June 2007

Pork Slaughter and Processing Sector Facility-Level Model

Final Report

Contract No. 53-3A94-03-12, Delivery Order 9

Prepared for

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1 Introduction

The pork 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.

The U.S. Department of Agriculture's Food Safety and Inspection Service (USDA, FSIS) contracted with RTI International to develop a pork 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 (FY) 2004, the most recent year for the data in the Enhanced Facilities Database (EFD); 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 pork market categories:

- market hogs (includes barrows and gilts) and
- other hogs (includes sows, stags, and boars).

The data used to develop the model were obtained from the 2005 update of the EFD, a database of meat, poultry, and egg facilities operating in the United States; the results of a survey of the meat 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 possible future regulations affecting pork plants. In particular, estimates of the costs of proposed regulations can be developed and incorporated into the model to address FSIS's analysis needs.

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 meat and poultry 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 the poultry slaughter and processing facility-level model.

In the future, FSIS may also consider other regulations that affect the pork slaughter and processing sector. FSIS has had existing contracts with RTI to develop analytical models that will be used in a regulatory impact analysis. A facility-level model of the beef slaughter industry, a beef processing industry market model, and a poultry-sector facility-level model have been completed. 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 pork-sector facility-level model that will allow FSIS to conduct regulatory impact analyses of the new inspection system in pork 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 pork 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 pork industry.

1.3 ORGANIZATION OF THE REPORT

This report is organized as follows. Section 2 provides a brief profile of the pork slaughter industry and describes baseline conditions in the industry as well as 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 pork 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 Pork Slaughter Industry Profile

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

The pork industry has seen many changes over the past few decades, including geographical shifts, increased integration, and a more diverse product offering. Consumer demand for leaner pork over the past 30 years has pressured producers to produce lean, uniform hogs, at lower costs and with greater efficiency for the pork slaughter industry.

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

2.1 SUPPLY CHARACTERIZATION OF THE PORK SLAUGHTER INDUSTRY

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

- § Market Hogs—barrows and gilts (also may include smaller roaster pigs) and
- § Other Hogs—any hog not considered a market hog, typically hogs used for breeding (includes sows, stags, and boars).

Establishments that slaughter hogs are classified in North American Industry Classification System (NAICS) code 311611 Animal (except poultry) Slaughtering (formerly Standard Industrial Code [SIC] 2011).

In this section, we describe the production of pork through all stages, from receipt of live hogs at the packing plant to sale of pork products.

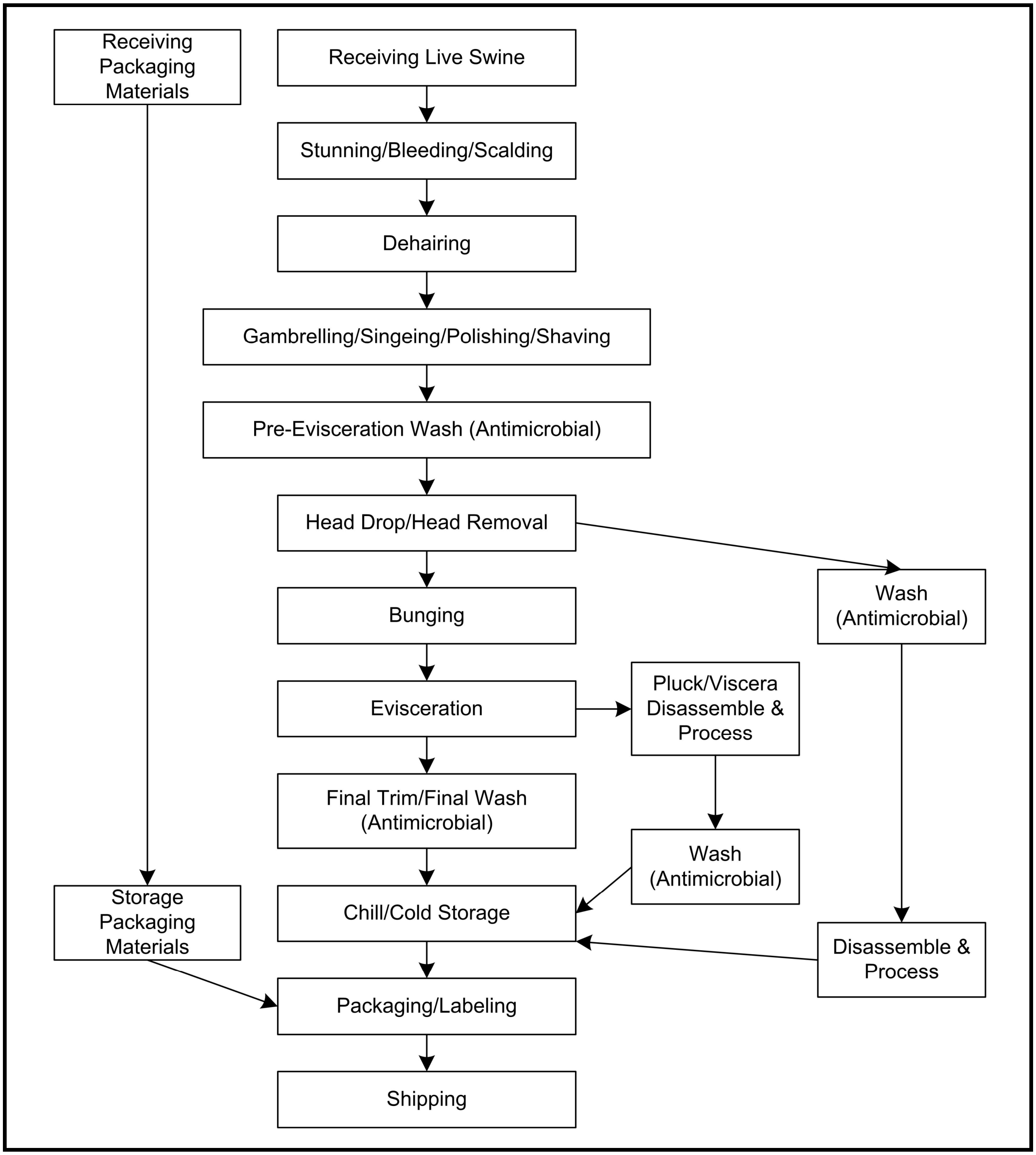
2.1.1 Stages of Production

There are three general stages of production for market hogs: farrow-to-wean stage, wean-to-feeder stage, and feeder-to-finish stage. Hogs are primarily produced by specialized operations that use separate production facilities for each stage of production (Muth et al., 2005). The length of time required for market hogs to move through all three stages is approximately 6 months.

When finished pigs reach a market weight of 250 to 290 pounds, they are shipped to a slaughter facility where they undergo antemortem inspection. Approved hogs are slaughtered, and carcasses are inspected to ensure they are fit for consumption. Figure 2-1 shows the process a typical pork slaughter facility follows. Market hogs have an average dressing percentage of 73 percent, and other hogs have an average dressing percentage of 64 percent (see Table 2-1 for the average weight of hogs at federal plants). Although some facilities only slaughter and ship whole carcasses, the majority of facilities also perform fabrication processes. These fabrication processes involve breaking the carcass into large cuts called primals and then further cutting the primals to produce subprimals and portion cuts. These smaller cuts are shipped together as boxed pork, but they still need further processing or repackaging before they can be sold to consumers. Some facilities package case-ready meats that are ready to be sold at retail. Unlike beef, pork is rarely quality graded by USDA's Agricultural Marketing Service (AMS). Rather, slaughter facilities rely on other quality measures such as lean percentage, back fat, and loin eye depth (Muth et al., 2005).

Hog production has historically been concentrated in the Corn Belt region of the United States so that hog-producing operations would be located near their feed supplies. States in this region include Iowa, Illinois, Minnesota, Indiana, and Nebraska. However, hog production has shifted over the past 15 years to states such as North Carolina, Oklahoma, Utah, and Wyoming. As hog production has shifted, so has the location of pork slaughter facilities to reduce transportation costs from farms to slaughter plants.

Figure 2-1. Process Flow Diagram: Pork Slaughter



Source: U.S. Department of Agriculture (USDA), Food Safety and Inspection Service (FSIS). September 1999. Generic HACCP Model for Pork Slaughter. HACCP-14. Washington, DC: USDA FSIS.

Table 2-1. Average Weight of Hogs at Federal Plants, 2004
The dressing percentage for barrows and gilts is more than 70 percent and more than 60 percent for sows.

Hog Type	Average Live Weight (lbs)	Average Dressed Weight (lbs)[a]
Market hogs (barrows and gilts)	267	196
Other hogs:		
Sows	491	313
Stags and boars	N/A[b]	220

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

[b]A separate value for average liveweight of stags and boars is not provided; however, the value is likely similar to the average liveweight for sows.

Sources: U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). March 2005. Livestock Slaughter 2004 Summary. Washington, DC: USDA.

U.S. Department of Agriculture (USDA), Agricultural Marketing Service (AMS). U.S. Slaughter Sow Report. Report #LS250. Washington, DC: USDA.

2.1.2 Production Inputs for Pork Slaughter Plants

The cost of live animals is the primary input cost for pork slaughter plants. As Figure 2-1 shows, live pork and packaging materials are the primary inputs to pork 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 animals represent over 74 percent of the total production cost for pork slaughter plants (Ollinger, MacDonald, and Madison, 2000). Labor accounts for 11 percent, while materials account for 8 percent and capital equipment accounts for 7 percent of plant production costs.

Table 2-2. Input Factor Shares at Pork Slaughter Plants
The cost of the live animal is 74 percent of the cost of production in pork slaughter plants.

Cost Category	Factor Share[a]
Labor	0.1121
Meat (live animal)	0.7426
Materials	0.0779
Capital equipment	0.0674

[a]Total may not add to 1.0 because of rounding.

Source: MacDonald, J., M. Ollinger, K. Nelson, and C. Handy. February 2000. Consolidation in U.S. Meatpacking. USDA/ERS Agricultural Economics Report No. 785. Washington, DC: USDA.

The facility-level model described in Section 3 incorporates production costs at the state level. Table 2-3 shows the 2004 state-level prices per hundredweight for market and other hogs. These prices were obtained directly from USDA's National Agricultural Statistics Service (NASS). The value of other hogs is the reported value for sows. In states for which prices were not reported, values were constructed by taking an average of adjacent states.

Table 2-3. Live Hog Prices by State ($/cwt), 2004

On average, market hogs were sold for approximately $135 per head and other hogs were sold for approximately $203 per head in 2004.

State	Market Hogs[a]	Other Hogs[b]
AK	53.69	45.88
AL	49.93	41.91
AR	49.28	42.80
AZ	49.08	41.08
CA	49.66	41.20
CO	49.48	42.22
CT	50.02	39.87
DE	50.14	40.09
FL	50.63	42.16
GA	51.33	42.40
HI	53.69	45.88
IA	52.47	44.52
ID	51.77	41.57
IL	53.54	40.77
IN	51.28	45.88
KS	49.37	42.83
KY	51.12	42.61
LA	48.56	39.30
MA	50.02	39.87
MD	50.38	40.54
ME	50.02	39.87
MI	48.32	39.91
MN	51.52	43.98
MO	48.09	41.78
MS	49.42	41.48
NC	52.48	42.68
ND	52.60	42.41
NE	52.74	42.58
NH	50.02	39.87

(continued)

Table 2-3. Live Hog Prices by State ($/cwt), 2004 (continued)

State	Market Hogs	Other Hogs
NJ	50.14	40.09
NM	47.88	39.76
NV	50.24	41.31
NY	50.02	39.87
OH	51.56	42.03
OK	46.32	41.26
OR	50.56	41.36
PA	49.90	39.64
RI	50.02	39.87
SC	52.48	42.68
SD	53.69	40.85
TN	50.43	42.33
TX	47.85	35.80
UT	49.88	41.27
VA	51.21	41.81
VT	50.02	39.87
WA	51.17	41.47
WI	48.52	39.70
WV	50.86	41.43
WY	52.27	41.82
Average	50.58	41.48

[a]Values for missing states for market hogs (AK, AL, AZ, CA, CO, CT, DE, FL, GA, HI, ID, KY, LA, MA, MD, ME, MS, MT, ND, NH, NJ, NM, NV, NY, OR, RI, SC, TN, UT, VA, VT, WA, WV, 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 hogs (same states as for market hogs) were constructed by averaging the values for adjacent states (AK and HI were set to the highest state price).

Notes: Values for other hogs were obtained by using the value of sows.

Sources: U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). July 2005. Barrows and Gilts: Monthly Prices Received by States, Agricultural Prices 2004 Summary. Washington, DC: USDA.

U.S. Department of Agriculture (USDA), National Agricultural Statistics Service. (NASS) July 2005. Sows: Monthly Prices Received by States, Agricultural Prices 2004 Summary. Washington, DC: USDA

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 indexes were combined into indexes for each species by multiplying each index by its factor share of production costs reported in Table 2-2. Electricity rates were used as a proxy for material costs.

