substitute production of one output for another as relative input and output prices change). However, facility information was insufficient to adequately model these potential changes in output. Also, many of the plants specialize in only one of these products and are unlikely to begin producing multiple products in response to the small changes in relative price expected under these regulations. Thus, we assumed no substitution between poultry products produced at the facility level.

In the absence of empirical measures of market power, we assumed that prices and quantities are determined in perfectly competitive markets based on relatively low industry profits as well as the HHI measure of industry concentration falling in the Justice Department's competitive range.

The poultry slaughter and processing industry is less concentrated than the meat industries, and profits are relatively low. In contrast to the meat industries, no empirical studies have attempted to measure the degree of market power in the poultry industry. In the absence of empirical measures of market power, we assumed that prices and quantities are determined in perfectly competitive markets based on relatively low industry profits, as well as the HHI measure of industry concentration falling in the Justice Department's competitive range (see Section 2.3.4). Under this condition, buyers and sellers take the market output price as given when making their production and consumption choices because no individual market participant has sufficient market power to influence the market price through their production or consumption decisions. Equilibrium prices and quantities are determined by the intersection of the market supply and demand curves.

In addition, the market for live poultry purchased by the poultry slaughter industry is assumed to behave competitively because of the large number of poultry producers. However, unlike the poultry products markets, which are assumed to be national in scope, the markets for live poultry are assumed to be localized because of limits on efficient transportation distance for live poultry. Thus, state-level prices are used for the live poultry inputs.

3.2.2 Supply Relationships in the Poultry Model

Based on available information, we determined that the level of detail of available facility data is sufficient to support a facility-level characterization of domestic supply.

Based on available information, we determined that the level of detail of available facility data is sufficient to support a facility-level characterization of domestic supply. Poultry slaughter facilities augment fixed factors of production (e.g., plant and equipment) with variable factor inputs (e.g., materials and labor) to produce poultry products. These fixed factors are the source of diminishing marginal returns, hence increasing marginal costs. Therefore, each supply segment (poultry products from young chickens, other chickens, turkeys, and other poultry) can be characterized by an upward-sloping supply curve (i.e., marginal costs are greater at higher production levels; thus, higher prices are necessary to induce producers to increase output, other things being equal).

An important aspect of the facility-level impacts is the quantity adjustments that take place. Supply functions relate the quantity of a good supplied to its price and other factors, such as the prices of inputs, the prices of substitute outputs, and technological factors. Because of data and resource limitations, factors other than the product's price are held constant in the Poultry Slaughter and Processing Facility-level Model.[3] Therefore, the focus of the supply function specification is to establish the quantitative relationship between price and quantity supplied in the affected market.

The supply function is that portion of the marginal cost curve bounded by zero and the facility's technical capacity. The facility owner is willing to supply output according to this schedule as long as the market price is high enough to cover average variable costs.

The supply function is that portion of the marginal cost curve bounded by zero and the facility's technical capacity. The facility owner is willing to supply output according to this schedule as long as the market price is high enough to cover average variable costs. If the market price falls below average variable costs, then the firm's best response is to cease production because total revenue does not cover total variable costs of production. In this scenario, producers lose more money by operating than by shutting down. Market-level supply functions can be viewed as the aggregate sum of the supply functions of all individual suppliers in the market. The change in market supply in response to price then is the sum of all suppliers' responses to price.

Changes in production costs will affect producers' decisions on production levels. However, some of the negative effect of

[3] Changes in production costs are modeled as a reduction in net price received.

increased production costs is mitigated when equilibrium output prices are increased because of market adjustments. Clearly, facility and product-line closures directly translate into quantity reductions, but the output of operating facilities will also change as will the supply of imports. Affected facilities that continue production may either increase or decrease their production levels depending on the relative magnitude of the variable compliance costs and the changes in market prices (i.e., change in net price received). Facilities that do not face an upward shift in their costs will respond to higher market prices by increasing production.

One group that often falls into this unaffected category is foreign producers. Foreign imports would tend to become more attractive to U.S. consumers if imported poultry products become cheaper relative to domestic production because of higher regulatory costs in the United States. Likewise, foreign imports would tend to become less attractive to U.S. consumers if domestic poultry products become cheaper relative to foreign production because of lower costs of production in the United States. A single supply curve was used to represent total imports supplied by all foreign producers in each product market.

An important measure of the magnitude of supply response to a change in market price is the price elasticity of supply, which is equal to the percentage change in quantity supplied resulting from a given percentage change in price divided by the percentage change in price. The larger the supply elasticity, the more responsive firms are to changes in market price. Available empirical estimates of supply elasticities were used to approximate the values for each of the four markets as described in Section 2.[4] Note that no value was included for other chicken imports because we assumed this product is not imported. Users have the option of modifying any of the default elasticity estimates in the model if estimates more appropriate for a particular application are available from other sources.

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[4]Because the live bird input is assumed to be used in fixed proportions to the output, we modeled supply as a function of net price, which is calculated as the output price on a carcass basis minus the price of live birds. Thus, these supply elasticities reflect the proportionate change in quantity supplied for a change in net price.

3.2.3 Demand Relationships in the Poultry Model

Consumption choices are a function of the price of the commodity, income, prices of related goods, tastes, and expectations of the future. In this analysis, we considered how these choices change in response to higher prices resulting from regulation, holding variables other than poultry product prices constant. The domestic demand equation accounts for cross-price effects between the four poultry products modeled, as mentioned above. Export demand for each of the four outputs was modeled as a function of own-price only.

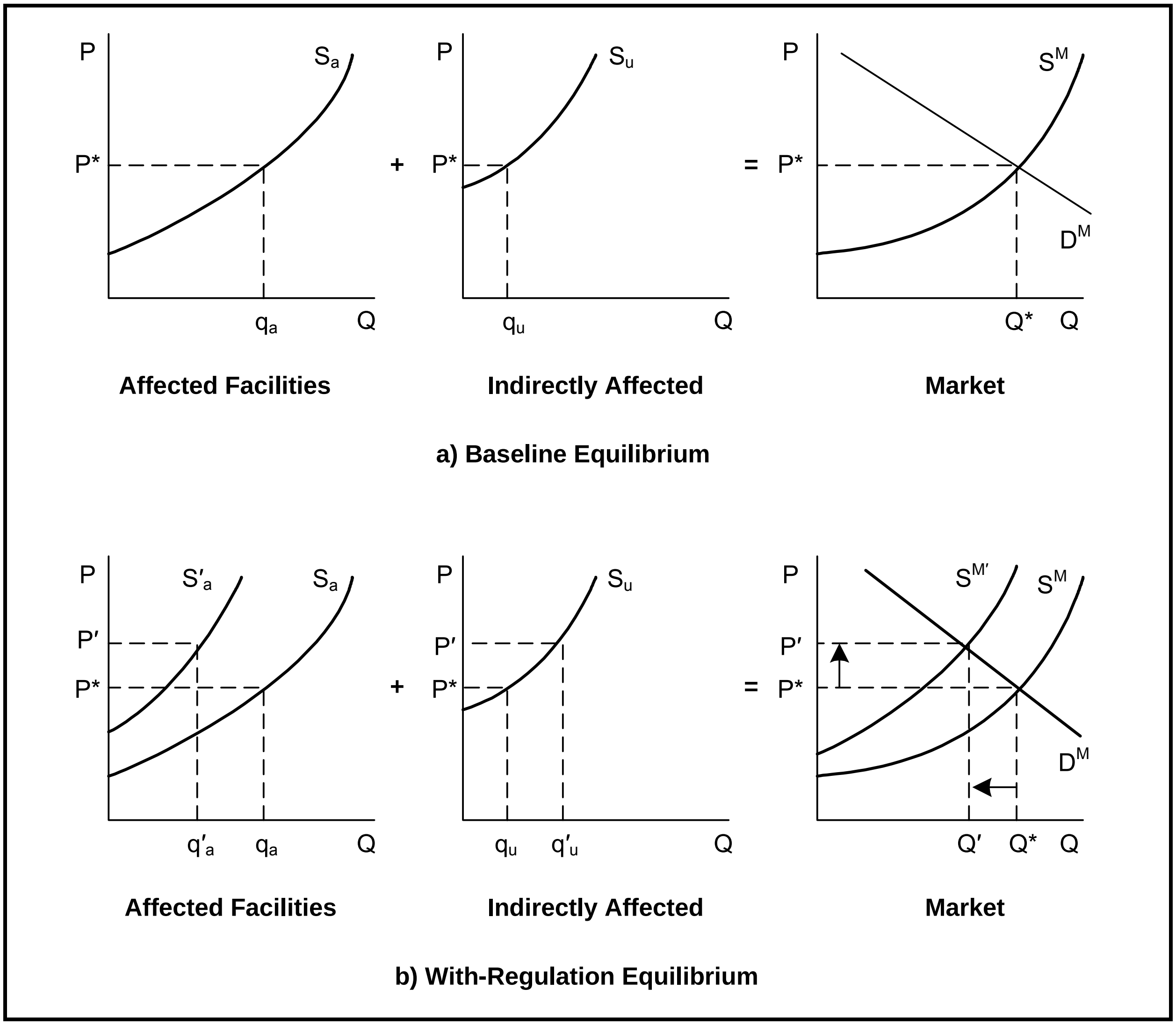
The model assumes downward-sloping demand curves in all output markets (i.e., the quantity demanded of a good falls when its price rises), consistent with the law of demand. Thus, increases in the prices of poultry products due to regulation are expected to result in a decrease in consumption, other things being equal. Domestic demand responsiveness to changes in price for poultry products in each of the four markets was based on available elasticity estimates from the literature as described in Section 2. As with the supply elasticities, users have the option of modifying any of the default demand elasticity estimates in the model if estimates more appropriate for a particular application are available from other sources.

3.2.4 Baseline and With-Regulation Market Equilibrium

As shown in Figure 3-3(a), baseline equilibrium market price and quantity (P*, Q*) in each market are determined by the intersection of the downward-sloping market demand curve (D^M) and the upward-sloping market supply curve (S^M). The market supply curve is the horizontal summation of individual supply curves of all domestic facilities that produce a given product and the import supply curve.

Increases in the cost of production under regulation lead to an upward shift in the supply curve for each affected facility. Alternatively, decreases in the costs of production lead to a downward shift in the supply curve for each affected facility. However, some facilities might not be affected by a regulation because of the type of products produced; because of controls already in place; or, in the case of voluntary regulations, because the facility did not volunteer to participate. These facilities are referred to as "unaffected facilities" in the modeling approach. Import supply is also treated as unaffected if the regulatory requirements only affect domestic plants.

Figure 3-3. Market Equilibrium Without and With Regulation
Regulations that increase the costs of production result in higher market prices and lower market quantities.



Facility-level supply shifts include both one-time or capital equipment costs and ongoing annual costs. Ex-ante estimates of the costs of compliance for each plant size—very small, small, and large—are assigned to each plant in the size category.[5] In the case of regulatory cost increases, the market supply curve shifts upward from S^M to $S^{M\prime}$, as shown in Figure 3-3(b). At the new equilibrium, price has increased from P* to P´, and market output has declined from Q* to Q´. The net

[5] The model also allows users to assign separate cost estimates, if available, to each plant rather than using the estimate for each size category.

change in market output reflects changes in output across all facilities in the industry. Depending on the relative magnitude of compliance costs across plants, selected facilities with low compliance costs may actually increase production if the increase in market price exceeds their increase in marginal cost of production.

In the case of net production cost decreases resulting from the regulations, the supply curve for affected or volunteer plants shifts downward. This shift would occur if increases in annualized capital and one-time costs are less than decreases in annual ongoing production costs. Opposite the situation displayed in Figure 3-3(b), equilibrium prices would fall, and market output would increase.