Table 2-4. Labor and Energy Rates and Respective Indices and Pork Cost Index, by State, 2004
The input shares used to calculate the cost index were derived from estimates in 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)	Pork Cost Index[c]
AL	13.86	93.44	4.21	77.01	86.70
AK	17.87	120.47	8.10	148.17	131.83
AZ	12.90	86.96	5.50	100.61	92.56
AR	13.18	88.85	4.19	76.65	83.85
CA	13.99	94.31	8.53	156.04	119.62
CO	15.75	106.18	5.32	97.32	102.55
CT	16.95	114.27	8.16	149.27	128.62
DE	14.69	99.03	4.99	91.28	95.85
FL	13.68	92.22	5.86	107.20	98.36
GA	13.33	89.86	4.45	81.40	86.39
HI	17.87	120.47	13.36	244.39	171.28
ID	15.25	102.81	3.83	70.06	89.38
IL	14.93	100.65	4.73	86.53	94.86
IN	15.65	105.50	4.14	75.73	93.30
IA	16.87	113.73	4.39	80.31	100.02
KS	15.60	105.17	4.59	83.96	96.47
KY	14.83	99.98	3.30	60.37	83.74
LA	13.36	90.09	5.82	106.46	96.80
ME	17.17	115.75	3.56	65.12	94.99
MD	14.49	97.68	4.51	82.50	91.46
MA	15.84	106.78	8.49	155.31	126.68
MI	15.02	101.26	4.91	89.82	96.57
MN	15.35	103.48	4.70	85.98	96.30
MS	12.08	81.44	4.80	87.81	84.05
MO	14.82	99.91	4.39	80.31	91.87
MT	16.39	110.49	4.14	75.73	96.24
NE	15.46	104.22	4.25	77.74	93.37
NV	14.38	96.94	7.25	132.62	111.57
NH	15.54	104.76	10.04	183.66	137.11
NJ	14.76	99.50	8.67	158.60	123.73
NM	13.76	92.76	5.10	93.29	92.98
NY	15.18	102.33	6.23	113.96	107.10
NC	13.56	91.41	4.89	89.45	90.61
ND	14.10	95.05	4.20	76.83	87.58

(continued)

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

State	Hourly Wages ($/hour)[a,b]	Hourly Wage Index (Average = 100)	Electricity Revenue (Cents/ kWh)	Electricity Revenue Index (Average = 100)	Pork Cost Index
OH	14.56	98.16	4.74	86.71	93.46
OK	11.56	77.93	4.72	86.34	81.38
OR	14.98	100.99	4.25	77.74	91.46
PA	14.63	98.63	5.86	107.20	102.14
RI	13.02	87.77	8.58	156.95	116.14
SC	13.78	92.90	4.14	75.73	85.86
SD	15.45	104.12	4.60	84.15	95.93
TN	13.89	93.64	4.48	81.95	88.85
TX	14.83	99.98	5.57	101.89	100.76
UT	14.34	96.69	4.07	74.45	87.58
VT	13.40	90.34	7.93	145.06	112.77
VA	15.10	101.80	4.30	78.66	92.31
WA	15.12	101.90	3.85	70.43	88.99
WV	17.87	120.47	3.83	70.06	99.80
WI	14.83	99.98	4.91	89.82	95.81
WY	15.87	106.96	3.90	71.34	92.36
Average	14.83	100.00	5.4666	100.00	100.00

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

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

[c]The cost index was constructed using 0.59 as the weight for hourly wages and 0.41 as the weight for energy based on Ollinger, MacDonald, and Madison (2000).

Hourly wages for nondurable goods industry source: U.S. Bureau of Labor Statistics. <http://data.bls.gov/cgi-bin/dsrv?sm>.

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

The hourly wage estimates in Table 2-4 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. Assuming 2,200 hours per year,[1] the average annual and hourly wage estimates (not including benefits) for 2004 are

[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, which equals 2,200 hours per year.

- $95,000 per year ($43.18 per hour) for plant/general managers,
- $63,300 per year ($28.77 per hour) for food safety/Hazard Analysis and Critical Control Point (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. 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.

2.1.3 Production Output for Pork Slaughter Plants

The variety of pork products produced by slaughter plants has changed since the 1970s. Pork was traditionally sold as whole carcasses and then cut up by a retailer. Now, slaughter plants ship smaller cuts packaged in boxes (i.e., boxed pork), portion cuts, and case-ready pork, as well as processed and ready-to-eat (RTE) pork.

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

- pork, not canned or made into sausage
  - fresh and frozen whole and half carcasses
  - fresh and frozen primal and fabricated cuts, including trimmings
  - fresh and frozen variety meats (edible organs)
- pork, processed or cured
  - sweet-pickled or dry-cured pork (not smoked, cooked, canned, or made into sausage)
  - dry salt pork (not canned or made into sausage)
  - smoked hams and picnics (not canned)
  - smoked slab bacon
  - smoked sliced bacon
  - other smoked pork (not canned or made into sausage)
  - boiled ham, barbecue pork, and other cooked pork
- sausage and similar products
  - fresh sausage (pork sausage, breakfast links)

- dry or semidry sausage (e.g., salami, cervelat, jerky, pepperoni, summer sausage, pork roll)
- frankfurters
- other sausage, smoked or cooked (e.g., bologna, liverwurst, Polish sausage)

§ jellied goods and similar preparations (headcheese)

§ canned meats

Pork slaughter plants also produce pork by-products, many of which are important for a variety of uses. Over 80 industrial and medicinal by-products can be produced from a hog carcass. Table 2-5 details the by-products sold by pork slaughter plants.

Table 2-5. Pork By-Products and Values as Reported by USDA, 2004
Plants receive approximately $9.56 in by-product revenue for a typical market hog weighing 267 pounds and $16.84 for a typical other hog weighing 491 pounds.

By-Product	Weight (lbs of by-product/cwt of live animal)	Price ($/cwt of by-product)[a]	Value ($/cwt of live animal)
Cheek meat, trimmed	0.28	$82.54	$0.23
Chitterlings	1.26	$39.22	$0.49
Ears, square cut	0.19	$100.03	$0.19
Tongues, green, boneless, small box	0.18	$73.51	$0.13
Hearts, slashed, domestic	0.28	$33.00	$0.09
Kidneys, inedible	0.25	$6.49	$0.02
Livers, inedible	1.25	$10.93	$0.14
Melts, inedible	0.17	$4.87	$0.01
Salivary glands	0.26	$28.50	$0.07
Snouts, partial lean	0.25	$37.54	$0.09
Stomachs, scalded, small box	0.43	$65.28	$0.28
Brains	0.07	$35.31	$0.02
Lungs, inedible	0.95	$2.24	$0.02
Choice white grease	0.50	$16.52	$0.08
Pork meat and bone meal	1.50	$229.87	$0.17
Pork blood meal	1.95	$585.74	$0.57
Lard	1.72	$25.13	$0.43
Blood plasma	2.01	$20.00	$0.40
Total	13.50	—	$3.43

[a]Meat bone meal and blood meal prices are dollars per ton.

Source: Schrader, Mike, USDA Market News. June 23, 2005. Personal communication with Justin Taylor, RTI. <http://www.ams.usda.gov/LSMNpubs/meattrade/NCMTR2004.pdf>. <http://www.ams.usda.gov/mnreports/NW_LS446.txt>.

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 pork industry, the following supply elasticities are required:

- own-price elasticities of supply and
- import supply elasticity for pork products.

Estimated supply elasticities were collected from published articles. The EconLit database, Agricola, and Google Scholar Internet search engines were employed to find estimates of pork supply elasticities.

Own-price supply elasticity estimates are available from the economics literature for market hogs but not for other hogs. For elasticities that are not available, we used assumed values within the expected range of values based on the nature of the relationship between the relevant variables. Table 2-6 contains the supply elasticities used in the facility-level pork model. The own-price pork supply elasticity for pork from market hogs is 0.650, which is an average of seven short- or intermediate-run supply elasticity estimates for pork or hogs. The supply elasticity for pork from other hogs is currently set at 0.325, reflecting the notion that the supply of other hogs may be less responsive to price changes. But if FSIS desires, this elasticity can be adjusted downward or upward in the electronic model. Supply elasticities in the long run pertain to supply response over a horizon of about 10 years. Because FSIS is interested in economic impacts of a regulation on pork slaughter and processing plants in the short and intermediate runs, we used the short and intermediate run estimates to calculate the average supply elasticities for use in the model. Because there are no studies that distinguish among supply responses across plant sizes, we assumed the same supply elasticity estimate for all plant sizes.[2]

Because no estimates of import supply elasticities are available from the literature, the import supply elasticity of 1.3 for market hogs is based on the assumption that import supply is

[2] We evaluated whether plant-specific supply elasticity estimates could be derived using data used in the electronic model and parameter estimates of hog slaughter plants' cost function reported in MacDonald and Ollinger (2000). However, plausible values could not be obtained based on a preliminary exploration.

twice as elastic as domestic supply. Although the United States does not currently import other hogs, we included a default value of 1.3 in case FSIS wishes to include an assumed value for the import volume for other hogs when running the model. 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.

Table 2-6. Supply Elasticities for Pork
Elasticities of supply for pork are relatively inelastic.

Elasticity Type	Market Hogs	Other Hogs
Own- Price Supply Elasticities		
Very small	0.65	0.325
Small	0.65	0.325
Large	0.65	0.325
Import supply elasticities for pork	1.3	1.3

N/A = not applicable (value is not included in the model).

Source: Based on various published sources.

2.2 DEMAND CHARACTERIZATION OF THE PORK SLAUGHTER INDUSTRY

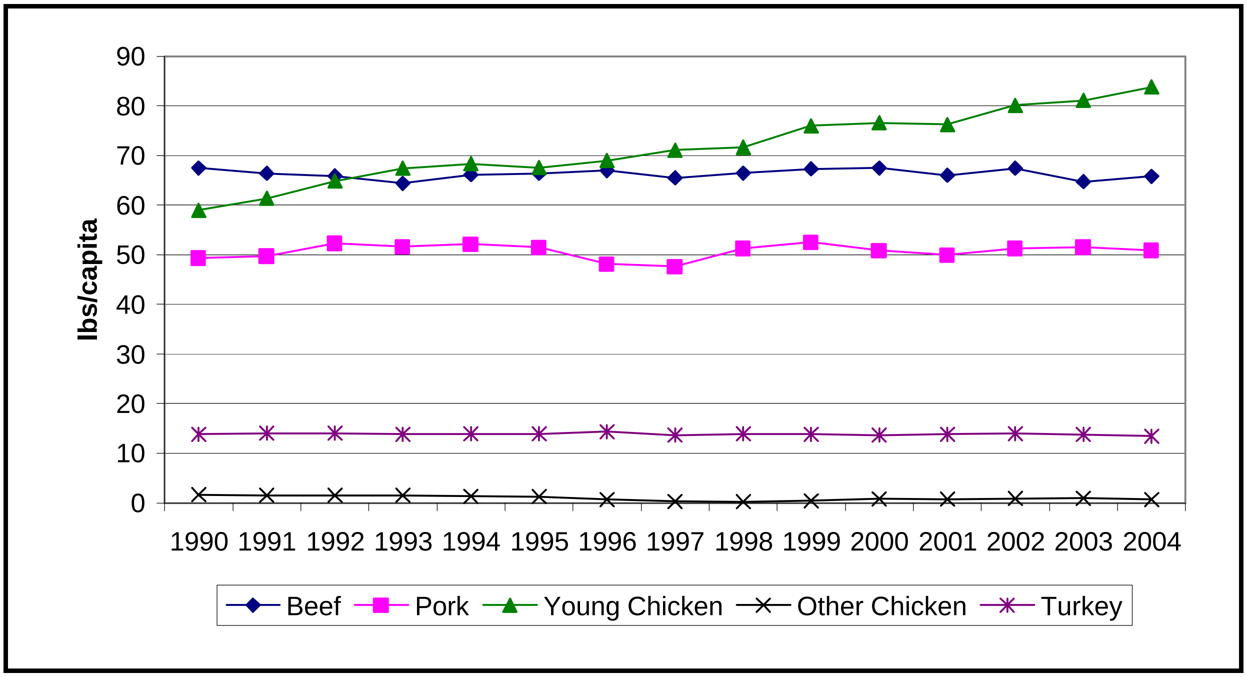
Pork is the world's most consumed meat. It accounts for 42 percent of the world's meat consumption and approximately one-fourth of meat consumption in the United States (National Pork Board, 2004). In this section, we describe consumption patterns and demand elasticities for pork.

2.2.1 Consumption

In the late 1970s, pork and beef began to lose market share to chicken (Grannis and Seidl, 1998). Figure 2-2 shows that pork consumption has fluctuated around 50 pounds per capita over the past decade. However, broiler consumption surpassed pork in 1986 despite increases in pork consumption from 45 pounds per person in the mid-1970s to almost 52 pounds currently. This increase in chicken consumption is likely due to consumer desires for healthier products. The pork industry responded by producing a leaner hog with pork that is 31 percent lower in fat and 29 percent lower in saturated fat than it was 20 years ago

(National Pork Board, 2004). According to the National Pork Board (2004), 70 percent of pork consumed in the home is processed, primarily bacon, ham, and sausage.

Figure 2-2. Per Capita Meat and Poultry Consumption, 1990–2004 (lbs)
Although pork consumption averages about 50 pounds per capita per year, pork consumption is less than beef and young chicken consumption.



[a]Boneless weight used; retail weight not available.

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

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 pork industry, the following demand elasticities are required:

- own-price demand elasticities for each pork type,
- cross-price demand elasticities between different types of pork,
- cross-price demand elasticities between pork and its close substitutes, and
- export demand elasticities for each pork type.

Pork demand elasticity estimates were identified from the economics literature for use in the facility-level pork model. Cross-price and export demand elasticity estimates were obtained in addition to own-price demand elasticity estimates (see Table 2-7). All elasticity estimates are averages of values found in the literature. However, users have the option of modifying the elasticities for each type of pork.

Table 2-7. Demand Elasticities for Pork
Elasticities of demand for pork are inelastic. The degree of substitution between pork and its close substitutes are very limited.

Elasticity Type	Pork from Barrows and Gilts	Pork from Other Hogs
Own-Price Demand	–0.636	–0.954
Cross-Price Demand		
Barrows and gilts	—	0.1
Other hogs	0.1	—
Beef demand with respect to pork price	0.045	0.045
Poultry demand with respect to pork price	–0.072	–0.072
Fish demand with respect to pork price	0.056	0.056
Export Demand	–1.819	–2.73

Sources: Based on various published articles and ERS publications (see Appendix B).

For own-price demand elasticity for pork from market hogs, we used –0.636, which is an average of 17 demand elasticity estimates for pork. For pork from other hogs, we assumed demand is 50 percent more elastic with an own-price demand elasticity of –0.954. For beef, poultry, and fish, the cross-price demand elasticities with respect to pork price are 0.045, –0.072, and 0.056, respectively. These estimates suggest that pork is a complement to poultry and a substitute for beef and fish. These cross-price effects are small in magnitude indicating limited degrees of substitutability or complementarity. Appendix B contains the values and sources for these demand elasticity estimates.

Because the economics literature does not provide estimates for the cross-price elasticity for each of the two types of pork, we assume a value of 0.1 for this elasticity, based on the fact that the intended uses vary substantially. Specifically, market hogs are used to produce primarily pork cuts while other hogs are used to produce sausage and other processed products. Note that users can modify the estimates of cross-price elasticities in the model.

For export demand elasticities, we used –1.819 for pork from market hogs, which is an average of five export demand elasticities reported in the economics literature. For pork from other hogs, we assumed export demand is 50 percent more elastic with an export demand own-price elasticity of –2.73.

2.3 INDUSTRY ORGANIZATION

Recent trends in the pork industry include higher concentration in hog production and slaughter and more vertical arrangements through the use of contracts (Muth et al., 2003). In this section, we describe some of the unique features of the organizational structure in the pork industry.

2.3.1 Company Specialization and Integration

Pork producers and slaughter facilities typically specialize in either market hogs or other hogs. Focusing on one type allows companies to standardize equipment and increase the speed of production.

Plant specialization has been facilitated by vertical integration within the industry. Integration allows processors to ensure their supply of pork by managing all phases of the production process. Pork processors have become increasingly integrated through production contracts for feeder and weaner pigs and through direct ownership of breeding stock and market hogs. According to Muth et al. (2003), Smithfield Foods and Premium Standard Farms are completely vertically integrated, owning every stage of the production process from genetic research to product packaging.

2.3.2 Number of Plants and Companies

In the United States, more hogs are slaughtered than any other type of red meat species. During FY 2004, 499 federally inspected plants slaughtered over 93 million market hogs, and 146 plants slaughtered approximately 3.5 million other hogs (see Table 2-8). In addition, 808 state-inspected plants (795 very small and 13 small plants) slaughtered some meat species in FY 2004. However, states do not provide information on the species slaughtered or the total volume slaughtered; thus, it is unknown how many hogs were slaughtered by state-inspected plants. However, the total volume of hogs slaughtered at state-inspected plants is likely to be sufficiently small that changes in these volumes would not affect market prices.

Table 2-9 shows all of the companies included in the pork facility-level model that own more than one pork slaughter plant. One of these is considered small businesses by the Small Business Administration (SBA).

Table 2-8. Plant Inventories and Slaughter Volumes for Federal Plants that Slaughtered Hogs in FY 2004
Most hog slaughter plants only slaughter barrows and gilts, but some plants also slaughter sows and boars. In addition, some plants only slaughter sows and boars.

Size	Barrows and Gilts		Sows and Boars	
	Number of Plants	Volume	Number of Plants	Volume
Very small	384	1,114,227	80	70,593
Small	86	6,008,656	62	2,924,316
Large	29	86,328,228	4	601,335
Total	499	93,451,111	146	3,596,244

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

Table 2-9. Known Companies with Multiple Pork Slaughter Plants
Eleven companies have multiple pork slaughter plants.

Company	Number of Pork Plants	Small Business Administration Classification	Employment[a]
Bob Evans Farms, Inc.	5	No	42,035
Cargill Inc.	2	No	101,000
Contigroup Companies, Inc. (owns Premium Standard Farms)	2	No	15,500
Hormel Foods Corporation	3	No	15,600
Pine Ridge Farms LLC	2	Yes	340
Sara Lee Corporation	2	No	150,400
Smithfield Foods, Inc.	8	No	46,400
Swift & Company	3	No	21,035
Tyson Foods, Inc.	7	No	114,000

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

Source: RTI International. 2004. Enhanced Facilities Database. Research Triangle Park, NC: RTI.

2.3.3 Pork 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 characteristics of pork slaughter plants, including sources of inputs, production processes, and age and different measures of the size of plants.[3] The information from the survey is useful in characterizing establishments, which can then aid in developing an economic model for estimating the effects of regulation on the industry.

Based on the results of the survey, almost all live hogs slaughtered in U.S. pork slaughter plants are from domestic sources. An estimated 88.1 percent of plants do not slaughter any imported hogs. In addition, 72.3 percent of pork slaughter plants that receive raw pork inputs do not receive any raw pork inputs from foreign sources. However, most pork slaughter plants (81.7 percent) receive or purchase some portion of their raw pork inputs from other U.S. plants. The remaining plants only process raw pork produced from hogs that are slaughtered within the plant.

In addition to slaughtering, an estimated 82.7 percent of plants grind or further process pork. Of those plants that further process, 81.8 percent do not produce RTE products, 45.3 percent produce RTE products, and 25 percent produce inputs for further processing by other plants. The mean annual production volume of raw, not ground pork products is estimated at 46.2 million pounds. In addition to raw, not ground pork products,

- 148 plants produced raw, ground pork (average 2.4 million pounds annually);
- 78 plants produced fully cooked, not shelf-stable pork (average 3.8 million pounds annually);
- 71 plants produced heat-treated, but not fully cooked, not shelf-stable pork (average 2.6 million pounds);
- 44 plants produced heat-treated, shelf-stable pork products (average 0.4 million pounds); and
- between 2 and 14 plants produced the remaining types of pork, such as thermally processed, commercially sterile and not heat-treated, shelf-stable pork.

The survey results also indicate several measures of plant size in addition to production volume. The average production space in a pork slaughter plant is 35,635 square feet, but 57.7 percent of the plants have less than 10,000 square feet. The average number of employees is 138, with 39.4 percent of pork slaughter plants having 10 to 499 employees and 6 percent of

[3] Results are from plants that slaughter at least 50 hogs annually.

plants having 500 or more. The majority of plants (70.8 percent) are in the under $2.5 million sales range category; annual sales in the remaining plants are distributed relatively evenly across the other sales categories. However, 23 pork slaughter plants have annual sales of $100 million or more. Because these 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 pork slaughter industry.

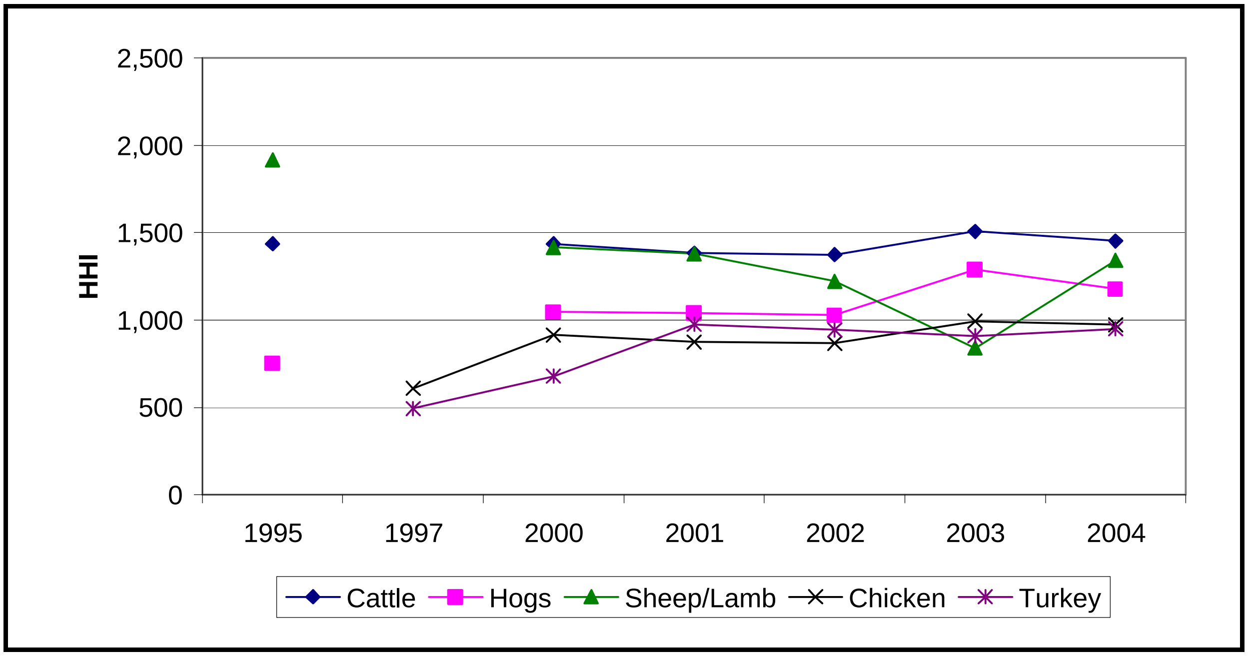
Pork slaughter plants vary widely in age. In addition, any one plant might have production areas that were built at different times. An average pork slaughter plant was built or most recently renovated in 1981, and 37.9 percent of plants were built or renovated since 1990. An estimated 64.8 percent of the square footage is 20 years old or more.

2.3.4 Market Power

Figure 2-3 shows the Herfindahl-Hirschman Indexes (HHIs) for beef, pork, lamb, chicken, and turkey. 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.

Industry concentration for hogs has been relatively stable in recent years, at a level near 1,000. Industries with an HHI below 1,000 are considered "competitive" industries by the U.S. Department of Justice. Based on the value of the HHI for the pork industry, the industry is slightly above the values for a "competitive" industry and would be classified as a moderately concentrated industry. However, economic studies to test market power have not been published for the pork industry. Thus, published information is not available to determine whether assuming perfect competition in the industry is appropriate.

Figure 2-3. HHI Values for Slaughter Facilities, 1997–2004
The pork slaughter industry is slightly over the “moderately concentrated” threshold of 1,000.



HHI = Herfindahl-Hirschman Index

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

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

2.4 MARKET-LEVEL DATA

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

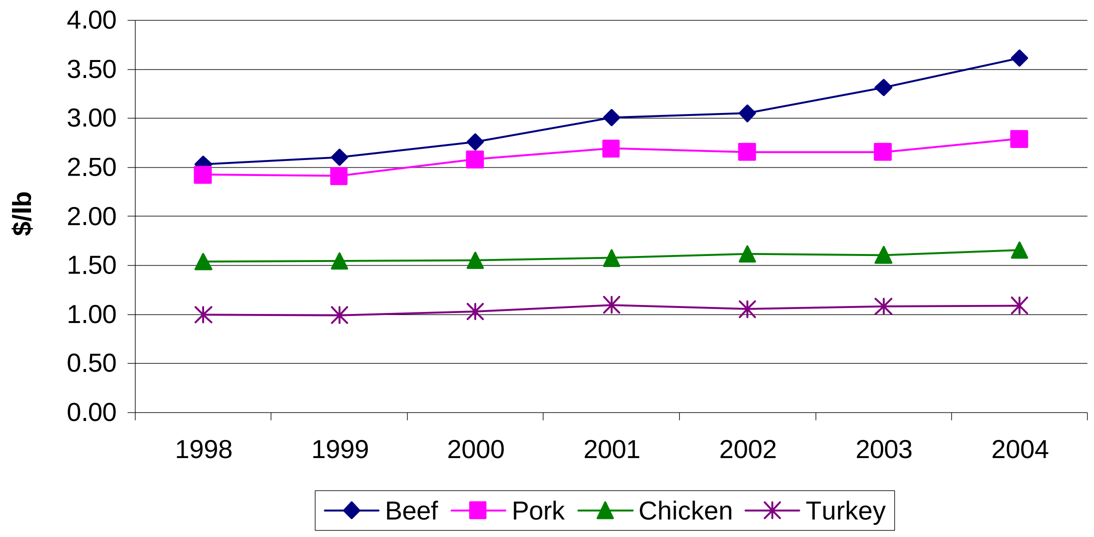
2.4.1 Prices

Pork products have consistently been less expensive than beef and more expensive than poultry on a per-pound average basis over the past 7 years. Figure 2-4 shows that the average nominal retail price for pork has risen by almost 15 percent, increasing from less than $2.43 per pound to $2.79 per pound from 1998 to 2004. In comparison, retail beef prices increased by more than 40 percent from 1998 to 2004. Adjusting the prices in Figure 2-4 for inflation indicates that real retail prices for pork rose in 2000 and 2001 but are now back at 1998 levels.

Figures 2-5 and 2-6 display input prices for the meat and poultry industries. The wholesale prices in Figure 2-5 are the prices paid by retailers and food service providers for meat and poultry products. The wholesale price patterns resemble those for retail prices in that chicken and turkey commodities have lower costs than beef; however, pork is much more cost competitive at the wholesale level. Lamb is considered a niche market product and receives higher prices at the wholesale level.

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 very evident. Prices for hogs and poultry are consistently lower than prices for cattle and lamb.