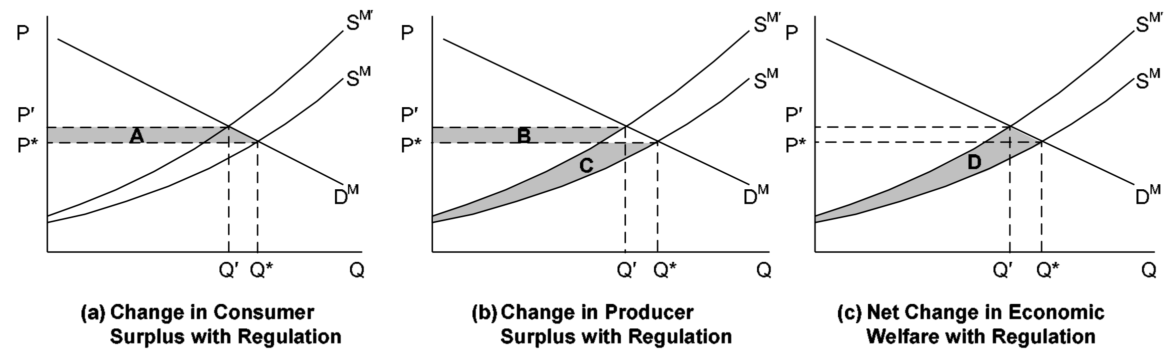
3.2.5 Social Costs

The net benefit of a regulatory action is traditionally measured by the change in economic welfare that it generates. Generally, regulatory impacts are distributed between consumers and producers. Consumers experience welfare impacts due to changes in market prices and consumption levels, while producers experience welfare impacts resulting from changes in profits corresponding to changes in production levels and market prices.

Consumer surplus derived from consumption of a good is the difference between the maximum price consumers are willing to pay for that good and the actual price paid. Consumer surplus in a market is measured as the area under the demand curve and above the market price of a product. Similarly, producer surplus is the difference between the minimum price producers are willing to accept for a good and the price they actually receive. It is measured as the area above the supply curve and below the market price. These areas represent consumers' net benefits of consumption and producers' net benefits of production, respectively.

As illustrated in Figure 3-4, following a shift in the supply curve from S^M to $S^{M'}$, area A is the loss in consumer surplus, and area B – C is the net change in producer surplus associated with a regulation that increases the costs of production. The net cost associated with this regulation in terms of economic welfare is then the sum of these areas [–A + (B – C)] or area D in Figure 3-4(c). However, it is important to emphasize that this

Figure 3-4. Economic Welfare Changes for a Regulation that Increases the Cost of Production: Consumer and Producer Surplus Changes
Consumer surplus decreases because of increases in costs of production, but producer surplus might increase or decrease depending on the shape of the supply and demand curves.



measure does not reflect the benefits that accrue to poultry product consumers from increased food safety. Improvements in food safety are expected to lead to an outward shift in the demand curve and would result in benefits to consumers that would at least partially offset the regulatory costs. However, assessment of the health benefits of food safety regulations is outside the scope of the current model, which was constructed to estimate the market effects of a regulation.

3.3 OPERATIONAL MODEL

To develop quantitative estimates of economic impacts, we operationalized the conceptual model described above using MS Excel© spreadsheet software with a Visual Basic™ interface. The purpose of this model is to provide a structure for analyzing the market adjustments expected to result from the FSIS regulations being analyzed. Given compliance costs for each category of affected facilities, the model determines a new equilibrium solution in each market modeled.

The model incorporates facility-specific information on production, market data, and model parameters characterizing domestic and export demands and import supply. This information is combined to provide an empirical characterization of the U.S. poultry slaughter and processing industry and product markets for a baseline year of 2004. This baseline year was chosen because it is consistent with the most recent facility data available from the updated Enhanced Facilities Database.

The model employs a process whereby prices approach equilibrium through successive correction, modeled as a Walrasian auctioneer. Regulations affect marginal costs of production, which affects the quantities that suppliers choose to produce and moves the market model into disequilibrium. Therefore, the model uses a price revision rule to generate new prices and calculate the quantity demanded and sum of quantity supplied across all facilities for each product at the new prices, closing down any facilities simulated to have negative profits at that price (i.e., setting quantity produced at that facility to zero). This process is repeated until all markets reach new equilibrium prices and quantities.

Solving for new market equilibriums could also be done using linear algebra. This tends to be more efficient when the supply and demand curves are continuous. However, in the presence of discontinuities such as potential facility closures, the Walrasian auctioneer approach is advantageous. Because one important consideration of regulatory impact and small business analyses is estimating the potential for the regulation to cause facility closures and unemployment, our model uses the auctioneer approach to solve for a new set of market equilibriums while simulating business closures.

Our general methodology for constructing the model can be summarized as follows:

1. Identify and characterize the most significantly affected products and markets that will be included in the model and select the appropriate level of disaggregation based on the goals of the analysis and data availability. Using these criteria, this model includes markets for four poultry products (young chicken meat, other chicken meat, turkey meat, and other poultry meat).
2. Collect baseline data to characterize each of the plants that slaughter poultry (and the companies that own them) using the Enhanced Facilities Database and a variety of secondary sources (see Section 2).
3. Construct facility-level marginal cost curves for all domestic facilities in all product markets included in the model that are consistent with baseline production data and expected responsiveness to changes in prices.

4. Develop aggregate product-level import supply, domestic demand, and export demand functions based on trade data and expected responsiveness to changes in prices.
5. Calibrate the model to match economic relationships observed in the poultry industry prior to imposing the regulations (i.e., ensure that supply and demand are both equal to baseline levels in all product markets at baseline prices). This is accomplished by adjusting domestic demand so that total supply in the model (domestic supply and import supply) equal total demand in the model (domestic demand plus export demand). Then, solve for the parameters in each facility or product market function that equilibrate simulated baseline output for the facility or product market to observed baseline output at baseline prices.

> Calibration is a key step in developing simulation models in any field. Economic model calibration consists of careful selection of model inputs to properly characterize the markets under study. Model parameters are adjusted in order to match model outputs to observed data.

6. Input the direct costs of complying with the regulation (size of the supply shift) for each facility. These costs are used to calculate the change in net price received by each facility.
7. Develop a mathematical simulation that embodies the expected economic reasoning of producers and consumers in the market in establishing equilibrium prices and quantities. In this case, we use the Walrasian auctioneer procedure described above in combination with all of the individual supply and demand curves developed.
8. Impose the supply shift estimates in the mathematical simulation to determine the postregulatory equilibrium prices and quantities and estimate the responses of affected products, plants, companies, and markets.
9. Aggregate estimated effects by size of the company to assess the effects on affected small businesses to provide information needed for regulatory analysis.
10. To address uncertainties in the model and to consider regulatory alternatives, conduct sensitivity analyses of the model assumptions (e.g., elasticity estimate assumptions).

Table 3-1 summarizes the key variables used in the model equations for ease of reference. Using this variable notation we describe key components of the spreadsheet model below.

Table 3-1. Variables Used in Market Model

Variable	Description
β	Multiplicative calibration factors in domestic supply functions
ε	Supply elasticities
γ	Additive calibration factors in domestic supply functions
η	Demand elasticities
τ	Multiplicative calibration factors in demand functions
μ	Multiplicative calibration factors in import supply functions
π	Profit
a_i	Farm (input) price of live birds for facility i based on state
A	Affected production (incur compliance costs)
c_i	Per-bird cost of compliance
D	Demand
Dom	Domestic
i	Facility index
I_i	Cost index for facility i based on state
M	Imports
n	Number of establishments
NP	Net price, equal to output price per bird (P) minus price of live birds (a_i)
OC	Other chicken
OP	Other poultry
P	Wholesale (output) price per bird
q	Submarket quantity (facility-level output or import supply) (number of birds)
Q	Market quantity (number of birds)
S	Supply
TY	Turkey
U	Unaffected production (incur no compliance costs)
X	Exports
YC	Young chicken

3.3.1 Domestic Supply of Poultry Products

The market supply of poultry products in each of the four defined submarkets is defined as

$$Q^{S_j} = q_{dom}^{S_j} + q_M^{S_j} = \sum_{i=1}^{n} q_i^{S_j} + q_M^{S_j}, \quad j = YC, OC, TY, OP \tag{3.1}$$

where Q^{S_j} is the market quantity supplied for product j; q^{S_j} denotes quantity supplied from a submarket, with subscripts for domestic (dom), import (M), and domestic facility (i) sources; n is the number of facilities; and YC, OC, TY, and OP represent young chickens, other chickens, turkeys, and other poultry, respectively.

Producers have some ability to vary output in response to changes in production costs. Supply functions, coupled with data on market prices, can be used to simulate each facility's optimal production rate, including zero output (shutdown).

Because of data and resource constraints, we calibrated facility-level supply functions to match baseline production simulated by the model to observed production rather than attempting to econometrically estimate these functions. Calibration of the supply functions for each facility requires specification of a function describing the relationship between market price and facility-level quantity supplied; selection of function parameters that will lead to consistency between modeled and observed production as well as characterizing expected responsiveness to changes in market conditions; and model verification.

A number of alternative functional forms are used to characterize production relationships that appear frequently in the economics literature (e.g., constant elasticity of substitution, Cobb-Douglas, generalized Leontief, miniflex Laurent, normalized quadratic, translog), as well as a wide variety of modifications and combinations of these and numerous other functional forms. Analysts typically choose among functional forms based on their theoretical properties, goodness of fit for econometrically estimated models (e.g., F-tests for nested models and stochastic dominance or other tests developed for nonnested models), and convenience.

The functional form selected to represent producer behavior in this model is the commonly used generalized Leontief profit function, from which the supply function can be derived.

The functional form selected to represent producer behavior in this model is the commonly used generalized Leontief profit function, from which the supply function can be derived.[6] We assumed a Leontief, fixed-proportion relationship between the bird input and the processed bird output (i.e., each processed bird output requires one live bird input). This fixed-proportions relationship between the inputs and outputs implies that the firm's profit function and supply function depend on the output price and price of the live bird input only in terms of the net price received for product j at facility i (NP_i^j):

$$NP_i^j = P^j - a_i^j,$$

where P^j is the market price of poultry product j and a_i^j is the cost of live birds for facility i. We then assumed that the variable proportions inputs combine with the live bird input according to a generalized (not fixed proportion) Leontief technology. The supply functions for the generalized Leontief technology are derived via Hotelling's lemma by differentiating the profit function with respect to price.

Because we have not estimated an econometric model, we cannot apply any of the goodness-of-fit tests and must rely on other considerations in selecting a functional form. In the course of developing previous facility-level models, we have found the generalized Leontief functional form to yield supply functions that appear reasonable and that generate estimates of baseline profits closer to observed industry values than other functional forms examined, including Cobb-Douglas.

In addition, because there are usually little to no data on input use available at the facility level, we have generally used a cost-share weighted index of variable input costs using data obtained at the state or regional level and do so in this application. The cost index varies across facilities located in different states or regions to represent differences in cost of production but does not allow for changes in the mix of inputs included within the index. This assumption is consistent with the use of a generalized Leontief functional form, which tends to provide a better fit when the elasticities of substitution between inputs are close to zero, because the use of this cost index implies that inputs making up the variable cost index are

[6]For additional details, see Chambers (1988) for a discussion of the generalized Leontief functional form (pp. 172–173).

used in fixed proportions (i.e., there is no substitution between inputs comprising this index), although not in fixed proportions to the live bird input.

For the majority of regulatory impact analyses, where supply shifts caused by regulatory costs are relatively small in percentage terms, the cost estimates generated using different functional forms will be similar, all else equal. For regulations that result in major structural changes within an industry, it may be necessary to further examine the choice of functional form and explore replacement of the variable cost index with a more detailed examination of input substitution.

The specification of a facility's profit function for each product using the generalized Leontief functional form is as follows:

$$\pi_i^j = \gamma_i^j NP_i^j + \beta_i^j \sqrt{I_i^j NP_i^j} + \theta_i^j I_i^j, \quad j = YC, OC, TY, OP, \quad (3.2)$$

where NP_i^j is the net price for poultry product j at facility i (varies based on production cost index for the state in which facility i is located); I is the variable proportion input for product j produced by facility i (characterized by a cost index described below); and γ, β, and θ are model parameters. The theoretical restrictions on the model parameters that ensure that the profit function is linearly homogeneous and convex in net price and I and that the supply curves are upward sloping are $\gamma_i^j > 0$ and $\beta_i^j < 0$.

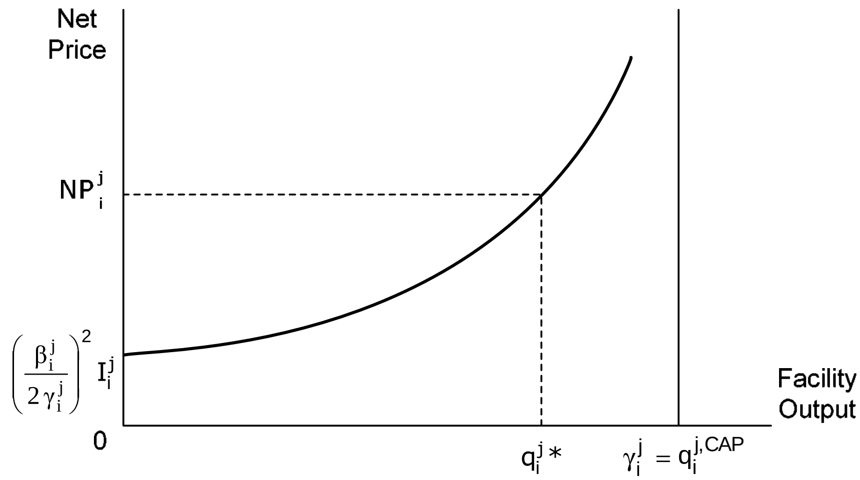
By applying Hotelling's lemma to this profit function, the following general form of the supply function for product j at facility i is obtained:

$$q_i^j = \frac{\partial \pi_i^j}{\partial NP^j} = \gamma_i^j + \frac{\beta_i^j}{2}\left[\frac{I_i^j}{NP_i^j}\right]^{\frac{1}{2}}, \quad j = YC, OC, TY, OP, \quad (3.3)$$

where q_i^j is the number of birds for output market j that are slaughtered by facility i.

Figure 3-5 illustrates the theoretical supply function for product j represented by Eq. (3.3). The upward-sloping supply curve is specified over a productive range with a lower bound of zero that corresponds to a shutdown net price equal to $\left(\frac{\beta_i^j}{2\gamma_i^j}\right)^2 I_i^j$ and an upper bound given by the productive capacity of the

Figure 3-5. Theoretical Supply Function for Product j at Facility i
Individual facility supply curves are constructed using baseline values for production volumes, market prices, supply elasticities, and a cost index.



facility ($q_i^{j,CAP}$) that is approximated by the supply parameter γ_i^j. The curvature of the supply function is determined by the β_i^j parameter.

The β_i^j parameter is related to facility i's supply elasticity for product j, which can be expressed as

$$\varepsilon_i^j = \frac{\frac{\partial q_i^j}{q_i^j}}{\frac{\partial NP_i^j}{NP_i^j}} = \frac{\partial q_i^j}{\partial NP_i^j} \bullet \frac{NP_i^j}{q_i^j} \quad . \tag{3.4}$$

Taking the derivative of the facility supply function (Eq. [3.3]) with respect to price yields

$$\frac{\partial q_i^j}{\partial NP_i^j} = -\frac{\beta_i^j}{4}\left[\frac{(I_i^j)^{\frac{1}{2}}}{(NP_i^j)^{\frac{3}{2}}}\right]. \tag{3.5}$$

Multiplying this expression by $\frac{NP_i^j}{q_i^j}$ results in the expression for the supply elasticity:

$$\varepsilon_i^j = -\frac{\beta_i^j}{4q_i^j}\left(\frac{I_i^j}{NP_i^j}\right)^{\frac{1}{2}}. \tag{3.6}$$

Because economic theory dictates that the supply elasticity is positive and q_i^j, NP_i^j, and I_i^j are all positive, β_i^j should be negative for all facilities for all products based on the expression in Eq. (3.6).

By rearranging terms, we can solve for β_i^j as

$$\beta_i^j = -4q_i^j\varepsilon_i^j\left(\frac{I_i^j}{NP_i^j}\right)^{-\frac{1}{2}}. \tag{3.7}$$

Values for the β_i^j parameter for each facility were then computed using Eq. (3.7), assuming that ε_i^j is equal to the market supply elasticity for each product for the facility's size class (large, small, very small; see Table 2.5)[7] and using the methodology described in Section 2.1.2 to calculate the variable production cost index, I_i^j.

The remaining supply function parameter, γ_i^j, approximates the productive capacity of each facility and varies across products.[8] This parameter does not affect the facility's production responsiveness to price changes (unlike the β parameter). Thus, the parameter γ_i^j is calculated to calibrate the model so that each facility's supply equation replicates the baseline production data for that facility using the formula

$$\gamma_i^j = q_i^j - \frac{\beta_i^j}{2}\left[\frac{I_i^j}{NP_i^j}\right]^{\frac{1}{2}} \tag{3.8}$$

and the facility-specific value of β_i^j calculated in Eq. (3.7).

3.3.2 Foreign Supply of Poultry

Unlike domestic supply, where the majority of direct regulatory impacts will typically be and there are sufficient data to use a facility-level specification, foreign supply of poultry was

[7]Theoretically, supply elasticities could be estimated for each product for each facility. However, we did not have sufficient data or resources to develop econometric estimates.

[8]If facility-level data on productive capacity were available, then γ_i^j could be set equal to facility capacity for each product and Eq. (3.3) used to solve for the value of β_i^j that calibrates the model to replicate baseline production data. However, these data were not available for use in calibration or to verify the accuracy of the calculated γ_i^j parameters.

characterized at an aggregate level. This model was not designed to look at the impacts on specific foreign countries or examine potential changes in the number of facilities, industry employment, or producer surplus outside the United States because those questions are not emphasized in regulatory impact analyses. In addition, poultry imports comprise a very small share of the U.S. market. Thus, import supply was characterized using a simpler functional form than used for domestic supply: a constant elasticity supply curve. This functional form requires data only on market price, quantity, and import supply elasticity and is consistent with the popular log-log specification used in empirical work in the literature.

Constant elasticity supply curves are specified as:

$$q_m^j = \mu_m^j \left(P^j\right)^{\varepsilon_m^j}, \tag{3.9}$$

where q_m^j is the quantity of imports for product j, P^j is the U.S. market price for product j, ε_m^j is the import supply elasticity for product j, and μ_m^j is a multiplicative parameter used to calibrate the supply function for each product to replicate the observed level of imports in the baseline.[9] As the name implies, the elasticity of supply for this function is constant regardless of price.

3.3.3 Domestic Demand for Poultry

Domestic demand for poultry products is modeled at an aggregate level because the primary focus is on total effects on consumers at the market level. Similar to the constant elasticity supply curves used for import supply, we rely on constant elasticity demand curves, which maintain a constant elasticity of demand regardless of price. This specification is consistent with the log-log models frequently used in empirical estimation and minimizes data requirements, relying only on baseline market prices and quantities along with assumed values for own-price and cross-price demand elasticities obtained from previous studies.

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[9] This calibration involves rearranging (3.8) as $\mu_m^j = \dfrac{q_m^j}{(P^j)^{\varepsilon_m^j}}$ and plugging in baseline values of q_m^j and P^j, as well as the value assumed for ε_m^j.

The domestic demand equations account for cross-price effects between poultry from young chickens, other chickens, turkeys, and other poultry. The demand functions are specified as

$$q_{dom}^{D_{YC}} = \tau_{dom}^{YC} (P^{YC})^{\eta^{YC}} (P^{OC})^{\eta^{YC,OC}} (P^{TY})^{\eta^{YC,TY}} (P^{OP})^{\eta^{YC,OP}} \quad (3.10)$$

$$q_{dom}^{D_{OC}} = \tau_{dom}^{OC} (P^{OC})^{\eta^{OC}} (P^{YC})^{\eta^{OC,YC}} (P^{TY})^{\eta^{OC,TY}} (P^{OP})^{\eta^{OC,OP}} \quad (3.11)$$

$$q_{dom}^{D_{TY}} = \tau_{dom}^{TY} (P^{TY})^{\eta^{TY}} (P^{YC})^{\eta^{TY,YC}} (P^{OC})^{\eta^{TY,OC}} (P^{OP})^{\eta^{TY,OP}} \quad (3.12)$$

$$q_{dom}^{D_{OP}} = \tau_{dom}^{OP} (P^{OP})^{\eta^{OP}} (P^{YC})^{\eta^{OP,YC}} (P^{OC})^{\eta^{OP,OC}} (P^{OP})^{\eta^{OP,TY}} \quad (3.13)$$

where $q_{dom}^{D_j}$ is domestic demand for young chickens (YC), other chickens (OC), turkeys (TY), and other poultry (OP), respectively; the τ parameters are multiplicative calibration factors (calculated in an analogous manner to those for import supply); and the η parameters are demand elasticities where a single superscript denotes the own-price elasticity and two superscripts denote the cross-price elasticity between those two products.[10]

3.3.4 Export Demand for Poultry

Similar to domestic demand, export demand for poultry is expressed using a constant elasticity demand curve functional form as follows:

$$q_X^{D_j} = \tau_X^j (P^j)^{\eta_X^j}, \quad (3.14)$$

where $q_X^{D_j}$ is the quantity of exports for product j, P^j is the U.S. market price for product j, η_X^j is the export demand elasticity for product j, and τ_X^j is a multiplicative parameter used to calibrate the demand function for each product to replicate the observed level of baseline exports through backsolving Eq. (3.14) for this parameter given estimates of baseline prices, quantities, and export demand elasticities.

This specification assumes that there are no cross-price effects between the different exported products. These products are likely to be destined for different regions of the world and may not be all that substitutable for one another within a given

[10]The cross-price elasticity is a measure of the change in quantity demanded for a product in response to a change in the price of another product. Negative values for cross-price elasticities indicate the goods are complements, positive values indicate they are substitutes, and a cross-price elasticity of zero implies that the products are neither complements nor substitutes.

export region. In addition, we assumed that there were no cross-price effects between domestic and export demand.

3.3.5 Baseline Scenario

The baseline scenario in the poultry slaughter facility-level model was established using available facility-level and market-level data for 2004. Table 3-2 displays market-level values obtained using secondary sources. We obtained wholesale prices for each type of poultry as follows:

- Wholesale prices for **young chickens** and **turkeys** were obtained from *Livestock, Dairy, and Poultry Outlook* (USDA, ERS, 2005b).
  - The young chicken price is from the series "Broilers—12 city average."
  - The turkey price is from the series "Turkeys Eastern region, Toms, 16–24 lbs."
- The wholesale price for **other chickens** was obtained from the "2002 Economic Census: Poultry Processing" for NAICS 3116154111, Egg-producing hens and/or fowl, whole or parts (including frozen) in U.S. Census Bureau (2004). Because poultry prices have been relatively flat in recent years, the value for 2002 was assumed to be representative of the value for 2004.
- The wholesale price for **other poultry** is not available in published sources and thus was derived by finding the minimum price that would allow all establishments that slaughter other poultry to have nonnegative profits in baseline.

Wholesale values representing output prices received by poultry slaughter and processing facilities are included in the model assuming a national market for poultry. These wholesale values are calculated by multiplying the wholesale price per pound for poultry in each market by the average dressed weight for each type of poultry obtained from *Poultry Slaughter 2004 Annual Summary* (USDA, ASB, 2005).

Farm values representing input prices paid by poultry slaughter and processing facilities are included in the model on a state-level basis. We assume that facilities pay on average the value of a live weight bird in the state in which the plant is located. We calculated these farm-level values by multiplying each

Table 3-2. Market-Level Data for the Poultry Facility-Level Model, 2004 Baseline
Baseline values in the model were obtained from the Enhanced Facilities Database and published data sources.