Figure 2-4. Nominal Meat and Poultry Retail Prices, 1998–2004 ($/lb)
Nominal retail pork prices have been increasing at a moderate rate over time. After adjusting for inflation, it is likely that pork prices have not risen in real terms.



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

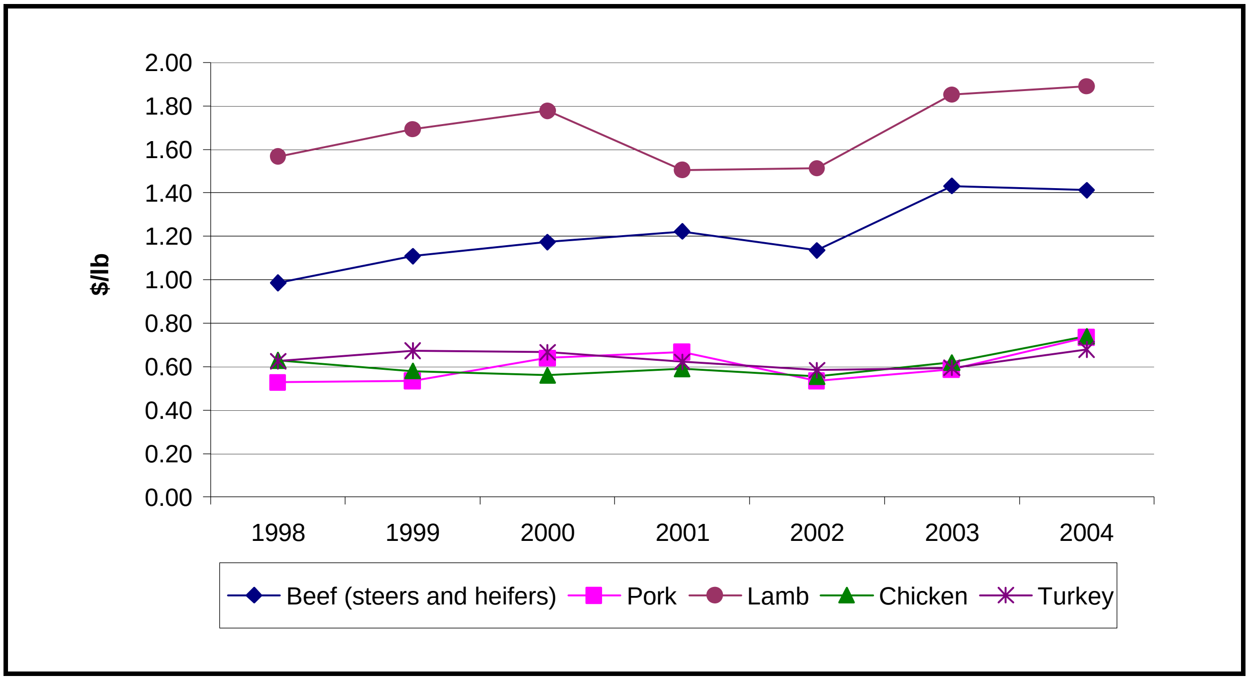
U.S. Department of Agriculture (USDA), Economic Research Service (ERS). 2005b. Livestock, Dairy, & Poultry Outlook. Washington, DC: USDA, ERS. <http://www.ers.usda.gov/publications/ldp/>.

Table 2-10 provides retail prices on the same meat and poultry commodities discussed above. These prices, obtained from scanner data from supermarkets across the country, show the same categories discussed for 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.

2.4.2 Pork Trade

The United States is the world's second largest exporter of pork, behind the European Union (USDA/Foreign Agricultural Services [FAS], 2005). Pork exports increased from over 1.3 billion pounds in 2000 to just over 2 billion pounds in 2004 (see Figure 2-7). In 2004, pork exports were valued at $2 billion (see Figure 2-8). The United States is also the world's second largest importer of pork, behind Japan. The United States tends to import more fresh or chilled pork and export more frozen pork (see Table 2-11).

Figure 2-5. Nominal Wholesale Meat and Poultry Prices, 1998–2004 ($/lb)
Pork prices are comparable to poultry prices at the wholesale level.



Sources: U.S. Department of Agriculture (USDA), Economic Research Service (ERS). 2005b. Livestock, Dairy, & Poultry Outlook. Washington, DC. USDA. <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 (AMS). 2002 National Carlot Meat Trade Review. <http://www.ams.usda.gov/lsmnpubs/meattrade/NCMTR2002.pdf>.

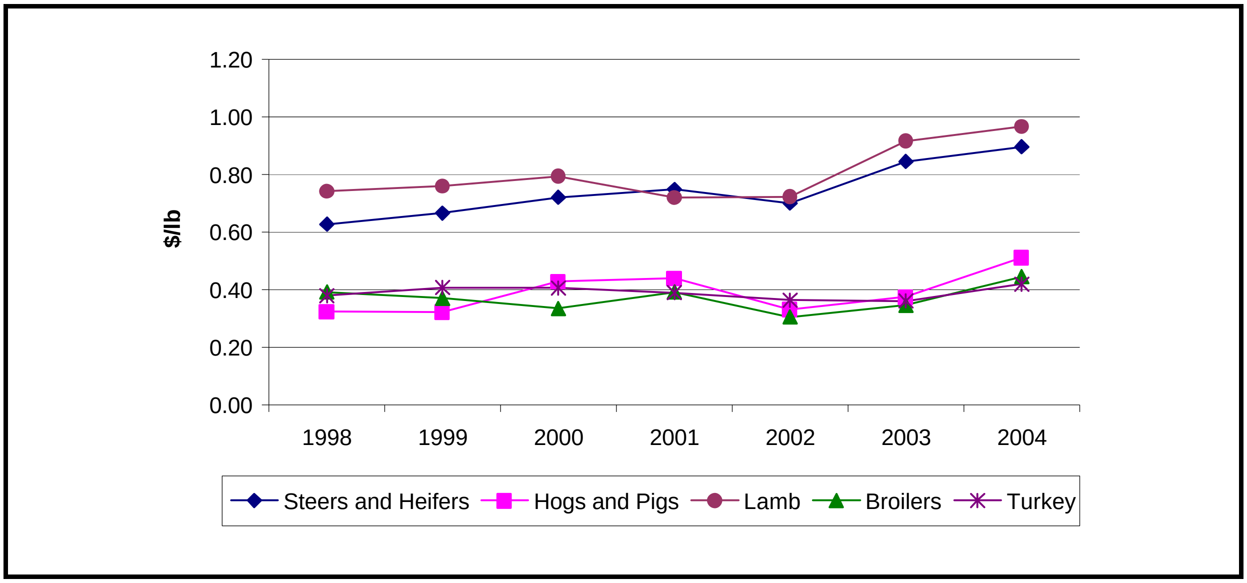
2002–2003 Beef (cows and bulls) prices from U.S. Department of Agriculture (USDA), Agricultural Marketing Service (AMS). 2003 Annual Meat Trade Review. <http://www.ams.usda.gov/lsmnpubs/meattrade/NCMTR2003.pdf>.

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

2.4.3 Model Baseline Year

The baseline year for the pork model is 2004. Using 2004 as the baseline allows us to incorporate current and complete annual data from most market sources. In addition, we are able to use the most recent facility data available from the updated EFD.

Figure 2-6. Nominal Livestock and Poultry Farm Prices, 1998–2004 ($/lb)
Hog farm prices are similar on a per pound basis to boiler and turkey prices.



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

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

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

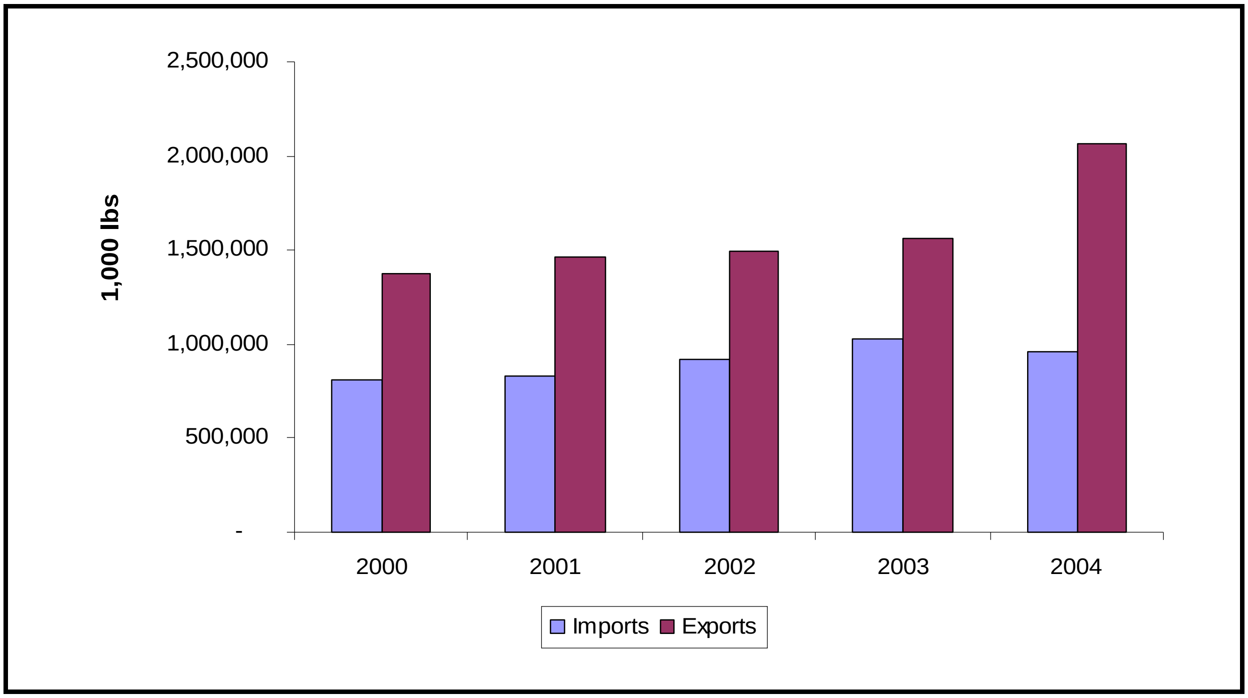
U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). 1999–2005 Poultry: Production and Value-Supplement, April edition. <http://usda.mannlib.cornell.edu/reports/nassr/poultry/pbh-bbp/>.

Table 2-10. 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

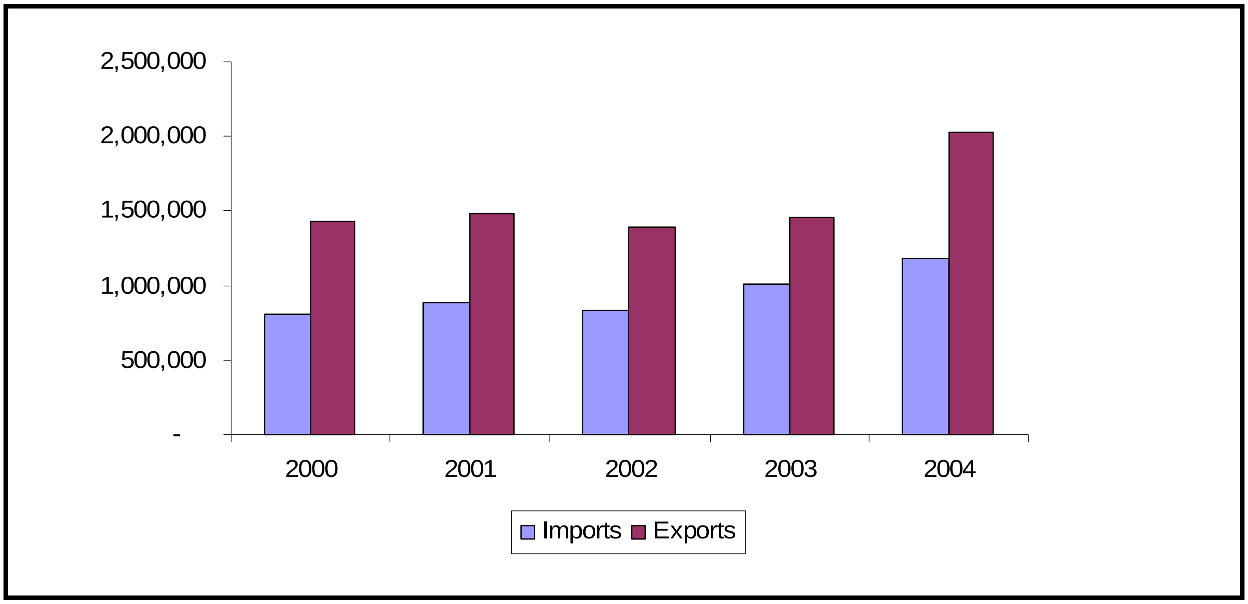
Source: U.S. Department of Agriculture (USDA), Economic Research Service (EPS). 2005c. Livestock Marketing Information Center. <http://www.lmic.info/meatscanner/ meatscanner.shtml>.

Figure 2-7. Volume of Pork Trade, 2000–2004 (1,000 lbs)
U.S. exports have increased substantially in recent years, while U.S. pork imports have increased gradually.



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

Figure 2-8. Value of Pork Trade, 2000–2004 ($1,000)
The value of U.S. pork imports and exports follows the trends in volumes.



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

Table 2-11. Volume of Pork Trade by Harmonized Tariff Schedule (HTS)-6 Code, 2000–2004 (1,000 lbs)
Most pork imports and exports comprise fresh or frozen meat, but processed pork and offal are also traded.