	Young Chickens (YC)	Other Chickens (OC)	Turkeys (TY)	Other Poultry (OP)
Wholesale Values				
Wholesale price ($/lb)	$0.74	$0.35	$0.68	$1.57
Average dressed weight (lbs)	3.89	3.52	21.45	4.93
Calculated wholesale price ($/bird)	$2.88	$1.23	$14.58	$7.74
Wholesale Quantities				
Domestic poultry production (lbs)	32,624,152,532	491,037,054	5,400,847,967	132,030,798
Domestic poultry production (number of birds)	8,386,671,602	139,499,163	251,787,784	26,781,095
Poultry imports (lbs)	36,231,767	0	4,929,785	1,198,799
Poultry imports (equivalent number of birds)	9,314,079	0	229,827	243,164
Poultry exports (lbs)	5,114,225,038	51,658,839	395,300,939	4,453,854
Poultry exports (equivalent number of birds)	1,314,710,807	14,675,806	18,428,948	903,419
Farm Values				
Farm price ($/lb)	*Varies by state*			
Average live weight	5.27	5.66	27.12	6.71

Note: Unit of analysis = 1 bird (or equivalent number of birds for imports and exports).

Sources: RTI International. 2005. Enhanced Facilities Database. Research Triangle Park, NC: RTI.

U.S. Census Bureau. August 2004. "2002 Economic Census: Poultry Processing." EC02-311-311615. Washington, DC: U.S. Census Bureau.

U.S. Department of Agriculture (USDA), Agricultural Statistics Board, National Agricultural Statistics Service (NASS). February 28, 2005. *Poultry Slaughter 2004 Annual Summary*. Washington, DC: USDA.

U.S. Department of Agriculture (USDA), Economic Research Service. 2005b. *Livestock, Dairy, & Poultry Outlook.* Washington, DC: USDA. <http://www.ers.usda.gov/publications/ldp/>.

U.S. International Trade Commission. Interactive Tariff and Trade DataWeb. <http://dataweb.usitc.gov/>. Accessed June 2005.

state-level farm price per pound for poultry in each market by the average live weight for each type of poultry. These state-level farm prices, which are listed in Table 2-3, were multiplied by the average live *Poultry Slaughter 2004 Annual Summary* (USDA, ASB, 2005) to calculate state-level farm values per carcass.

We calculated the market volumes by type of poultry by adding up individual facility slaughter volumes from the Animal Disposition Reporting System (ADRS) as reported in the Enhanced Facilities Database. Poultry import and export volumes (total pounds) were obtained from the U.S. International Trade Commission's online DataWeb. Because chicken imports are not separately identified for young chickens and other chickens, we assumed young chickens constitute 99 percent of chicken imports and other chickens constitute 1 percent. Pounds of imports and exports were converted to a carcass equivalent basis by dividing volumes by average dressed weight per bird.

After developing the domestic supply, import supply, and export demand curves using available price and quantity data, we calibrated the model by solving for the domestic quantity demanded that ensures that the empirical specification of the supply curve intersects the empirical specification of the demand curve at baseline equilibrium market prices and quantities for each of the poultry products modeled. These calibrated functions represent the baseline scenario in the market prior to implementing the regulation. In addition, we included a per-bird fixed-cost component to represent overhead costs such as administrative labor, marketing labor, depreciation expenses, and interest payments. Estimates of the fixed cost component were obtained by Dr. Tom Vukina at North Carolina State University and were based on Agristats data for 2004 (Vukina, 2005). The specific values are $0.167 per bird for young chickens, $0.119 per bird for other chicken, $1.754 per bird for turkey, and $0.204 per bird for other poultry. The fixed-cost components are assumed not to vary under different regulatory scenarios.

Establishments in the model are classified as small or large businesses based on number of employees. By default, we assumed that all establishments classified as large are owned by large businesses because the SBA definition of a large business for NAICS 311615 is 500 or more employees. Very small and small establishments may also be owned by large businesses if the business owns a combination of establishments, which could include poultry slaughter and other types of establishments, with total employment exceeding 500 employees.

3.3.6 Model Calibration

To perform regulatory impact analysis, the model must allow for comparing an observable historical equilibrium generated by existing conditions and a hypothetical equilibrium generated by the model under a new regulation or other policy.

To perform regulatory impact analysis, the model must allow for comparing an observable historical equilibrium generated by existing conditions and a hypothetical equilibrium generated by the model under a new regulation or other policy. The assumption of an "observable" equilibrium leads to the need for and construction of a data set that fulfills the equilibrium conditions in a competitive market model of the poultry slaughter and processing industry. As mentioned above, the base year of analysis is 2004. The baseline data set for this model was constructed from a number of sources, as described in Section 2.

For the particular functions assumed for supply and demand, we chose parameter values so that the model will exactly reproduce the 2004 equilibrium values as a baseline (pre-regulation) solution to the model. This procedure is commonly referred to in the general equilibrium literature as "calibration." Calibration is typically augmented by a literature search or econometric estimation for key parameters (literature search only for this model). Typically, the key parameters are elasticities. In this case, we used estimates of key elasticities from the agricultural economics literature and assumed functional forms of the supply and demand relationships to calibrate the model.

3.3.7 Incorporation of Compliance Costs

The model provides a method for users to input ex-ante estimates of the costs of complying with a regulation. The model applies these estimated compliance costs to the domestic supply curves developed for each facility. By simulating economic decisions of producers and consumers in the market, the model solves for the new estimated market equilibrium.

Facility responses and market adjustments can be conceptualized as an interactive feedback process. Facilities face increased production costs due to compliance, which cause facility-specific production responses. The cumulative effect of these responses leads to a change in the market price that all producers (affected and unaffected) and consumers face, which leads to further responses by all producers and consumers and thus new market prices, and so on. The set of new postregulatory equilibrium prices and quantities are the result of a series of iterations between producer and consumer responses and market adjustments until a stable market price arises where total market supply equals total market demand for all poultry products. This process is simulated given the producer and consumer response functions developed above and market adjustment mechanisms to arrive at the postcompliance equilibrium.

Because costs differ depending on whether a facility is affected or unaffected, supply of poultry products for each category of facility is calculated separately. The annual compliance costs estimated for each facility for each product produced at that facility, c_i^j, will enter the supply function as a change in net price. Thus, the supply function shown in Eq. (3.3) becomes

$$q_i^{j,A} = \gamma_i^j + \frac{\beta_i^j}{2}\left[\frac{I_i^j}{NP_i^j - c_i^{j,A}}\right]^{\frac{1}{2}} \qquad (3.15)$$

for affected facilities (denoted by superscript "A") producing product j.

3.3.8 Solving for Market Equilibrium With Regulation

The process for determining equilibrium prices (and quantities) is modeled as a Walrasian auctioneer that calls out a price for each product and evaluates reactions to that price by all participants (producers and consumers, both foreign and domestic), comparing quantities supplied and demanded to determine the next price that will guide the market closer to equilibrium (i.e., market supply equal to market demand). We developed an algorithm to simulate the auctioneer process and find a new equilibrium price and quantity for all four poultry product markets simultaneously. The result of this approach is a vector of simulated postcompliance product prices that equilibrates supply and demand for all product markets.

The algorithm used to determine the new market equilibrium in the spreadsheet model is as follows (Depro and Thomas, 2003):

1. Introduce the supply shift (i.e., impose compliance costs), thereby changing production decisions for affected facilities as shown in Eq. (3.15).
2. Use the supply function specification to recalculate the market supply in each market, adding up supply from all

domestic facilities, affected and unaffected, and import supply.

3. Determine new prices in all product markets using a price revision rule. We use a rule similar to one described in Kimbell and Harrison (1986). This revision rule increases price when excess demand exists, decreases price when excess supply exists, and leaves the price unchanged when supply and demand are equal based on the following calculation:

$$\text{revised price} = \text{previous price} \bullet \left(\frac{\textit{quantity demanded}}{\textit{quantity supplied}}\right)^{Z}$$

where Z influences the magnitude of the price revision and the speed of convergence.[11]

4. Recalculate market supply with new prices using Eq. (3.3) for unaffected domestic facilities, Eq. (3.9) for import supply, and Eq. (3.15) for affected domestic facilities, and compute market demand in each market using Eqs. (3.10), (3.11), (3.12), and (3.13) for domestic product demand and Eq. (3.14) for export demand.

5. It is possible that the regulation may induce a producer to shut down operations rather than incur the costs of compliance. Because closures affect the equilibrium solution, the model algorithm checks for closures on each iteration. [12] The method used in the model to simulate firm closure decisions is to calculate the profitability of producing each product at each facility. If the total revenue derived from a product is less than the total cost of producing it, then the facility will stop producing that product in the model (q_i^j=0). If a facility stops producing all products that it produced in the baseline based on this criterion, then that facility shuts down altogether.

6. Compare supply and demand in each market. If equilibrium conditions are not met in all markets

[11] There is a trade-off between the speed of convergence and the likelihood of convergence. Larger values of Z result in bigger price revisions, which will move the market more quickly towards equilibrium but could result in price changes between rounds being too large to converge, particularly if the price changes result in firms oscillating between continued production and exiting the market. For this model, we set Z=0.1.

[12] The importance of assessing the potential number of facility closures for regulatory analysis is one of the key reasons for using this algorithm, which allows for the nonlinearities of facilities entering and exiting the market as prices change while iterating towards a solution.

simultaneously, reopen all facilities that closed under Step 5 and determine a new set of prices, adjusting the price used in the previous round as described in Step 3. Repeat until market convergence is obtained (i.e., the difference between supply and demand is arbitrarily close to zero).

Once the model converges, it generates tables of results summarizing the estimated impacts of the regulations (sample tables are shown in Section 4).

3.3.9 Postregulatory Impact Estimates

The model results can be summarized as facility, company, market, and societal impacts due to the regulations.

The formats of the results tables for each type of postregulatory impact are provided in Section 4.

Facility impacts include an evaluation of postregulatory compliance costs; product line and facility closures, and changes in production, production costs, and profits. In addition, we computed the change in employment attributable to the changes in output at each facility. Output changes are caused by product-line and facility closures, if any, as well as adjustments in production at facilities that continue to operate under regulation.

For each regulation, the variable portion of postregulatory compliance cost at each facility depends on the postcompliance output rate, while the fixed portion is a constant lump-sum incurred at the facility if it continues to operate under regulation. At the industry level, the postregulation compliance cost is the sum of variable and fixed compliance costs across all facilities continuing to operate in the postcompliance equilibrium. These costs will typically differ from the estimated compliance costs estimated before accounting for market adjustments. This is because some product lines and facilities may shut down as firms choose not to bear the compliance costs and output rates change at affected facilities in response to variable compliance costs.

The economic model accommodates both product-line and facility closures in moving from the precompliance to postcompliance equilibrium. Within a model iteration, recalculating market prices allows for the possibility that product lines and facilities may become unprofitable. In such a case, the model closes that product line or facility by setting production to zero and market quantities are adjusted accordingly.

The model also generates information on the change in market prices and facility production, which is used to compute the change in total revenue, total cost, and total profits at the facility level.

In addition, regulations may displace workers from jobs by affecting production levels. The methodology used to estimate change in employment depends on whether the facility is expected to remain in operation. For facilities that close down in the model, the reduction in employment at that facility equals total baseline employment at the facility. For those facilities that continue operation, the change in employment (EMP) was assumed to be proportional to the change in facility-level output:

$$\Delta EMP_i^j = EMP_i^j \Delta q_i^j , \qquad (3.16)$$

Thus, estimated total change in industry employment was calculated by summing employment changes across all facilities, both those that continue to operate and those that shut down.

Impacts at the company level were generated by summing impacts across all facilities owned by that company.

Market impacts include estimated changes in equilibrium prices and quantities and changes in international trade. Market adjustments are a result of moving from the precompliance to postcompliance equilibrium. Given the compliance costs, the interaction of facility-level responses and price revision mechanism, modeled as a Walrasian auctioneer, results in a new postcompliance equilibrium with new prices and quantities for all four product markets, including impacts on foreign trade. In addition, the market adjustments in prices and quantities were used to calculate the change in aggregate economic welfare described below under societal impacts.

At the societal level, the model provides estimates of changes in economic welfare, measured by consumer and producer surplus. Changes in producer surplus are approximated by summing the change in facility-level profits across all facilities:

$$\Delta PS_j = \sum_i \pi_i^j . \qquad (3.17)$$

Changes in consumer surplus are calculated using a linear approximation to the demand curve, which provides a reasonable approximation to the assumed demand curve as long as the change in price is relatively small, as is generally the case in regulatory analyses:

$$\Delta CS_j = -q_{dom}^{D_j} \Delta P^j + 0.5 \Delta q_{dom}^{D_j} \Delta P^j \,. \qquad (3.18)$$

3.4 SENSITIVITY ANALYSIS

As with any analysis, many underlying assumptions influence model results. Thus, it is important to examine the impact of varying parameters and model assumptions on the conclusions of the economic impact analysis. This enables an examination of the relative importance of different model assumptions and permits generation of a plausible range of economic impact estimates. The market model allows users to modify market inputs, elasticities, affected facilities, and one-time and ongoing compliance costs. In addition to enabling sensitivity analysis for a given regulation, the model can be used to compare any number of regulatory alternatives by altering the size of the supply shifts or the types of establishments affected by the regulation.

4 Instructions for Using the Poultry Slaughter and Processing Facility-Level Model

In this section, we provide a brief overview of the model; provide instructions for selecting the model inputs, modifying the data used in the model equations, and entering compliance cost estimates; provide instructions for adjusting the baseline; and describe the model's output.

4.1 AN OPERATIONAL OVERVIEW OF THE MODEL

Users have the option of running the model with the existing industry data or modifying any of the default values.

The poultry slaughter facility-level model is a stand-alone program and thus can be run directly from a diskette or from your hard drive. The model contains a characterization of the poultry slaughter and processing industry for the baseline year 2004.[1] Users enter estimates of the changes in costs associated with a proposed regulation. Then, users have the option of running the model with the existing industry data or modifying any of the default values. When users enter compliance costs and run the model, it generates estimates of the market-level effects of the regulation based on standard microeconomic principles.

[1]As explained in the next section, users may recreate the 2004 baseline assuming that plants operating under the HACCP-based inspection models project (HIMP) were instead operating under traditional inspection.

The model was developed in Microsoft Excel© with Visual Basic™ components. It contains 11 tabs, or worksheets:

- Interface—directs the user through each step to operate the model
- Model Inputs—allows the user to view and alter elasticity estimates and enter compliance costs by plant size and product type
- Market Inputs—allows the user to view and alter the default market prices and export and import quantities used in the model
- Market Data—displays the complete set of default values used in the model, the convergence indicator,[2] and the producer and consumer surplus measures
- Baseline—displays individual facilities included in the model with baseline revenue, production cost, and profit estimates
- With Regulation—displays individual facilities included in the model with compliance costs imposed
- Parameters—displays individual facilities included in the model and their β and γ parameters (see Section 3 for formulas containing these parameters)
- Compliance Costs—displays individual facilities included in the model and their compliance cost estimates
- Cost Index—displays the production cost index by state for each poultry type (see Section 3 for formulas containing the cost index)
- Company Level—displays individual companies included in the model and their baseline and with-regulation revenue, production cost, and profit estimates
- EIA Tables—displays the set of model results tables for use in an economic impact analysis

The Baseline, With Regulation, Parameters, Control Costs, and Company Level sheets contain confidential information about poultry slaughter plants; use discretion when opening these sheets.

[2]This parameter indicates whether the model successfully converged such that all markets are in equilibrium (within the model precision).

4.2 RUNNING THE MODEL

To run the poultry slaughter facility-level model, open the Excel file **Poultry FLM.xls**. If a warning about macros appears, click **Enable Macros**. The file will open to the "Interface" worksheet (see Figure 4-1). The left side of the Interface worksheet details the steps needed to run the model, and the right side provides hyperlinks to the model results tables.

Step 1: Choose Model Baseline

To start using the model, you must first choose the model baseline. You may either choose the standard 2004 baseline or simulate an adjusted 2004 baseline. The adjusted 2004 baseline allows you to simulate what market conditions would have been if plants operating under HIMP inspection were instead operating under traditional inspection. To choose the standard 2004 baseline:

- Click the **Choose Baseline** button.
- When the pop-up window opens (see Figure 4-2), ensure that "2004 Baseline" is selected and click **OK**.
- Skip to Step 2 below.

Use the adjusted 2004 baseline option to reflect estimated market conditions assuming that plants operating under HIMP were instead operating under traditional inspection.

To choose the adjusted 2004 baseline, you must first enter the differences in costs of operation for plants that operate under HIMP inspection. If you have not yet entered these cost differences, click **Cancel** and follow the instructions in Section 4.3 below. After you have completed the instructions in Section 4.3, then

- Click the **Choose Baseline** button.
- When the pop-up window opens (see Figure 4-2), select "Adjusted 2004 Baseline" and click **OK**.
- When the second pop-up window opens reminding users to enter cost adjustments before simulating the adjusted baseline (see Figure 4-3), click **OK**.
- When the pop-up window notifies you that the model is now in baseline, click **OK**.

If you would like to review the results of the adjusted baseline before proceeding, you can view the output tables by clicking on the **EIA Tables** tab. The values in the baseline cells will now reflect the adjusted 2004 baseline estimates, and the table names will indicate that the baseline is adjusted. For either type of baseline, the remaining set of steps below is the same.

Figure 4-1. The Interface Screen for the Poultry Slaughter Facility-Level Model
The interface screen guides users through entry of model inputs and viewing of model outputs.

Figure 4-2. The Choose Baseline Pop-Up Screen
The screen allows users to select the standard 2004 baseline or an adjusted (without HIMP inspection) baseline.

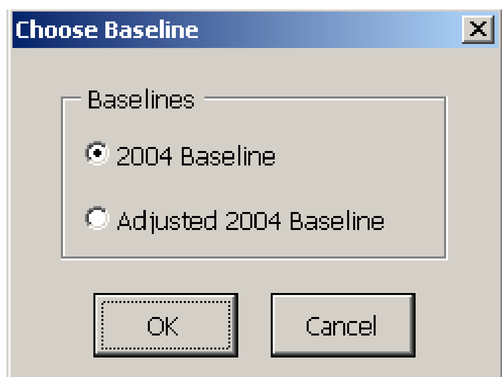
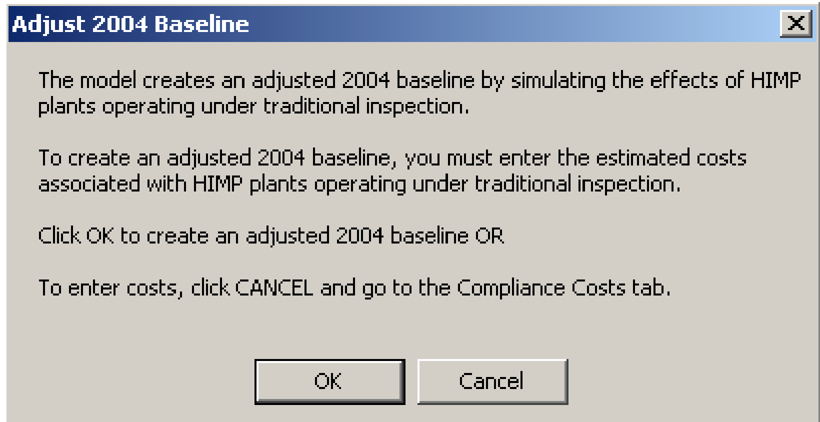


Figure 4-3. The Adjusted 2004 Baseline Pop-Up Screen
The screen reminds users to first enter HIMP cost adjustments prior to running the adjusted 2004 baseline scenario.



Step 2: View or Modify Default Settings (Optional)

The data used in the model were collected from various primary and secondary sources. These data are used as the model's default settings. To view or modify the default settings, select any of the optional buttons as follows:

- **View Market Inputs**—allows the user to view or modify wholesale prices and quantities and farm prices for each of the poultry markets.
- **View Elasticities**—allows the user to view or modify own-price supply and demand elasticities, import and export elasticities, and cross-price demand elasticities for each of the poultry markets.
- **View Affected Products**—allows the user to view or modify plant sizes and poultry types affected by the regulation.

Cells highlighted in yellow can be modified; cells that are not highlighted contain formulas and are therefore locked.

The buttons on the interface direct you to the appropriate location within the model. Cells highlighted in yellow can be modified; cells that are not highlighted contain formulas and are therefore locked. To temporarily modify any of the default settings, click in the appropriate cell and type over the existing data. Dollar signs and commas will be automatically inserted as appropriate.

To return to the Interface screen, click on the **Return to Interface** hyperlink located on each worksheet.

Step 3: Enter Compliance Costs

To enter compliance costs, you may either

- enter cost estimates by plant size and poultry type (Method 1) or
- enter individual cost estimates by facility (Method 2).

In either case, you may enter positive values, representing cost increases, or negative values, representing cost savings (e.g., if these are achieved through more efficient operations).

To enter cost estimates by plant size and poultry type (Method 1):

Note that all tabs that allow user inputs have a button **Restore Defaults** if you need to start over in making changes.

- Click the **View Costs** button on the interface.
- Enter capital cost estimates (including other one-time costs) for a typical very small, small, and large plant. These costs are assumed to apply to the entire plant across all types of poultry slaughtered.
  - If some species are not affected by the regulation, you can click on the ✓ for the species under **Affected Product**. Clicking on the ✓ will change the cell to empty; therefore, the model will not include slaughter volumes for that species when calculating per-unit capital costs or impose compliance costs for that species. Note that you can designate whether each species is affected for very small, small, and large plants.
- Enter variable cost (or ongoing cost) estimates for a typical very small, small, and large plant for each type of poultry.
- If you desire, you may alter the default values for **Life of Equipment** and **Discount Rate** under **Discount Inputs**. These values are used to amortize capital and other one-time costs to create an equivalent annual payment.
- If all facilities are affected by the regulation, click the hyperlink **Return to Interface** and go to Step 4 below. The model will automatically populate the individual compliance cost estimates for each establishment in the **Compliance Costs** tab.
- If some facilities are not affected by the regulation, click the hyperlink **Go to Compliance Costs**.
  - For each facility not affected by the regulation, change the “1” to “0” in the “Affected Plant/Product” column.
  - Click the hyperlink **Return to Interface** and go to Step 4 below.

To enter cost estimates by individual facility (Method 2):

- Click the **View Costs** button on the interface and then click the hyperlink **Go to Compliance Costs** OR click on the tab **Compliance Costs** at the bottom of the worksheet.
- Enter capital (including one-time) cost estimates and variable (or ongoing) cost estimates for each individual facility by type of poultry slaughtered.
- If a facility is unaffected by the regulation, you may either leave zero values for compliance costs or change the "1" to "0" in the "Affected Plant/Product" column.
- After entering all the compliance cost estimates, click the hyperlink **Return to Interface** at the top of the worksheet and go to Step 4.

Step 4: Run the Model

Once you have modified the default settings and entered cost estimates, you are ready to run the model as follows:

- Click the **Run Model** button.
- When the pop-up window appears indicating the markets are now in equilibrium, click **OK**.

Step 5: View the Model Results

After running the model, you may view the model results tables by either of the following methods:

- Click on the output table names on the **Interface** screen.
- Click on the tab **Model Output Tables**.

Instructions for printing or saving results are provided in Section 4.4.

4.3 ENTERING COST DIFFERENCES TO SIMULATE AN ADJUSTED 2004 BASELINE

You may skip this section if you are using the standard 2004 baseline in the model.

As noted above, to operate the model with the adjusted 2004 baseline, you must first enter the differences in costs of operation for plants that operate under HIMP instead of traditional inspection. For example, if a plant was operating under traditional instead of HIMP inspection, it might have lower capital equipment costs (per plant) but higher variable costs (per bird). You must enter these cost differences and simulate the adjusted 2004 baseline prior to entering the costs of complying with a new proposed regulation.