HTS-6 Code	Description	Imports					Exports				
		2000	2001	2002	2003	2004	2000	2001	2002	2003	2004
20311	Carcasses and half-carcasses of swine, fresh or chilled	10,014	3,695	5,734	8,342	12,407	82,756	67,131	73,922	45,064	54,776
20312	Meat of swine, hams, shoulders, and cuts thereof, with bone in, fresh or chilled	168,586	166,409	177,038	192,414	185,711	136,135	137,956	142,791	165,853	310,478
20319	Meat of swine, nesoi, fresh or chilled	327,390	359,642	427,438	445,619	389,625	269,654	308,183	306,820	337,679	429,833
20321	Carcasses and half-carcasses of swine, frozen	154	86	46	—	1	23,267	9,559	12,845	49,247	21,231
20322	Meat of swine, hams, shoulders, and cuts thereof with bone in, frozen	12,209	9,852	11,031	24,241	14,372	165,517	83,282	54,788	49,195	85,003
20329	Meat of swine, nesoi, frozen	189,254	176,755	188,272	213,221	227,531	341,636	468,466	456,141	480,891	565,866
20630	Offal of swine, edible, fresh or chilled	34,297	46,086	35,690	33,633	24,019	12,274	27,020	63,024	65,719	101,145
20641	Livers of swine, edible, frozen	64	581	57	61	284	19,185	11,021	4,708	4,190	2,122
20649	Offal of swine except livers, edible, frozen	9,084	8,960	7,550	8,537	10,290	245,998	273,780	238,884	226,348	334,639
21011	Hams, shoulders, and cuts thereof, of swine, bone in, salted, in brine, dried or smoked	3,657	2,822	4,898	3,793	2,883	10,922	18,320	15,257	19,961	17,248
21012	Meat of swine, bellies (bacon, etc.), and cuts thereof, salted, in brine, dried or smoked	47,850	43,259	44,205	72,185	66,346	38,438	29,879	39,153	39,457	46,494
21019	Meat of swine, nesoi, salted, in brine, dried or smoked	10,428	14,791	19,044	24,821	21,601	28,521	30,471	84,441	77,322	93,317

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 (EIA) methodology incorporates market-level data, facility-level data, and compliance cost estimates into a modeling framework based on microeconomic theory.

Pork 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 or altering their input mix. The impacts of these adjustments on equilibrium prices and quantities will result in 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 as well as the underlying economic theory.

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

[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.

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 pork 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

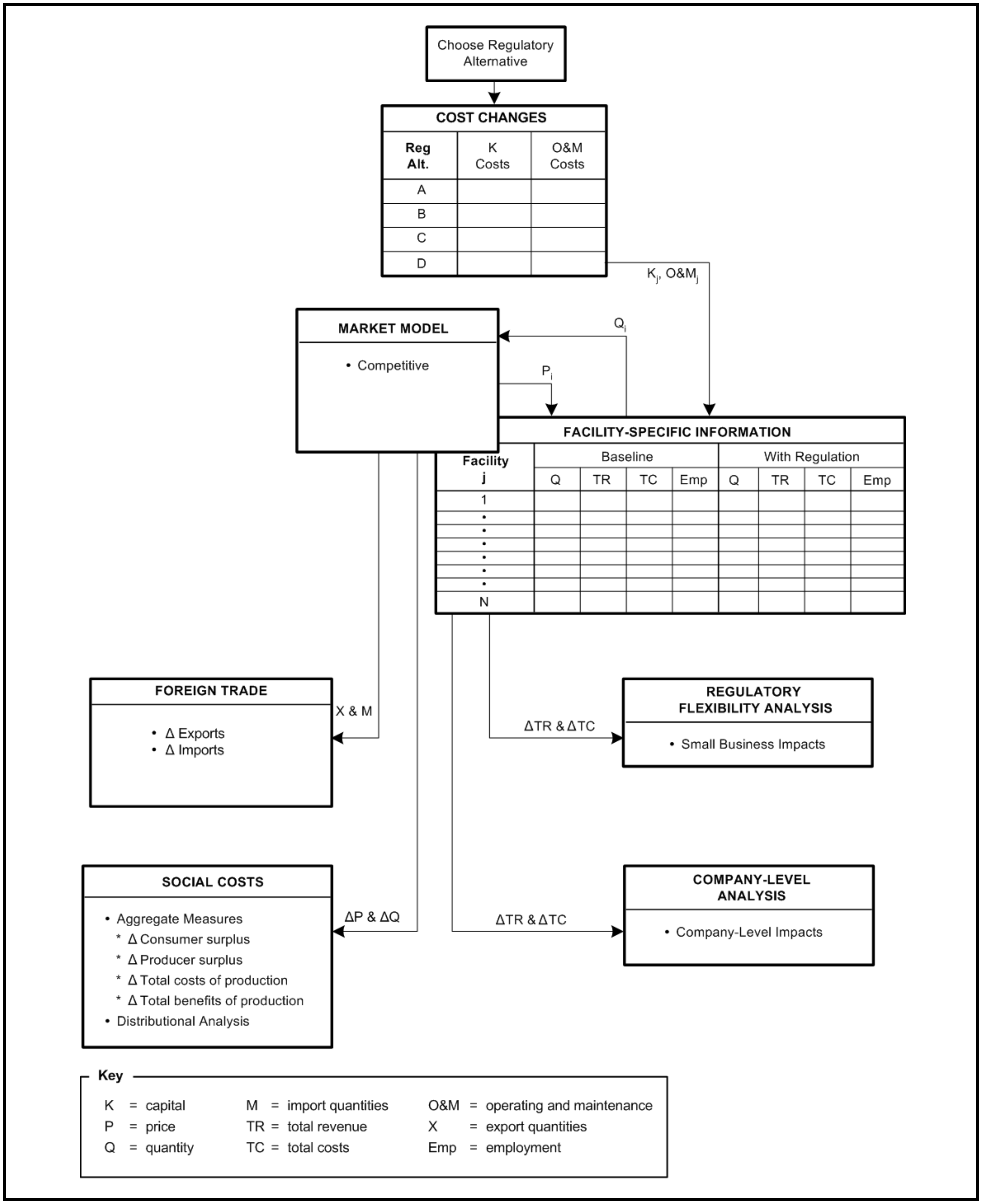
- enter estimates of capital and other one-time costs by size of plant and type of pork slaughtered,
- enter estimates of ongoing costs by size of plant and type of pork slaughtered, and
- designate “affected” plants (for some or all types of pork slaughtered) that are either required to implement changes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

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 model is flexible enough to allow for both positive and negative ongoing cost savings depending on the nature of the regulation. For example, a particular regulation might allow plants to achieve ongoing cost savings, after making necessary capital equipment investments, because labor costs are reduced or plant throughput increases.

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

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.



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-Level 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-Level 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 for impacts broken down by company size.
- **Market-Level 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-Level 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, implementing regulations affecting the industry affects the costs of production. 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 provides a description of 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.

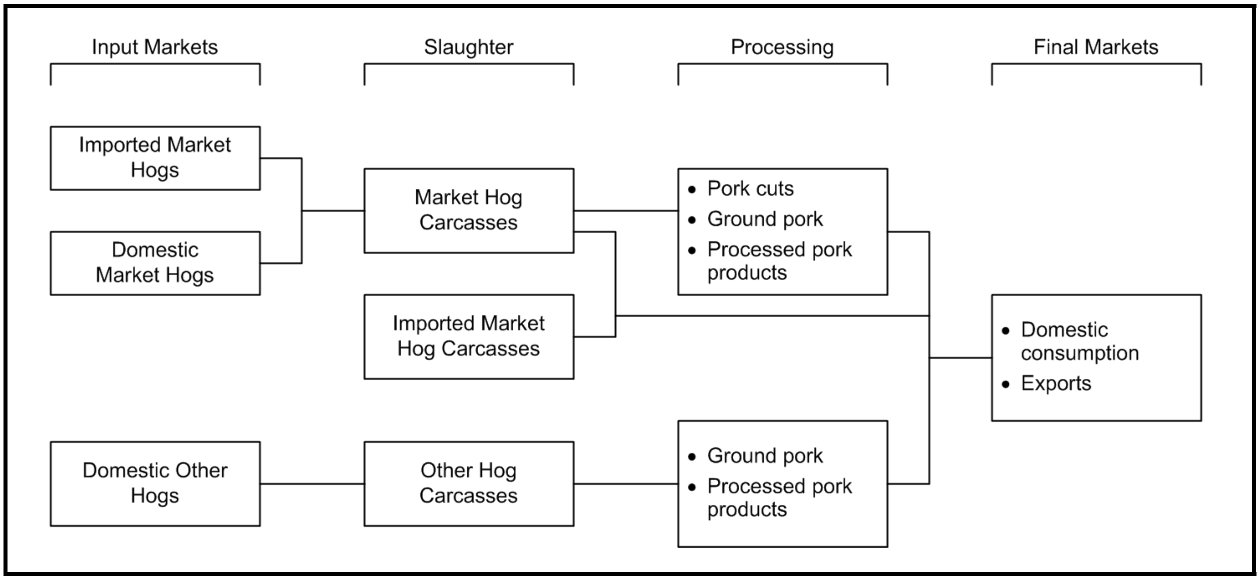
For the purposes of the model, the primary products of the pork slaughter and processing industry were divided into two primary markets:

- pork produced from market hogs (barrows and gilts) and
- pork produced from other hogs (sows, boars, and stags).

As described in Section 2, there are important differences between 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 pork inputs and pork product

[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.

Figure 3-2. Market Linkages in Pork Production
Pork slaughter is divided into two separate markets in the modeling approach.



Note: A small percentage of hogs are marketed as "roaster" hogs prior to reaching typical market weight.

consumption. The model focuses on production of carcasses as the primary output, as an intermediate output, or as a final output, of pork slaughter establishments.

Although the markets for each type of pork product are assumed to be different, pork 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 pork 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.

Although both markets have their own equilibrium price and quantity in the model, there are some linkages between them. Because there is some substitution between these 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 pork products by buyers in response to relative price changes, which is important for addressing net impacts on the pork slaughter and processing industry.

There may also be some substitution of other products (e.g., beef, poultry, seafood) for pork products. The benefits to producers of these alternative protein sources would partially offset costs to the pork industry in terms of net welfare changes associated with regulations on the pork industry. In addition, increasing demand for pork substitutes would increase prices in those markets and would have feedback effects on the demand for pork. However, inclusion of these substitution effects with feedback effects on pork prices and quantities would likely have little effect on model results for this regulation, but would substantially complicate the model. Nevertheless, the current model accounts for effects of changes in pork price relative to other meat prices on the quantities demanded for other meats, but not the feedback effects on pork prices and quantities.

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 reflect these 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.

The pork slaughter and processing industry is moderately concentrated, but profits remain relatively low. In contrast to the beef slaughter industry, empirical studies measuring the degree of market power in the pork industry have not yet been published in refereed journals. However, a recent study by Vukina et al. (2007) found statistical evidence of market power in live hog procurement, and thus the model may need to be modified in the future if additional empirical research finds evidence of market power in the pork industry. The current model assumes that prices and quantities are determined in perfectly competitive markets based on the intersection of the market supply and demand curves. Under this condition, buyers and sellers take the market output price as given when making their production and consumption choices.

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

3.2.2 Supply Relationships in the Pork 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. Pork slaughter facilities augment fixed factors of production (e.g., plant and equipment) with variable factor inputs (e.g., materials and labor) to produce pork product outputs. These fixed factors are the source of diminishing marginal returns, hence increasing marginal costs. Therefore, each supply segment (pork products from market hogs and other hogs) 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).

In addition to impacts on domestic producers, regulation of the U.S. pork slaughter industry will have impacts on foreign producers. Foreign imports would tend to become more attractive to U.S. consumers if imported pork products become cheaper relative to domestic pork products because of higher regulatory costs in the United States. Likewise, foreign imports would tend to become less attractive to U.S. consumers if domestic pork products become cheaper relative to foreign products because of lower production costs in the United States. A single supply curve was used to represent total imports supplied by all foreign producers in each 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 relates the quantity of a good supplied as a function of its price and other factors, such as the price of inputs, the price of substitute outputs, and technological factors. Because of data and resource limitations, factors other than the product's price are held constant. 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. 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. Thus, the change in market supply in response to price 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 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.

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 divided by the percentage change in price. The larger the supply elasticity, the more responsive firms are to changes in market price. Empirical estimates of the domestic supply elasticity for pork are available in the economics literature, but published import supply elasticities are not available.[3] For the domestic supply elasticity for pork from market hogs, we used a value of 0.65, which is an average of seven values available from the economics literature. For pork from other hogs, we assumed its supply is less responsive to price changes, and we used a value of 0.325. For the import supply elasticity for pork from market hogs, we used a value of 1.3, which is twice the value of the domestic supply elasticity. We assumed that pork from other hogs is not imported. If desired, users may alter these default values and also indicate separate estimates for the domestic supply elasticity for very small, small, and large plants.

3.2.3 Demand Relationships in the Pork 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

[3] Because the live hog input is assumed to be used in fixed proportions to pork 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 hogs. Thus, these supply elasticities reflect the proportionate change in quantity supplied for a change in net price.

these choices change in response to higher prices resulting from regulation, holding nonprice variables constant. The domestic demand equation accounts for cross-price effects between the outputs modeled, as mentioned above. Export demand for each of the outputs was modeled as a function of own-price only.

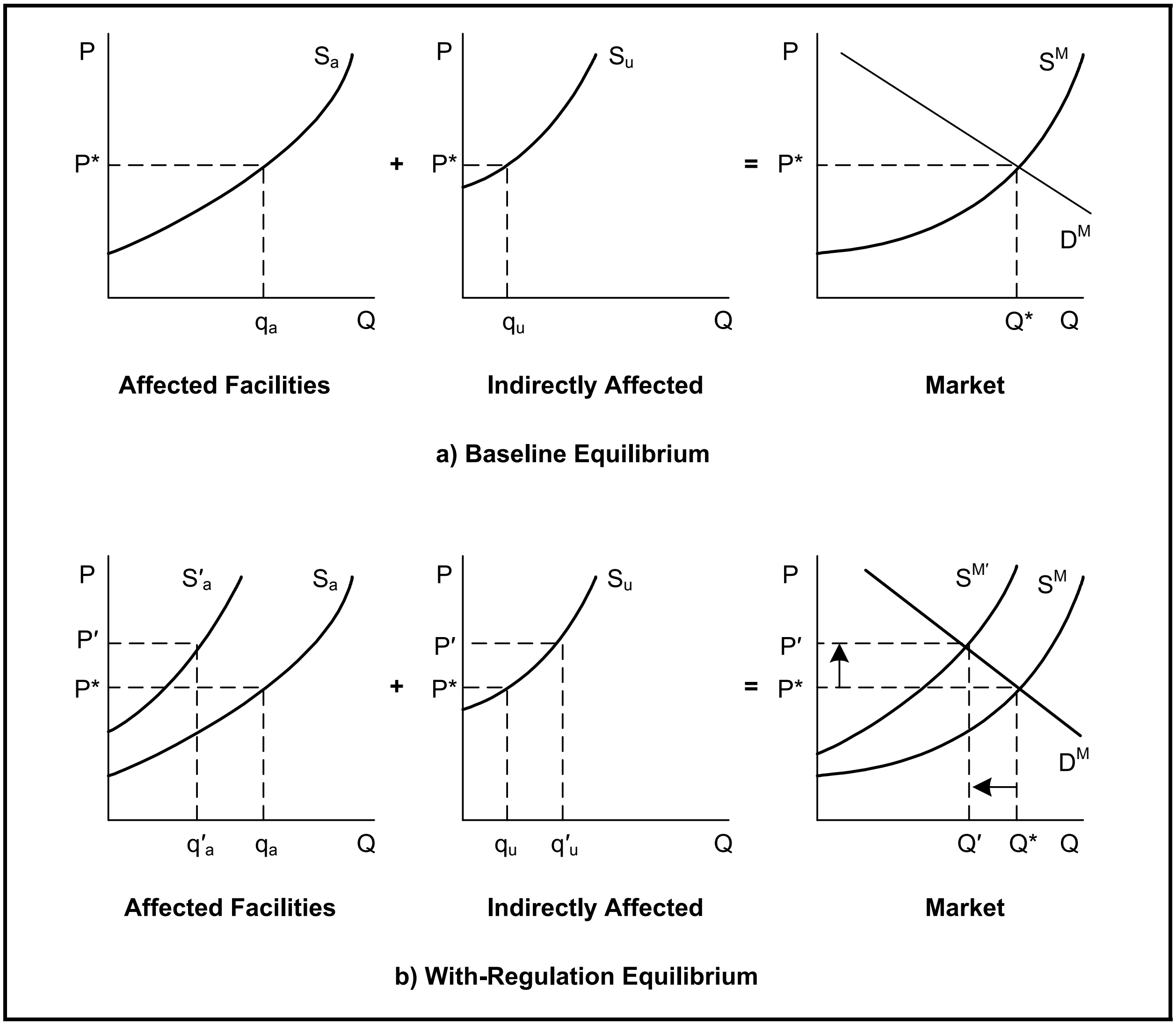
The model assumes downward-sloping demand curves in all output markets (i.e., the quantity demanded of a good falls when its price rises), consistent with the law of demand. Thus, increases in the prices of pork products due to regulation are expected to result in a decrease in consumption, everything else being equal. For the demand elasticity for domestic pork from market hogs, we used an estimate of –0.636, which is an average of 17 elasticity estimates available in the economics literature. For the demand elasticity for exported pork from market hogs, we used an estimate of –1.819, which is an average of five elasticity estimates found in the economics literature. For pork from other hogs, we assumed that both domestic demand and export demand are 50 percent more responsive than those for pork from market hogs. Therefore, the domestic and export demand elasticities for pork from other hogs are set at –0.95 and –2.73, respectively. For the cross-price elasticity of demand between pork from market hogs and pork from other hogs, we used a value of 0.1. If desired, model users can alter any of these default values.

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 is 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,

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.



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.

Facility-level supply shifts include both one-time or capital equipment costs and ongoing annual costs and are applied to each plant depending on its size. In the case of regulatory cost increases, the market supply curve shifts upward from S^M to $S^{M'}$, 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 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.

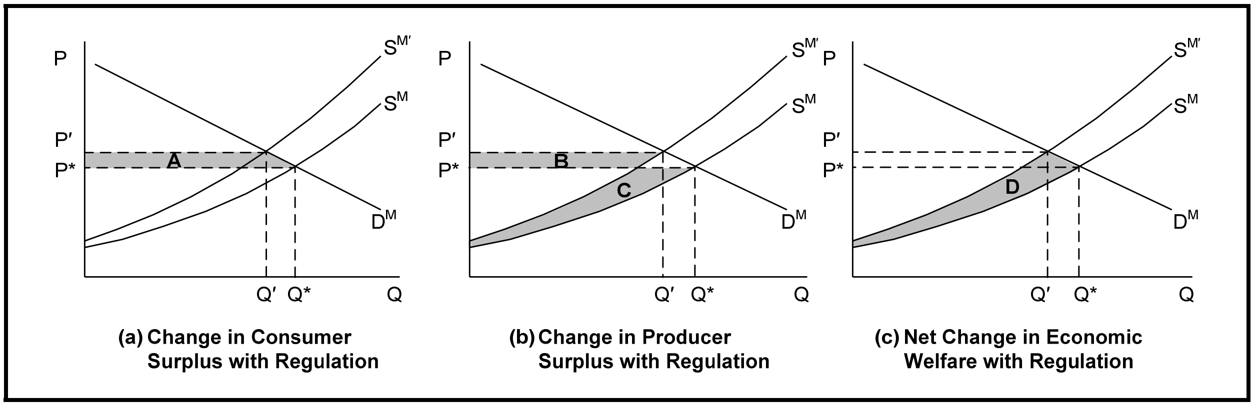
3.2.5 Social Costs

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. Producer surplus 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 measure does not reflect the benefits that accrue to pork product consumers from increased food safety. Previous studies (e.g., Piggott and Marsh [2004]; Marsh, Schroeder, and Mintert, [2004]) have shown that negative food safety information affects consumer demand for meat by shifting the demand curve for the implicated meat species downward. If consumers' perception of pork quality is improved after the new regulation is implemented, the welfare cost implied in Figure 3-4 would be overstated. In Section 3.3, we show how perceived quality improvement, if any, could be incorporated into the operational model.

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



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. pork 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 EFD when this task was initiated.

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 equilibrium could also be done using linear algebra. This tends to be more efficient when the supply and demand 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 two pork products (pork from market hogs and pork from other hogs), as described in Section 3.2.1.
2. Collect baseline data to characterize each of the plants that slaughter pork (and the companies that own them) using EFD and a variety of secondary sources (see Section 2).
3. Develop a mathematical simulation of baseline production data in key markets based on construction of facility-level marginal cost curves that are derived from

a Generalized Leontief profit function and consistent with expected responsiveness to changes in prices.[4]

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 pork 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 accompanied 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.
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 or demand 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.

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

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 hogs for facility i based on state
A	Affected production (incur compliance costs)
c_i	Per-carcass equivalent cost of compliance
D	Demand
Dom	Domestic
I	Facility index
I_i	Cost index for facility i based on state
M	Imports
MH	Market hogs
n	Number of establishments
OH	Other hogs
NP	Net price, equal to output price per hog carcass (P) minus the cost of the live hog (a_i)
q	Submarket quantity (facility-level output on import supply) in carcass-equivalent units
Q	Market quantity in carcass-equivalent units
S	Supply
U	Unaffected production (incur no compliance costs)
X	Exports

3.3.1 Domestic Supply of Pork Products

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

$$Q^{S_j} = q_{dom}^{S_j} + q_M^{S_j} = \sum_{i=1}^{n} q_i^{S_j} + q_M^{S_j}, \quad j = MH, OH, \qquad (3.1)$$

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; MH represents market hogs; and OH represents other hogs.

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 there is insufficient facility-level data to econometrically estimate these functions, we instead calibrated facility-level supply functions to match baseline production simulated by the model to observed production. 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 is the commonly used Generalized Leontief profit function, from which the supply function can be derived.[5] We assumed a Leontief, fixed-proportion relationship between the hog input and the processed pork output (i.e., each processed pork output requires one live hog 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 hog 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 pork product j and a_i^j is the cost of live hogs for facility i. We then assumed that the variable

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

proportions inputs combine with the live hog 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 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:

$$\pi_i^j = \gamma_i^j NP_i^j + \beta_i^j \sqrt{I_i^j NP_i^j} + \theta_i^j I_i^j, \quad j = MH, OH, \qquad (3.2)$$

where P^j is the output price for pork product j; a_i^j is the price of live hogs used to produce product j at facility i (based on 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.

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:

$$q_i^j = \frac{\partial \pi_i^j}{\partial NP_i^j} = \gamma_i^j + \frac{\beta_i^j}{2}\left[\frac{I_i^j}{NP_i^j}\right]^{\frac{1}{2}}, \quad j = MH, OH, \tag{3.3}$$

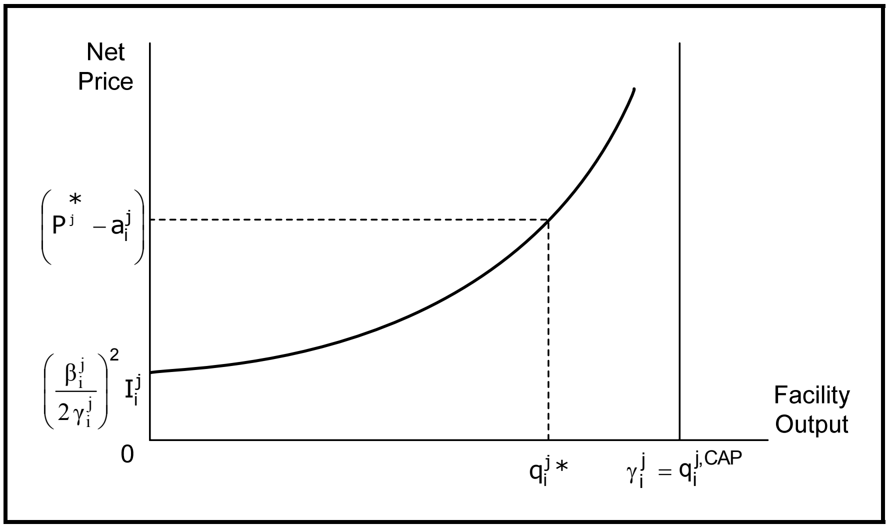
where q_i^j is the number of hogs for output market j that are slaughtered by facility i. The theoretical restrictions on the model parameters to ensure upward-sloping supply curves are $\gamma_i^j \geq 0$ and $\beta_i^j < 0$.

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 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 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

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

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.



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

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

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

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

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

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

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 2-6)[6] 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.[7] This parameter does not affect the facility's production responsiveness to price changes (unlike the β parameter). Thus, the parameter γ_i^j is used to calibrate the model so that each facility's supply equation replicates the baseline production data for that facility using the formula

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

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

3.3.2 Foreign Supply of Pork

Unlike domestic supply, which will incur the majority of the direct regulatory impacts and for which there are sufficient data to use a facility-level specification, foreign supply of pork was 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, pork 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

[6] 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.

[7] 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.

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.

The import supply function was characterized using a Cobb-Douglas functional form defined as

$$q_m^j = \mu_m^j \left(P^j\right)^{\varepsilon_m^j}, \qquad (3.8)$$

where q_m^j is the carcass-equivalent 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 that calibrates the supply function for each product to replicate the observed level of imports in the baseline.[8] The Cobb-Douglas function (3.8) has a constant elasticity of supply regardless of price.

3.3.3 Domestic Demand for Pork

Domestic demand for pork 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 curve 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.

In general, it is difficult to empirically quantify changes in consumer perception of food safety, if any, following a regulatory change. Existing econometric estimates of food safety elasticity of demand in the literature indicate that consumer reaction to food safety events in the United States may be limited. Marsh, Schroeder, and Mintert (2004) studied the impact of FSIS meat product recalls on U.S. meat consumption. They found that FSIS meat recalls negatively

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

affected demand for beef and pork, but the economic significance of these impacts is very small. The own-recall elasticity of pork demand is −0.004389 in the long run, meaning that a 1 percent increase in the number of FSIS pork product recalls will reduce pork demand by 0.004389 percent. Based on this empirical evidence, it may be conjectured that consumer response to improved pork product quality due to a regulation may be small in magnitude.