After you have simulated the adjusted 2004 baseline, the steps for running the model are the same as for the standard 2004 baseline.

To enter the estimated cost differences, go to the **Compliance Costs** tab by clicking on the tab on the bottom of the worksheet. Plants that are operating under HIMP inspection as of early 2006 are highlighted in blue. To enter the cost differences:

- In the yellow "Affected Plant/Product" column, enter "1" for each plant that operates under HIMP inspection for that product type (that is, enter "1" in each of the blue rows) and enter "0" for all of the remaining rows.
- In the yellow "Variable Costs" column, enter the estimated per-bird difference in the cost of production for each of the plants that operates under HIMP inspection. This value may be positive or negative. You may leave the cells blank for all the remaining plants.
- In the yellow "Capital Costs" column, enter the estimated per-plant differences in capital costs for each of the plants that operates under HIMP. This value may be positive or negative. You may leave the cells blank for all the remaining plants.

After entering the production cost differences, click on the **Return to Interface** hyperlink at the top of the worksheet OR click on the **Interface** tab at the bottom of the worksheet. Then return to Step 1 of the instructions provided in Section 4.2 above. All of the remaining steps for running the model are the same regardless of which type of baseline is used.

Note that values you have entered in the **Compliance Costs** tab will be overwritten if you enter compliance costs on the **Model Inputs** tab. However, if you enter individual plant compliance cost estimates in the **Compliance Costs** tabs, you will need to remove or change your previously entered cost differences used for simulating the adjusted 2004 baseline.

4.4 MODEL RESULTS

As noted above, the results of the model appear in the Model Output Tables sheet. The output tables include the following:

1. Baseline Characterization of U.S. Poultry Market: 2004
2. Summary of Market-Level Impacts of Regulation: 2004
3. Summary of National-Level Industry Impacts of Regulation: 2004
4. Distribution of Social Costs Associated with Regulation: 2004

5. Capacity and Compliance Costs Comparisons for Small and Large Companies: 2004
6. Capacity and Compliance Costs Comparisons for Very Small, Small, and Large Plants: 2004
7. Summary of Small Business Impacts of Regulation: 2004
8. Summary of HACCP Size Impacts of Regulation: 2004

The tables are formatted so that they can be copied directly into an economic impact analysis report. The table templates (shown in baseline with no compliance costs) are included at the end of this section (Tables 4-1 through 4-8). When the model is operated, these tables display estimated effects of the rule on revenues, profitability, and employment under both baseline and "with-regulation" scenarios.

In addition to printing or saving the model results, you may also print or save the input sheets.

To print the output tables, follow these steps:

- Click **File**, then **Print**.

When the Print window opens:

- Select **All** in the Print Range frame
- Select **Active Sheets** in the Print What frame
- Click **OK**

The spreadsheet will print in landscape setting.

Instead of printing the model results, you may wish to save them into another Excel spreadsheet. To do this, follow these steps:

- Click **Edit.**
- Click Move or Copy Sheet.
- When the Move or Copy window opens, select **(new book)** under the To Book: drop-down arrow and check the **Create a Copy** box.
- Click **OK**.

To return to the Interface worksheet, click on the **Return to Interface** hyperlink located below each table.

Table 4-1. Baseline Characterization of U.S. Poultry Market: 2004

	Young Chickens	Other Chickens	Turkey	Other Poultry
Market Price ($/bird)[a]	$2.88	$1.23	$14.58	$7.74
Market Quantity (birds/year)				
Domestic production	8,386,671,602	139,499,163	251,787,784	26,781,095
Exports	1,314,710,807	14,675,806	18,428,948	903,419
Imports	9,314,079	—	229,827	243,164

[a]Market price is calculated by multiplying the wholesale price per pound by the average dressed weight.

Table 4-2. Summary of Market-Level Impacts of Regulation: 2004

			Changes from Baseline	
	Baseline	With Regulation	Absolute	Percent
Young Chickens				
Market Price ($/bird)	$2.88	$2.88	$—	0.0%
Market Quantity (birds/year)	8,395,985,681	8,395,985,681	—	0.0%
Domestic production	8,386,671,602	8,386,671,602	—	0.0%
Exports	1,314,710,807	1,314,710,807	—	0.0%
Imports	9,314,079	9,314,079	—	0.0%
Other Chickens				
Market Price ($/bird)	$1.23	$1.23	$—	0.0%
Market Quantity (birds/year)	139,499,163	139,499,163	—	0.0%
Domestic production	139,499,163	139,499,163	—	0.0%
Exports	14,675,806	14,675,806	—	0.0%
Imports	—	—	—	0.0%
Turkeys				
Market Price ($/bird)	$14.58	$14.58	$—	0.0%
Market Quantity (birds/year)	252,017,611	252,017,611	—	0.0%
Domestic production	251,787,784	251,787,784	—	0.0%
Exports	18,428,948	18,428,948	—	0.0%
Imports	229,827	229,827	—	0.0%
Other Poultry				
Market Price ($/bird)	$7.74	$7.74	$—	0.0%
Market Quantity (birds/year)	27,024,259	27,024,259	—	0.0%
Domestic production	26,781,095	26,781,095	—	0.0%
Exports	903,419	903,419	—	0.0%
Imports	243,164	243,164	—	0.0%

Table 4-3. Summary of National-Level Industry Impacts of Regulation: 2004

	Baseline	With Regulation	Changes from Baseline	
			Absolute	Percent
Poultry Revenues ($/year)	$28,191,440,474	$28,191,440,474	$—	0.0%
Costs ($/year)				
Regulatory compliance	$—	$—	$—	
Poultry production	$26,355,424,849	$26,355,424,849	$—	0.0%
Operating Profits (%)	6.51%	6.51%	0.00%	—
Operating Product Types (#)	377	377	0	0.0%
Operating Slaughter Operations (#)	297	297	0	0.0%
Employment (FTEs)	193,884	193,884	0	0.0%

FTEs = Full-time equivalents

Table 4-4. Distribution of Social Costs Associated with Regulation: 2004

Stakeholder	Change in Value ($)
Consumer surplus, total	$—
Young chicken consumers	$—
Other chicken consumers	$—
Turkey consumers	$—
Other poultry consumers	
Producer surplus, total	$(0)
Young chicken producers	$(0)
Other chicken producers	$0
Turkey producers	$(0)
Other poultry producers	
Total surplus	$(0)

Table 4-5. Capacity and Compliance Costs Comparisons for Small and Large Companies: 2004

Company Size (SBA Definition)	Number of Companies	Number of Facilities	Share of Facilities	Production (birds/year)		Total Compliance Costs[a]	
				Total	Share	Total	Share
Small	109	110	37%	410,619,667	5%	$—	0%
Large	49	187	63%	8,394,119,977	95%	$—	0%
TOTAL	158	297	100%	8,804,739,644	100%	$—	0%

[a]Compliance costs represent premarket adjustments (i.e., the cost incurred prior to production volume alterations and plant closures).

Table 4-6. Capacity and Compliance Costs Comparisons for Very Small, Small, and Large Plants: 2004

Plant Size (HACCP Definition)	Number of Facilities	Share of Facilities	Production (birds/year)		Total Compliance Costs[a]	
			Total	Share	Total	Share
Very small	54	18%	6,359,111	0%	$—	0%
Small	92	31%	1,474,181,333	17%	$—	0%
Large	151	51%	7,324,199,200	83%	$—	0%
TOTAL	297	100%	8,804,739,644	100%	$—	0%

[a]Compliance costs represent premarket adjustments (the cost incurred prior to production volume alterations and plant closures).

Table 4-7. Summary of Small Business Impacts of Regulation: 2004

	Baseline	With Regulation	Changes from Baseline	
			Absolute	Percent
Poultry Revenues ($/year)	$1,358,730,766	$1,358,730,766	$—	0.0%
Costs ($)				
Regulatory compliance	$—	$—	$—	
Poultry production	$1,246,444,953	$1,246,444,953	$—	0.0%
Operating Profits (%)	8.26%	8.26%	0.00%	—
Operating Entities				
Product types	172	172	—	0.0%
Slaughter operations	110	110	—	0.0%
Employment	9,161	9,161	—	0.0%

Table 4-8. Summary of HACCP Size Impacts of Regulation: 2004

			Changes from Baseline	
	Baseline	**With Regulation**	**Absolute**	**Percent**
Very Small				
Poultry revenues ($/year)	$22,434,963	$22,434,963	$—	0.0%
Costs ($)				
Regulatory compliance	$—	$—	$—	
Poultry production	$21,254,591	$21,254,591	$—	0.0%
Operating profits (%)	5.26%	5.26%	0.00%	—
Operating entities				
Product types	88	88	—	0.0%
Slaughter operations	54	54	—	0.0%
Employment	787	787	—	0.0%
Small				
Poultry revenues ($/year)	$4,883,553,668	$4,883,553,668	$—	0.0%
Costs ($)				
Regulatory compliance	$—	$—	$—	
Poultry production	$4,545,880,616	$4,545,880,616	$—	0.0%
Operating profits (%)	6.91%	6.91%	0.00%	—
Operating entities				
Product types	125	125	—	0.0%
Slaughter operations	92	92	—	0.0%
Employment	27,740	27,740	—	0.0%
Large				
Poultry revenues ($/year)	$23,285,451,843	$23,285,451,843	$—	0.0%
Costs ($)				
Regulatory compliance	$—	$—	$—	
Poultry production	$21,788,289,642	$21,788,289,642	$—	0.0%
Operating profits (%)	6.43%	6.43%	0.00%	—
Operating entities				
Product types	164	164	—	0.0%
Slaughter operations	151	151	—	0.0%
Employment	165,357	165,357	—	0.0%

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Appendix A: Supply Elasticity Estimates

Table A-1. Broiler Supply Elasticity Estimates for Facility-Level Poultry Model

Source	Data Frequency and Time Period	Estimate	Standard Error
Chavas, J-P. 1982. On the Use of Price Ratio in Aggregate Supply Response: Some Evidence From the Poultry Industry. *Canadian Journal of Agricultural Economics.* 64(4):345-358. November.	Quarterly data, 1965–1975	0.072	NR
Holt, M.T. and S.V. Aradhyula. 1990. Price Risk in Supply Equations: An Application of GARCH Time-Series Models to the U.S. Broiler Market. *Southern Economic Journal.* 57(1):230-242. July.	Quarterly data, 1969–1986	0.216	NR
Holt, M.T. and S.V. Aradhyula. 1990. Price Risk in Supply Equations: An Application of GARCH Time-Series Models to the U.S. Broiler Market. *Southern Economic Journal.* 57(1):230-242. July.	Quarterly data, 1969–1986	0.232	NR
Aradhyula, S.V. and M.T. Holt. 1989. Risk Behavior and Rational Expectations in the U.S. Broiler Market. *American Journal of Agricultural Economics.* November.	Quarterly data, 1967–1986	0.305	NR
Holt, M.T. and S.V. Aradhyula. 1990. Price Risk in Supply Equations: An Application of GARCH Time-Series Models to the U.S. Broiler Market. *Southern Economic Journal.* 57(1):230-242. July.	Quarterly data, 1969–1986	0.399	NR
Chavas, J-P., and S.R. Johnson. 1982. Supply Dynamics: The Case of U.S. Broilers and Turkeys. *American Journal of Agricultural Economics.* 64(3):558-564. August.	Quarterly data, 1965–1975	0.064	NR
	Average	0.215	
	Median	0.224	
	Minimum	0.072	
	Max	0.399	