The demand functions are specified in such a way that the user can impose a percentage change in pork demand as a result of a proposed new regulation. The percentage is determined by the user but is bounded between ±15 percent to ensure that the empirical specification of the supply curve intersects the empirical specification of the demand curve. The domestic demand equations account for a potential increase in pork demand resulting from a new regulation, as well as the conventional cross-price effects between pork from market hogs and other hogs. The demand functions are specified as

$$q_{dom}^{D_{MH}} = (1 + \alpha^{MH})\tau_{dom}^{MH}(P^{MH})^{\eta^{MH}}(P^{OH})^{\eta^{MH,OH}} \tag{3.9}$$

$$q_{dom}^{D_{OH}} = (1 + \alpha^{OH})\tau_{dom}^{OH}(P^{OH})^{\eta^{OH}}(P^{MH})^{\eta^{OH,MH}} \tag{3.10}$$

where $q_{dom}^{D_j}$ is domestic demand for pork from market hogs (MH) and other hogs (OH); the τ parameters are multiplicative calibration factors; 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[9]; the α parameters are factors bounded between ±15 percent used to simulate a demand increase as a result of a new regulation. In the baseline, the α parameters are set to 0.

3.3.4 Export Demand for Pork

Similar to domestic demand, export demand for pork is expressed using a Cobb-Douglas functional form as follows:

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[9] 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.

$$q_X^{D_j} = \tau_X^j (P^j)^{\eta_X^j} \qquad (3.11)$$

where $q_X^{D_j}$ is the carcass-equivalent 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 that calibrates the demand function for each product to replicate the observed level of baseline exports through backsolving Eq. (3.11) 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 because of a lack of data on cross-price elasticities. Also, these products are likely to be destined for different regions of the world and may not be very substitutable for one another within a given 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 pork 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 pork as follows:

- Wholesale prices per pound for **pork from market hogs** was obtained from the U.S. Census Bureau's *Animal (Except Poultry) Slaughtering: 2002* (U.S. Census Bureau, 2004) by dividing the total value of product shipments by the total quantity for NAICS 311611A121, Fresh and Frozen Pork Primal and Fabricated Cuts (including trimmings), Not Canned or Made into Sausage, made in slaughtering plants.
- The wholesale price per pound for **pork from other hogs** is not available in published sources and thus was derived by finding the minimum price that would allow all establishments that slaughter other hogs to have nonnegative profits in baseline.
- The wholesale price per pound for **pork by-products** was obtained from the AMS (Schrader, 2005).

Wholesale values representing the total value derived from a hog by pork slaughter and processing facilities are included in the model assuming a national market for pork. These wholesale values are constructed by adding (1) the wholesale value of pork obtained from each hog (wholesale price per

Table 3-2. Market-Level Inputs for the Pork Facility-Level Model, 2004 Baseline
Baseline values in the model were obtained from published data sources.

	Market Hogs (YC)	Other Hogs (OC)
Wholesale Values		
Wholesale price ($/lb)	$0.87	$0.79
Average dressed weight (lb)	196	313
By-product price ($/lb)	$0.03	$0.03
Average by-product price ($/lb)	36	66
Constructed wholesale price	$171.77	$249.56
Wholesale Quantities		
Pork imports (lb)	955,070,454	—
Pork imports (carcass equivalent)	4,872,808	—
Pork exports (lb)	1,855,936,537	206,215,171
Pork exports (carcass equivalent)	9,469,064	658,834
Farm Values		
Average liveweight	267	491

Note: Unit of analysis = 1 hog (carcass equivalent).

Sources: U.S. Census Bureau. December 2004. *2002 Economic Census: Pork Processing*. EC02-311-311611 (RV). Washington, DC: U.S. Census Bureau.

U.S. Department of Agriculture (USDA), Agricultural Statistics Board, National Agricultural Statistics Service (NASS). March 2005. *Pork Slaughter: 2004 Summary*. Mt An 1-2-1(05)a. Washington, DC: USDA.

U.S. Department of Agriculture (USDA), Economic Research Service (ERS). 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.

pound for pork times the average dressed weight for each type of pork obtained from *Livestock Slaughter 2004 Annual Summary* [USDA, NASS, 2005]) and (2) the value of by-products (wholesale price per pound for by-products times the average by-product weight obtained from *Weekly USDA By-Product Drop Value (Hog)* [USDA, AMS, 2005]).[10]

Farm values representing input prices paid by pork 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 liveweight hog in the state in which the plant is

[10] The by-product weight reported by AMS represents market hogs. To calculate the by-product weight for other hogs, we multiplied the same proportion (by-product weight/live weight) by the live weight for other hogs.

located. We constructed these farm-level values by multiplying each state-level farm price per pound for hogs in each market by the average liveweight for each type of hog. These state-level farm prices, which are listed in Table 2-3, were multiplied by the average live weight in *Livestock Slaughter: 2004 Summary* (USDA, NASS, 2005) to calculate state-level farm values per carcass.

We calculated the **market volumes** by type of pork by adding up individual facility slaughter volumes from the Animal Disposition Reporting System (ADRS) as reported in the EFD. Pork **import and export volumes** (total pounds) were obtained from the U.S. International Trade Commission's online DataWeb. Because pork imports and exports are not identified separately by pork from market hogs versus pork from other hogs, we assumed that all pork imports are derived from market hogs, and 90 percent of pork exports are derived from market hogs (with the remainder of exports derived from other hogs). Pounds of imports and exports were converted to a carcass-equivalent basis by dividing volumes by average dressed weight per hog.

After developing the supply and 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 pork products modeled. In addition, we calculated a miscellaneous cost component for each facility as a percentage of the total variable cost (animal, labor, and material costs). This percentage is calculated to be 7.2 percent based on MacDonald and Ollinger (2000). Specifically, it is the ratio of capital cost to the sum of animal, labor, and material costs reported in Table 2 of MacDonald and Ollinger (2000). These calibrated functions represent the baseline scenario in the market prior to implementing the regulation.

Establishments in the model are classified as small or large businesses based on the 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 311611 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 pork 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 pork 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 (preregulation) 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

After implementation of a regulation, production costs will change for affected slaughter facilities. The model applies the compliance cost shifts to the domestic supply curves developed for each facility, leading to a new market equilibrium by simulating economic decisions of producers and consumers in the market.

Facility responses and market adjustments can be conceptualized as an interactive feedback process. Facilities face increased production costs because of 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 interactions between producer and consumer responses and market adjustments until a stable market price arises where total market supply equals total market demand for all pork 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 pork products for each category of facility is calculated separately. The annual compliance costs estimated for each product produced at each 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

$$q_i^{j,A} = \gamma_i^j + \beta_i^j \left[\frac{I_i^j}{(P^j - a_i^j) - c_i^{j,A}} \right]^{\frac{1}{2}} \quad (3.12)$$

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 found a new equilibrium price and quantity for the two pork 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. (3.12).
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. Excess demand exists at the initial equilibrium price.
3. Determine new prices using a price revision rule, similar to the one described in Kimbell and Harrison (1986). Prices increase when excess demand exists, decrease when excess supply exists, and remain unchanged when supply and demand are equal based on the following calculation:

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

   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. (3.8) for import supply, and Eq. (3.12) for affected domestic facilities, and compute market demand in each market using Eqs. (3.9), and (3.10) for domestic product demand and Eq. (3.11) 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

[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 toward 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 toward a solution.

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 simultaneously, reopen all facilities that closed under Step 5 and determine a new set of prices (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, as described 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 changes 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:

$$\Delta EMP_i^j = EMP_i^j \Delta q_i^j \, , \tag{3.13}$$

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 Walrasian auctioneer, result in a new postcompliance equilibrium with new prices and quantities for these two 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:

$$\Delta PS_j = \sum_i \pi_i^j \, . \quad (3.14)$$

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:

$$\Delta CS_j = -q_{dom}^{D_j} \Delta P^j + 0.5 \Delta q_{dom}^{D_j} \Delta P^j \, . \quad (3.15)$$

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 examination enables an assessment 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 Pork 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; 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 pork slaughter facility-level model is a stand-alone program and thus can be run directly from a diskette or hard drive. The model contains a characterization of the pork slaughter and processing industry for the baseline year 2004 and allows users to 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.

The model was developed in Microsoft Excel with Visual Basic components. It contains 12 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,[1] 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)
- Control Costs—displays individual facilities included in the model and their compliance cost estimates
- Cost Index—displays the production cost index by state for each pork 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
- Defaults—stores the default data for the model

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

4.2 RUNNING THE MODEL

To run the pork slaughter facility-level model, open the Excel file Pork 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.

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

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

Step 1: Set Model to Baseline

To start using the model, you must first ensure that the model is set to the baseline. This step resets the model to baseline conditions without any imposed compliance costs. To set the model to baseline

§ Click the Set to Baseline button.

§ When the pop-up window indicates that the model is in baseline, click OK.

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 pork 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 pork markets.

- View Affected Products—allows the user to view or modify plant sizes and pork 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 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 pork 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 values are achieved through more efficient operations).

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

Note that all tabs that allow user inputs have a Restore Defaults button if you need to reset.

- 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 hogs slaughtered.
  - If some types are not affected by the regulation, you can click on the ü for the type under Affected Product. Clicking on the ü will change the cell to empty; therefore, the model will not include slaughter volumes for that type when calculating per-unit capital costs or impose compliance costs for that type. Note that you can designate whether each type 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 pork.
- 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. The model will automatically populate the individual compliance cost estimates for each establishment in the Control Costs tab.
- § If some facilities are not affected by the regulation, click the hyperlink Go to Control Costs.
  - – For each facility not affected by the regulation, change the 1 to 0 in the Affected Plant/Product column.
  - – Click the hyperlink Return of 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 Control Costs or click on the Control Costs tab 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 pork 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: Enter Demand Shifts (Optional)

If you desire, you may specify the percentage change in consumer demand for pork from market hogs and from other hogs due to the proposed regulation. The user-supplied percentage change is bounded between ±15 percent to ensure model convergence (see Section 3.3.3 for formulas for demand shifts). To enter demand shift estimates:

- § Click the View Demand Shifts button on the interface.
- § Enter percentage increases or decreases in demand for market hogs and other hogs.
- § Click the hyperlink Return of Interface and go to Step 5 below.

Step 5: Run the Model

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

- § Click the Run Model button.

§ When the pop-up window appears indicating the model has reached equilibrium, click OK.

Step 6: 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's name on the Interface screen or

§ Click on the EIA Tables tab.

Instructions for printing or saving results are provided in Section 4.3.

4.3 MODEL RESULTS

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

1. Baseline Characterization of U.S. Pork 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
9. Summary of Secondary Effects of Regulation on Consumption of Key Substitutes: 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 4-9). 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. Table 4-1 presents baseline data for all pork markets combined, and Table 4-2 presents a comparison between baseline values and with-regulation values by pork type. Table 4-3 presents a summary of national impacts in market terms, and Table 4-4 presents a summary in consumer and producer terms. Tables 4-5 and 4-7 present results by size of business and can be used in addressing the requirements of SBREFA, which mandates analysis of regulatory impacts on small businesses. Tables 4-6 and 4-8 present results by HACCP plant size (very small, small, and large). Table 4-9 summarizes the secondary effect of the proposed regulation on consumption of substitute products.

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. Pork Market: 2004

	Market Hogs	Other Hogs
Market Price ($/CE) [a]	$171.57	$249.56
Market Quantity (CE/year)		
Domestic production	93,378,628	3,593,599
Exports	9,469,064	658,834
Imports	4,872,808	—

CE = carcass equivalent

[a]Market price is constructed based on the value of meat and edible by-products.

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

	Baseline	With Regulation	Changes from Baseline	
			Absolute	Percent
Market Hogs				
Market price ($/CE)	$171.77	$171.77	—	0.0%
Market quantity (CE/year)	98,251,436	98,251,436	—	0.0%
Domestic production	93,378,628	93,378,628	—	0.0%
Exports	9,469,064	9,469,064	—	0.0%
Imports	4,872,808	4,872,808	—	0.0%
Other Hogs				
Market price ($/CE)	$249.56	$249,56	—	0.0%
Market quantity (CE/year)	3,593,599	3,593,599	—	0.0%
Domestic production	3,593,599	3,593,599	—	0.0%
Exports	658,834	658,834	—	0.0%
Imports	—	—	—	0.0%

CE = carcass equivalent

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

	Baseline	With Regulation	Changes from Baseline	
			Absolute	Percent
Pork Revenues ($/year)	$16,936,047,876	$16,936,047,876	—	0.0%
Costs ($/year)			—	
Regulatory compliance	$—	$—	—	0.0%
Pork production	$16,585,749,921	$16, 585,749,921		0.0%
Operating Profits (%)	2.07%	2.07%	0.0%	0.0%
Operating Product Types (#)	626	626	—	0.0%
Operating Slaughter Operations (#)	528	528	—	0.0%
Employment (FTEs)	58,637	58,637	—	0.0%

FTEs = Full-time equivalents

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

Stakeholder	Change in Value ($)
Consumer Surplus, Total	$—
Market hog consumers	$—
Other hog consumers	$—
Producer Surplus, Total	$0
Market hog producers	$0
Other hog producers	$0
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 (CE/year)		Total Compliance Costs[a]	
				Total	Share	Total	Share
Small	489	490	93%	9,508,472	10%	$—	0%
Large	16	38	7%	87,463,755	90%	$—	0%
TOTAL	505	528	100%	96,972,227	100%	$—	0%

CE = carcass equivalent

[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	Number of Facilities	Share of Facilities	Production (CE/year)		Total Compliance Costs[a]	
			Total	Share	Total	Share
Very small	390	74%	1,134,975	1%	$—	0%
Small	108	20%	8,907,689	9%	$—	0%
Large	30	6%	86,929,563	90%	$—	0%
TOTAL	528	100%	96,972,227	100%	$—	0%