Table A-2. Turkey Supply Elasticity Estimates for Facility-Level Poultry Model

Source	Data Frequency and Time Period	Estimate	Standard Error
Chavas, J-P., and S.R. Johnson. 1982. Supply Dynamics: The Case of U.S. Broilers and Turkeys. *American Journal of Agricultural Economics.* 64(3):558-564. August.	Quarterly data, 1965–1975	0.210	NR
Chavas, J-P. 1982. On the Use of Price Ratio in Aggregate Supply Response: Some Evidence From the Poultry Industry. *Canadian Journal of Agricultural Economics.* 64(4):345-358. November.	Quarterly data, 1965–1975	0.222	NR
Soliman, M.A. 1971. Econometric Model of the Turkey Industry in the United States. *Canadian Journal of Agricultural Economics.* 19:47-60. October.	Annual data, 1946–1966	0.353	NR
	Average	0.262	
	Median	0.222	
	Minimum	0.210	
	Max	0.353	

Appendix B: Demand Elasticity Estimates

Table B-1. Chicken Own-Price Elasticity Estimates for the Facility-Level Poultry Model

Source	Data Frequency and Time Period	Estimate	Standard Error
Kesavan, T., Zuhair A. Hassan, Helen H. Jensen, and Stanley R. Johnson. (1993). "Dynamics and Long-Run Structure in the U.S. Meat Demand." Canadian Journal of Agricultural Economics, Vol. 41, No. 2, (July 1993) pp. 139-153.	Quarterly data, 1965–1988	–1.250	NR
Arzac, E.R. and M. Wilkinson. 1979. A Quarterly Econometric Model of United States Livestock and Feed Grain Markets and Some of Its Policy Implications. American Journal of Agricultural Economics. May 1979.	Quarterly data, 1965–1975	–0.980	NR
Alston, Julian M., and James A. Chalfant (1993). The Silence of the Lambdas: A Test of the Almost Ideal and Rotterdam Models." American Journal of Agricultural Economics, Vol. 75, No. 2, (May 1993) pp. 304-313.	Quarterly data, 1967–1988	–0.940	NR
Capps, Oral, Jr. (1989). "Utilizing Scanner Data to Estimate Retail Demand Functions for Meat Products." American Journal of Agricultural Economics, Vol. 71, No. 3, (August 1989) pp. 750-760.	Weekly data, 1986–1987	–0.660	NR
Thurman, Walter N. (1987). "The Poultry Market: Demand Stability and Industry Structure." American Journal of Agricultural Economics, Vol. 69, No. 1, (February 1987) pp. 30-37	Annual data, 1955–1981	–0.640	NR
Lemieux, C. M., and Wohlgenant. 1989. "ex Ante evaluation of the Economic Impact of Agricultural Biotechnology: The Case of Porcine Somatotropin." American Journal of Agricultural Economics. (November 1989) Vol. 71, No. 4, pp. 903-914.	Annual data, 1956–1983	–0.560	NR
Huang, K.S. 1986. U.S. Demand for Food: A Complete System of Price and Income Effects. Technical Bulletin Number 1714. Washington D.C.:U.S. Department of Agriculture, Economic Research Service.	Annual data, 1953–1983	–0.531	0.061
Gao, X.M. and J.S. Shonkwiler (1993). "Characterizing Taste Change in a Model of U.S. Meat Demand: Correcting for Spurious Regression and Measurement Errors." Review of Agricultural Economics, Vol. 15, No. 2, (May 1993) pp. 313-324	Annual data, 1956–1987	–0.470	NR
Huang, K. S. 1993. A Complete System of US Demand for Food. Technical Bulletin Number 1821. Washington D.C.: U.S. Department of Agriculture, Economic Research Service.	Annual data, 1953–1990	–0.372	0.056

(continued)

Table B-1. Chicken Own-Price Elasticity Estimates for the Facility-Level Poultry Model (continued)

Source	Data Frequency and Time Period	Estimate	Standard Error
Huang, K. S. 1993. A Complete System of US Demand for Food. Technical Bulletin Number 1821. Washington D.C.: U.S. Department of Agriculture, Economic Research Service.	Annual data, 1953–1991	−0.372	NR
Hahn, William F. (1994). "A Random Coefficient Meat Demand Model." Journal of Agricultural Economics Research, Vol. 45, No. 3, (Fall 1994) pp. 21-30.	Monthly data, 1981–1992	−0.299	NR
Eales, James S., and Laurian J. Unnevehr (1993). "Simultaneity and Structural Change in U.S. Meat Demand." American Journal of Agricultural Economics, Vol. 75, No. 2, (May 1993) pp. 259-268.	Annual data, 1962–1989	−0.276	NR
Eales, James S., and Laurian J. Unnevehr (1993). "Simultaneity and Structural Change in U.S. Meat Demand." American Journal of Agricultural Economics, Vol. 75, No. 2, (May 1993) pp. 259-268.	Annual data, 1962-–1989	−0.233	NR
Huang, Kuo S., and William F. Hahn. (1995). U.S. Quarterly Demand for Meats. U.S. Department of Agriculture, Technical Bulletin No. 1841. February 1995.	Quarterly data, 1979–1990	−0.197	NR
Eales, James S., and Laurian J. Unnevehr (1993). "Simultaneity and Structural Change in U.S. Meat Demand." American Journal of Agricultural Economics, Vol. 75, No. 2, (May 1993) pp. 259-268.	Annual data, 1962–1989	−0.162	NR
Eales, James S., and Laurian J. Unnevehr (1993). "Simultaneity and Structural Change in U.S. Meat Demand." American Journal of Agricultural Economics, Vol. 75, No. 2, (May 1993) pp. 259-268.	Annual data, 1962–1989	−0.150	NR
Hahn, William F. (1988). "Effects of Income Distribution on Meat Demand." Journal of Agricultural Economics Research, Vol. 40, No. 2, (Spring 1988) pp. 19-24.	Annual data, 1960–1984	−0.140	NR
Eales, J.S., J. Hyde, and L.F. Schrader. 1998. A Note on Dealing with Poultry in Demand Analysis. Journal of Agricultural and Resource Economics. 23(2):558-567. December.	Quarterly data, 1980–1996	−0.140	0.070
Eales, J.S., J. Hyde, and L.F. Schrader. 1998. A Note on Dealing with Poultry in Demand Analysis. Journal of Agricultural and Resource Economics. 23(2):558-567. December.	Quarterly data, 1980–1996	−0.130	0.070

(continued)

Table B-1. Chicken Own-Price Elasticity Estimates for the Facility-Level Poultry Model (continued)

Source	Data Frequency and Time Period	Estimate	Standard Error
Moschini, Giancarlo, and Karl D. Meilke (1989). “Modeling the Pattern of Structural Change in U.S. Meat Demand.” American Journal of Agricultural Economics, Vol. 71, No. 2, (May 1989) pp. 253-261.	Quarterly data, 1967–1987	−0.100	NR
	Average	−0.430	
	Median	−0.335	
	Minimum	−1.250	
	Max	−0.100	

Table B-2. Poultry Own-Price Elasticity Estimates for the Facility-Level Poultry Model (Applied to "Other Chickens" and "Other Poultry")

Source	Data Frequency and Time Period	Estimate	Standard Error
Choi, Seungmook, and Kim Sosin (1990). Testing for Structural Change: The Demand for Meat." American Journal of Agricultural Economics, Vol. 72, No. 1 (February 1990) pp. 227-236.	Annual data, 1953–1984	–0.893	NR
Yen, Steven T., Lin, Biling-Hwan, Smallwood, David M. "Quasi- and Simulated-Likelihood Approaches to Censored Demand Systems: Food Consumption by Food Stamp Recipients in the United States." American Journal of Agricultural Economics, (May 2003), 85(2), 458-478.	Cross-sectional data, 1996–1997	–0.840	0.090
Yen, Steven T., Lin, Biling-Hwan, Smallwood, David M. "Quasi- and Simulated-Likelihood Approaches to Censored Demand Systems: Food Consumption by Food Stamp Recipients in the United States." American Journal of Agricultural Economics, (May 2003), 85(2), 458-478.	Cross-sectional data, 1996–1997	–0.820	0.060
Yen, Steven T., Lin, Biling-Hwan, Smallwood, David M. "Quasi- and Simulated-Likelihood Approaches to Censored Demand Systems: Food Consumption by Food Stamp Recipients in the United States." American Journal of Agricultural Economics, (May 2003), 85(2), 458-478.	Cross-sectional data, 1996–1997	–0.780	0.090
Yen, Steven T., Lin, Biling-Hwan, Smallwood, David M. "Quasi- and Simulated-Likelihood Approaches to Censored Demand Systems: Food Consumption by Food Stamp Recipients in the United States." American Journal of Agricultural Economics, (May 2003), 85(2), 458-478.	Cross-sectional data, 1996–1997	–0.770	0.060
Yen, Steven T., Lin, Biling-Hwan, Smallwood, David M. "Quasi- and Simulated-Likelihood Approaches to Censored Demand Systems: Food Consumption by Food Stamp Recipients in the United States." American Journal of Agricultural Economics, (May 2003), 85(2), 458-478.	Cross-sectional data, 1996–1997	–0.760	0.060
Yen, Steven T., Lin, Biling-Hwan, Smallwood, David M. "Quasi- and Simulated-Likelihood Approaches to Censored Demand Systems: Food Consumption by Food Stamp Recipients in the United States." American Journal of Agricultural Economics, (May 2003), 85(2), 458-478.	Cross-sectional data, 1996–1997	–0.730	0.050
Huang, Kuo S., and Biling-Hwan Lin. (2000). Estimation of Food Demand and Nutrition from Household Survey Data. U.S. Department of Agriculture, Technical Bulletin No. 1887. August 2000.	Annual data, 1987–1988	–0.644	0.030

(continued)

Table B-2. Poultry Own-Price Elasticity Estimates for the Facility-Level Poultry Model (Applied to "Other Chickens" and "Other Poultry")

Source	Data Frequency and Time Period	Estimate	Standard Error
Boetel, Brenda L., Liu, Donald J. "Evaluating the effects of Generic Advertising and Food Health Information within a Meat Demand System." Agribusiness, 2003, 19(3), 345-354.	Quarterly data, 1976–2000	–0.424	NR
Wohlgenant, Michael K. (1989) "Demand for Farm Output in a Complete System of Demand Functions." American Journal of Agricultural Economics, Vol. 71, No. 2 (May 1989) pp. 241-252	Annual data, 1956–1983	–0.420	NR
Brester, Gary W., and Michael K. Wohlgenant (1991). "Estimating Interrelated Demands for Meats Using New Measures for Ground and Table Cut Beef." American Journal of Agricultural Economics, Vol. 73, No. 4 (November 1991) pp. 1182-1194.	Annual data, 1962–1989	–0.296	NR
Marsh, Thomas L., Schroeder, Ted C., Mintert, James. "Impacts of Meat Product Recalls on Consumer Demand in the USA." Applied Economics, 2004, 36, 897-909.	Quarterly data, 1982–1998	–0.082	NR
	Average	–0.620	
	Median	–0.730	
	Minimum	–0.893	
	Max	–0.082	

Table B-3. Turkey Own-Price Elasticity Estimates for Facility-Level Poultry Model

Source	Data Frequency and Time Period	Estimate	Standard Error
Cheney, Laura M., Brown, A. Blake, Yamano, Takashi, Masterovsky, Michael. "Issues of Demand Specification and Industry Structure in Turkeys and Broiler Chickens." Journal of Agricultural and Applied Economics, (April 2001) Vol. 11, No, 1, pp. 25-34.	Annual data, 1960–1995	−1.371	0.206
Huang, K.S. 1986. U.S. Demand for Food: A Complete System of Price and Income Effects. Technical Bulletin Number 1714. Washington D.C.:U.S. Department of Agriculture, Economic Research Service.	Annual data, 1953–1983	−0.680	0.133
Eales, J.S., J. Hyde, and L.F. Schrader. 1998. A Note on Dealing with Poultry in Demand Analysis. Journal of Agricultural and Resource Economics. 23(2):558-567. December.	Quarterly data, 1980–1996	−0.630	0.270
Huang, K. S. 1993. A Complete System of US Demand for Food. Technical Bulletin Number 1821. Washington D.C.: U.S. Department of Agriculture, Economic Research Service.	Annual data, 1953–1991	−0.535	NR
Huang, K. S. 1993. A Complete System of US Demand for Food. Technical Bulletin Number 1821. Washington D.C.: U.S. Department of Agriculture, Economic Research Service.	Annual data, 1953–1990	−0.535	0.122
Hahn, William F. (1994). "A Random Coefficient Meat Demand Model." Journal of Agricultural Economics Research, Vol. 45, No. 3, (Fall 1994) pp. 21-30.	Monthly data, 1981–1992	−0.459	NR
Soliman, M.A. 1971. Econometric Model of the Turkey Industry in the United States. Canadian Journal of Agricultural Economics. 19:47-60. October.	Annual data, 1946–1966	−0.412	NR
Soliman, M.A. 1971. Econometric Model of the Turkey Industry in the United States. Canadian Journal of Agricultural Economics. 19:47-60. October.	Annual data, 1946–1966	−0.411	NR
Soliman, M.A. 1971. Econometric Model of the Turkey Industry in the United States. Canadian Journal of Agricultural Economics. 19:47-60. October.	Annual data, 1946–1966	−0.394	NR
Soliman, M.A. 1971. Econometric Model of the Turkey Industry in the United States. Canadian Journal of Agricultural Economics. 19:47-60. October.	Annual data, 1946–1966	−0.372	NR

(continued)

Table B-3. Turkey Own-Price Elasticity Estimates for Facility-Level Poultry Model (continued)

Source	Data Frequency and Time Period	Estimate	Standard Error
	Average	–0.580	
	Median	–0.497	
	Minimum	–1.371	
	Max	–0.372	

Table B-4. Export Demand Elasticity Estimates for the Facility-Level Poultry Model (Estimates with Incorrect Signs are Excluded

Type	Source	Data/Time Period	Estimate	Standard Error
Poultry exports to Singapore	Jan, Man-ser, Huang, Chung L., Epperson, James E. "Measuring the Effects of Non-Price Promotion on U.S. Poultry Meat Product Exports." Selected Paper for the American Agricultural Economics Association Annual Meetings 1998.	Annual data, 1986–1996	−3.371	3.012
Poultry exports to Japan	Jan, Man-ser, Huang, Chung L., Epperson, James E. "Measuring the Effects of Non-Price Promotion on U.S. Poultry Meat Product Exports." Selected Paper for the American Agricultural Economics Association Annual Meetings 1998.	Annual data, 1986–1996	−2.831	2.301
Poultry exports to Hong Kong	Shahid, Abdus and Gempesaw, Conrado M. 2002. "The Role of Promotion Programs for U.S. Poultry Exports." Agricultural and Resource Economics Review. (April 2002) Vol. 59, No. 1, pp. 59-70.	Annual data, 1980–1998 (elasticity at mean)	−2.347	1.411
Poultry exports to Hong Kong	Jan, Man-ser, Huang, Chung L., Epperson, James E. "Measuring the Effects of Non-Price Promotion on U.S. Poultry Meat Product Exports." Selected Paper for the American Agricultural Economics Association Annual Meetings 1998.	Annual data, 1986–1996	−1.397	0.985
Poultry exports to S. Africa	Jan, Man-ser, Huang, Chung L., Epperson, James E. "Measuring the Effects of Non-Price Promotion on U.S. Poultry Meat Product Exports." Selected Paper for the American Agricultural Economics Association Annual Meetings 1998.	Annual data, 1986–1996	−1.339	5.353
Poultry exports to Japan	Shahid, Abdus and Gempesaw, Conrado M. 2002. "The Role of Promotion Programs for U.S. Poultry Exports." Agricultural and Resource Economics Review. (April 2002) Vol. 59, No. 1, pp. 59-70.	Annual data, 1990–1998	−0.700	0.083

(continued)

Table B-4. Export Demand Elasticity Estimates for the Facility-Level Poultry Model (Estimates with Incorrect Signs are Excluded (continued)

Type	Source	Data/Time Period	Estimate	Standard Error
Poultry exports to Saudi Arabia	Shahid, Abdus and Gempesaw, Conrado M. 2002. "The Role of Promotion Programs for U.S. Poultry Exports." Agricultural and Resource Economics Review. (April 2002) Vol. 59, No. 1, pp. 59-70.	Annual data, 1990–1998	−0.431	0.161
Poultry exports to Egypt	Shahid, Abdus and Gempesaw, Conrado M. 2002. "The Role of Promotion Programs for U.S. Poultry Exports." Agricultural and Resource Economics Review. (April 2002) Vol. 59, No. 1, pp. 59-70.	Annual data, 1990–1998	−0.402	NR
Poultry exports to China	Shahid, Abdus and Gempesaw, Conrado M. 2002. "The Role of Promotion Programs for U.S. Poultry Exports." Agricultural and Resource Economics Review. (April 2002) Vol. 59, No. 1, pp. 59-70.	Annual data, 1990–1998	−0.126	NR
		Average	−1.438	
		Median	−1.339	
		Minimum	−3.371	
		Max	−0.126	

Table B-5. Cross-Price Demand Elasticity Estimates for the Facility-Level Poultry Model (Estimates with Incorrect Signs are Excluded)

Type	Source	Data/Time Period	Estimate	Standard Error
Chicken wrt beef	Alston, Julian M., and James A. Chalfant (1993). The Silence of the Lambdas: A Test of the Almost Ideal and Rotterdam Models." American Journal of Agricultural Economics, Vol. 75, No. 2, (May 1993) pp. 304-313.	Quarterly data, 1967–1988	0.040	NR
Chicken wrt beef	Hahn, William F. (1988). "Effects of Income Distributionon Meat Demand." Journal of Agricultural Economics Research, Vol. 40, No. 2, (Spring 1988) pp. 19-24.	Annual data, 1960–1984	0.150	NR
Chicken wrt beef	Gao, X.M. and J.S. Shonkwiler (1993). "Characterizing Taste Change in a Model of U.S. Meat Demand: Correcting for Spurious Regression and Measurement Errors." Review of Agricultural Economics, Vol. 15, No. 2, (May 1993) pp. 313-324	Annual data, 1956–1987	0.230	NR
Chicken wrt beef	Thurman, Walter N. (1987). "The Poultry Market: Demand Stability and Industry Structure." American Journal of Agricultural Economics, Vol. 69, No. 1, (February 1987) pp. 30-37	Annual data, 1955–1981	0.230	NR
Chicken wrt beef	Lemieux, C. M., and Wohlgenant. 1989. "ex Ante evaluation of the Economic Impact of Agricultural Biotechnology: The Case of Porcine Somatotropin." American Journal of Agricultural Economics. (November 1989) Vol. 71, No. 4, pp. 903-914.	Annual data, 1956–1983	0.300	NR
Chicken wrt beef	Eales, James S., and Laurian J. Unnevehr (1993). "Simultaneity and Structural Change in U.S. Meat Demand." American Journal of Agricultural Economics, Vol. 75, No. 2, (May 1993) pp. 259-268.	Annual data, 1962–1989	0.385	NR
Chicken wrt pork	Kesavan, T., Zuhair A. Hassan, Helen H. Jensen, and Stanley R. Johnson. (1993). "Dynamics and Long-Run Structure in the U.S. Meat Demand." Canadian Journal of Agricultural Economics, Vol. 41, No. 2, (July 1993) pp. 139-153.	Quarterly data, 1965–1988	0.020	NR
Chicken wrt pork	Eales, James S., and Laurian J. Unnevehr (1993). "Simultaneity and Structural Change in U.S. Meat Demand." American Journal of Agricultural Economics, Vol. 75, No. 2, (May 1993) pp. 259-268.	Annual data, 1962–1989	0.041	NR

(continued)

Table B-5. Cross-Price Demand Elasticity Estimates for the Facility-Level Poultry Model (Estimates with Incorrect Signs are Excluded) (continued)

Type	Source	Data/Time Period	Estimate	Standard Error
Chicken wrt pork	Huang, K. S. 1993. A Complete System of US Demand for Food. Technical Bulletin Number 1821. Washington D.C.: U.S. Department of Agriculture, Economic Research Service.	Annual data, 1953–1990	0.047	0.059
Chicken wrt pork	Huang, K. S. 1993. A Complete System of US Demand for Food. Technical Bulletin Number 1821. Washington D.C.: U.S. Department of Agriculture, Economic Research Service.	Annual data, 1953–1990	0.048	NR
Chicken wrt pork	Gao, X.M. and J.S. Shonkwiler (1993). "Characterizing Taste Change in a Model of U.S. Meat Demand: Correcting for Spurious Regression and Measurement Errors." Review of Agricultural Economics, Vol. 15, No. 2, (May 1993) pp. 313-324	Annual data, 1956–1987	0.110	NR
Chicken wrt pork	Lemieux, C. M., and Wohlgenant. 1989. "ex Ante evaluation of the Economic Impact of Agricultural Biotechnology: The Case of Porcine Somatotropin." American Journal of Agricultural Economics. (November 1989) Vol. 71, No. 4, pp. 903-914.	Annual data, 1956–1983	0.210	NR
Chicken wrt pork	Thurman, Walter N. (1987). "The Poultry Market: Demand Stability and Industry Structure." American Journal of Agricultural Economics, Vol. 69, No. 1, (February 1987) pp. 30-37	Annual data, 1955–1981	0.350	NR
Poultry wrt beef	Yen, Lin, Smallwood. "Quasi- and Simulated-Likelihood Approaches to Censored Demand Systems: Food Consumption by Food Stamp Recipients in the United States." AJAE, 2003, 85(2), 458-478.	Cross-sectional data, 1996–1997	0.000	0.030
Poultry wrt beef	Yen, Lin, Smallwood. "Quasi- and Simulated-Likelihood Approaches to Censored Demand Systems: Food Consumption by Food Stamp Recipients in the United States." AJAE, 2003, 85(2), 458-478.	Cross-sectional data, 1996–1997	0.030	0.040
Poultry wrt beef	Yen, Lin, Smallwood. "Quasi- and Simulated-Likelihood Approaches to Censored Demand Systems: Food Consumption by Food Stamp Recipients in the United States." AJAE, 2003, 85(2), 458-478.	Cross-sectional data, 1996–1997	0.030	0.050

(continued)

Table B-5. Cross-Price Demand Elasticity Estimates for the Facility-Level Poultry Model (Estimates with Incorrect Signs are Excluded) (continued)

Type	Source	Data/Time Period	Estimate	Standard Error
Poultry wrt beef	Yen, Lin, Smallwood. "Quasi- and Simulated-Likelihood Approaches to Censored Demand Systems: Food Consumption by Food Stamp Recipients in the United States." AJAE, 2003, 85(2), 458-478.	Cross-sectional data, 1996–1997	0.040	0.030
Poultry wrt beef	Yen, Lin, Smallwood. "Quasi- and Simulated-Likelihood Approaches to Censored Demand Systems: Food Consumption by Food Stamp Recipients in the United States." AJAE, 2003, 85(2), 458-478.	Cross-sectional data, 1996–1997	0.090	0.040
Poultry wrt beef	Yen, Lin, Smallwood. "Quasi- and Simulated-Likelihood Approaches to Censored Demand Systems: Food Consumption by Food Stamp Recipients in the United States." AJAE, 2003, 85(2), 458-478.	Cross-sectional data, 1996–1997	0.090	0.050
Poultry wrt beef	Boetel, Liu. "Evaluating the effects of Generic Advertising and Food Health Information within a Meat Demand System." Agribusiness, 2003, 19(3), 345-354.	Quarterly data, 1976–2000	0.377	NR
Turkey wrt chicken	Cheney, Laura M., Brown, A. Blake, Yamano, Takashi, Masterovsky, Michael. "Issues of Demand Specification and Industry Structure in Turkeys and Broiler Chickens." Journal of Agricultural and Applied Economics, (April 2001) Vol. 11, No, 1, pp. 25-34.	Annual data, 1960–1995	0.329	0.192
		Average	0.150	
		Median	0.090	
		Minimum	0.000	
		Maximum	0.385	

Note: "wrt" means "with respect to."