CE = carcass equivalent

[a]Compliance costs represent premarket adjustments (i.e., 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
Pork Revenues ($/year)	$1,824,550,720	$1,824,550,720	$—	0.0%
Costs ($)				
Regulatory compliance	$—		$—	0.0%
Pork production	$1,773,887,351	$1,773,887,351	$—	0.0%
Operating Profits (%)	2.78%	2.78%	0%	0.0%
Operating Entities				
Product types	584	584	—	0.0%
Slaughter operations	490	490	—	0.0%
Employment	9,652	9,652	—	0.0%

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

	Baseline	With Regulation	Changes from Baseline	
			Absolute	Percent
Very Small				
Pork revenues ($/year)	$200,280,624	$200,280,624	$—	0.0%
Costs ($)				
Regulatory compliance	$—	$—	$—	0.0%
Pork production	$195,447,039	$195,447,039	$—	0.0%
Operating profits (%)	2.41%	2.41%	0.0%	0.0%
Operating entities				
Product types	451	451	—	0.0%
Slaughter operations	390	390	—	0.0%
Employment	3,512	3,512	—	0.0%
Small				
Pork revenues ($/year)	$1,757,478,979	$1,757,478,979	$—	0.0%
Costs ($)				
Regulatory compliance		$—	$—	0.0%
Pork production	$1,703,758,934	$1,703,758,934	$—	0.0%
Operating profits (%)	3.06%	3.06%	0.0%	0.0%
Operating entities				
Product types	142	142	—	0.0%
Slaughter operations	108	108	—	0.0%
Employment	6,916	6,916	—	0.0%
Large				
Pork revenues ($/year)	$14,978,288,273	$14,978,288,273	—	0.0%
Costs ($)				
Regulatory compliance		$—	$—	0.0%
Pork production	$14,686,543,949	$14,686,543,949	$—	0.0%
Operating profits (%)	1.95%	1.95%	0.0%	0.0%
Operating entities				
Product types	33	33	—	0.0%
Slaughter operations	30	30	—	0.0%
Employment	48,209	48,209	—	0.0%

Table 4-9. Summary of Secondary Effects of Regulation on Consumption of Key Substitutes: 2004

	Cross-Price Elasticity	Baseline	With Regulation	Changes from Baseline	
				Absolute	Percent
Effect of pork price changes on					
Beef consumption (pounds)	0.0450	19,350,100,000	19,350,100,000	—	0.0%
Poultry consumption (pounds)	–0.0720	24,836,267,000	24,836,267,000	—	0.0%
Total fish consumption (pounds)	0.0560	4,854,000,000	4,854,000,000	—	0.0%

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Appendix A: Supply Elasticity Estimates

Table A-1. Pork Supply Elasticities

Source	Data Frequency and Time Period	Estimate	Standard Error	Note
Short-run				
Holt, M.T., and S.R. Johnson, 1988, "Supply Dynamics n the U.S. Hog Industry." Working paper 86-WP 12, Center for Agricultural and Rural Development, Iowa State University. July 1986.	Quarterly 1967–1984	0.007	NR	Within 4 quarters
Buhr, B.L. 1993. "A Quarterly Econometric Simulation Model of the U.S. Livestock and Meat Sector." Staff paper P93-12, Department of Agricultural and Applied Economics, University of Minnesota.	Quarterly 1973–1989	0.6	NR	Within 4 quarters
Lemieux, C.M., and M.K. Wohlgenant, 1989, "'Ex ante'" Evaluation of the Economic Impact of Agricultural Biotechnology: The Case of Porcine Somatotropin." American Journal of Agricultural Economics 71:903-914.	Annual 1970–1983	0.4	NR	Hog supply, within one year
RTI International. 2007. GIPSA Livestock and Meat Marketing Study, Volume 4: Hog and Pork Industries. Research Triangle Park, NC: RTI International.	Annual State-level 1994–2001	0.79	NR	Hog supply, within 1 year
Intermediate-run				
Holt, M.T., and S.R. Johnson. 1988. "Supply Dynamics n the U.S. Hog Industry." Working paper 86-WP 12, Center for Agricultural and Rural Development, Iowa State University. July 1986.	Quarterly 1967–1984	0.230	NR	Within 10 quarters
Buhr, B.L. 1993. "A Quarterly Econometric Simulation Model of the U.S. Livestock and Meat Sector." Staff paper P93-12, Department of Agricultural and Applied Economics, University of Minnesota.	Quarterly 1973–1989	0.724	NR	Within 10 quarters

(continued)

Table A-1. Pork Supply Elasticities (continued)

Source	Data Frequency and Time Period	Estimate	Standard Error	Note
Intermediate-run (continued)				
Lemieux, C.M., and M.K. Wohlgenant. 1989. "'Ex ante'" Evaluation of the Economic Impact of Agricultural Biotechnology: The Case of Porcine Somatotropin." American Journal of Agricultural Economics 71:903-914.	Annual 1970–1983	1.8	NR	Hog supply, within 5 years
		Average Median Maximum Minimum	0.650 0.6 1.8 0.007	Short-run and intermediate run
Long-run				
Holt, M.T., and S.R. Johnson. 1988. "Supply Dynamics n the U.S. Hog Industry." Working paper 86-WP 12, Center for Agricultural and Rural Development, Iowa State University. July 1986.	Quarterly 1967–1984	0.403	NR	
Buhr, B.L. 1993. "A Quarterly Econometric Simulation Model of the U.S. Livestock and Meat Sector." Staff paper P93-12, Department of Agricultural and Applied Economics, University of Minnesota.	Quarterly 1973–1989	0.735	NR	
RTI International. 2007. GIPSA Livestock and Meat Marketing Study, Volume 4: Hog and Pork Industries. Research Triangle Park, NC: RTI International.	Annual State-level 1994–2001	4.2	NR	Hog supply, within 10 years
		Average Median Maximum Minimum	0.989 0.662 4.2 0.007	Short-run, intermediate run, and long run

Appendix B: Demand Elasticity Estimates

Table B-1. Domestic Demand Elasticities

Source	Data Frequency and Time Period	Estimate	Standard Error	Note [a,b]
Lemieux, C.M., and M.K. Wohlgenant, 1989, "'Ex ante'" Evaluation of the Economic Impact of Agricultural Biotechnology: The Case of Porcine Somatotropin." *American Journal of Agricultural Economics* 71:903-914.	NA	–0.7 or –0.9	NR	Assumed value
Marsh, T.L., T.C. Schroeder, and J. Mintert. 2004. "Impact of Meat Product Recalls on Consumer Demand in the USA." *Applied Economics* 36:897-909.	Quarterly 1982–1998	–0.495	0.0695	Compensated, unconditional
Piggott, N.E., and T.L. Marsh. 2004. "Does Food Safety Information Impact U.S. Meat Demand?" *American Journal of Agricultural Economics* 86:154-174.	Quarterly 1982–1999	–0.688 (1) –0.330 (2)	NR	(1) Uncompensated, conditional (2) Compensated, conditional
Brester, G.W., and T.C. Schroeder. 1995. "The Impacts of Brand and Generic Advertising on Meat Demand." *American Journal of Agricultural Economics* 77:969-979.	Quarterly 1970–1993	–0.69	0.0567	Compensated, unconditional
Mazzocchi, M. 2006. "No News Is Good News: Stochastic Parameters Versus Media Coverage Indices in Demand Models after Food Scares." *American Journal of Agricultural Economics* 88:727-741.	Quarterly 1982–1999	–0.68	0.28	Long-run uncompensated, conditional
Sarmiento, C. 2005. "A Varying Coefficient Approach to Global Flexibility in Demand Analysis: A Semiparametric Approximation." *American Journal of Agricultural Economics* 87:38-47.	Annual 1950–2000	–0.83	0.256	Evaluated at year 1995, unconditional, not clear whether compensated or uncompensated
Moschini, G., and K.D. Meilke. 1989. "Modeling the Pattern of Structural Change in U.S. Meat Demand." *American Journal of Agricultural Economics* 71:253-261.	Quarterly 1967–1987	–0.839	0.072	Uncompensated, conditional

(continued)

Table B-1. Domestic Demand Elasticities (continued)

Source	Data Frequency and Time Period	Estimate	Standard Error	Note [a,b]
Eales, J.S., and L.J. Unnevehr. 1993. "Simultaneity and Structural Change in U.S. Meat Demand." *American Journal of Agricultural Economics* 75:259-268.	Annual 1962–1989	−1.234	0.278	Uncompensated, unconditional
Kinnucan, H.W., H. Xiao, C.J. Hsia, and J.D. Jackson. 1997. "Effects of Health Information and Generic Advertising on U.S. Meat Demand." *American Journal of Agricultural Economics* 79:13-23.	Quarterly 1976–1993	−0.688	NR	Compensated, conditional
Alston, J.M., and J.A. Chalfant. 1993. "The Silence of the Lambdas: A Test of the Almost Ideal and Rotterdam Models." *American Journal of Agricultural Economics* 75:304-313.	Quarterly 1967–1988	−0.17 (1) −0.07 (2)	NR	(1) Uncompensated, conditional, Rotterdam Demand System (2) Uncompensated, conditional, Almost Ideal Demand System
Huang, K.S., and B.H. Lin. 2000. "Estimation of Food Demand and Nutrient Elasticities from Household Survey Data." Technical bulletin number 1887, ERS.	Cross-sectional 1987–1988	−0.687	0.051	Not clear whether compensated or uncompensated
Beach, R.H., C. Zhen, N.E. Piggott, M.K. Wohlgenant, C.L. Viator, and S.C. Cates. 2007. *An Economic Analysis of the Effectiveness of the Pork Checkoff Program*. Research Triangle Park, NC: RTI International.	Quarterly 1982–2005	−0.558	0.172	Uncompensated, conditional
Brester, G.W., and M.K. Wohlgenant. 1991. "Estimating Interrelated Demands for Meats Using New Measures for Ground and Table Cut Beef." *American Journal of Agricultural Economics* 73:1182-1194.	Annual 1962–1989	−0.779	NR	Compensated, unconditional

(continued)

Table B-1. Domestic Demand Elasticities (continued)

Source	Data Frequency and Time Period	Estimate	Standard Error	Note [a,b]
Boetel, B.L., and D.J. Liu. 2003. "Evaluating the Effect of Generic Advertising and Food Health Information within a Meat Demand System." *Agribusiness* 19:345-354.	Quarterly 1976–2000	−0.484	NR	Compensated, conditional
		Average	−0.636	
		Median	−0.688	
		Maximum	−1.234	
		Minimum	−0.070	

[a] "Uncompensated" refers to the Marshallian demand elasticity; "compensated" denotes the Hicksian demand elasticity.

[b] "Conditional" means the demand model is a conditional demand where expenditure term is the group expenditure on meats; "unconditional" denotes unconditional demand where the expenditure term is usually chosen, to be the personal consumption expenditure, which include not only meat expenditures but also expenditures on other nondurable goods, services, and durable goods.

Table B-2. Cross-Price Demand Elasticities: Beef Quantity WRT Pork Price

Source	Data Frequency and Time Period	Estimate	Standard Error	Note
Marsh, T.L., T.C. Schroeder, and J. Mintert. 2004. "Impact of Meat Product Recalls on Consumer Demand in the USA." *Applied Economics* 36:897-909.	Quarterly 1982–1998	0.024	0.047	Compensated, unconditional
Piggott, N.E., and T.L. Marsh. 2004. "Does Food Safety Information Impact U.S. Meat Demand?" *American Journal of Agricultural Economics* 86:154-174.	Quarterly 1982–1999	−0.111 (1) 0.207 (2)	NR	(1) Uncompensated, conditional (2) Compensated, conditional
Brester, G.W., and T.C. Schroeder. 1995. "The Impacts of Brand and Generic Advertising on Meat Demand." *American Journal of Agricultural Economics* 77:969-979.	Quarterly 1970–1993	0.10	0.030	Compensated, unconditional

(continued)

Table B-2. Cross-Price Demand Elasticities: Beef Quantity WRT Pork Price (continued)

Source	Data Frequency and Time Period	Estimate	Standard Error	Note
Mazzocchi, M. 2006. "No News Is Good News: Stochastic Parameters Versus Media Coverage Indices in Demand Models after Food Scares." *American Journal of Agricultural Economics* 88:727-741.	Quarterly 1982–1999	−0.02	0.32	Long-run uncompensated, conditional
Sarmiento, C. 2005. "A Varying Coefficient Approach to Global Flexibility in Demand Analysis: A Semiparametric Approximation." *American Journal of Agricultural Economics* 87:38-47.	Annual 1950–2000	NR	NR	
Moschini, G., and K.D. Meilke. 1989. "Modeling the Pattern of Structural Change in U.S. Meat Demand." *American Journal of Agricultural Economics* 71:253-261.	Quarterly 1967–1987	−0.078	0.041	Uncompensated, conditional
Eales, J.S., and L.J. Unnevehr. 1993. "Simultaneity and Structural Change in U.S. Meat Demand." *American Journal of Agricultural Economics* 75:259-268.	Annual 1962–1989	NR	NR	
Kinnucan, H.W., H. Xiao, C.J. Hsia, and J.D. Jackson. 1997. "Effects of Health Information and Generic Advertising on U.S. Meat Demand." *American Journal of Agricultural Economics* 79:13-23.	Quarterly 1976–1993	0.274	NR	Compensated, conditional
Alston, J.M., and J.A. Chalfant. 1993. "The Silence of the Lambdas: A Test of the Almost Ideal and Rotterdam Models." *American Journal of Agricultural Economics* 75:304-313.	Quarterly 1967–1988	−0.12 (1) −0.13 (2)	NR	(1) Uncompensated, conditional, Rotterdam Demand System (2) Uncompensated, conditional, Almost Ideal Demand System
Huang, K.S., and B.H. Lin. 2000. "Estimation of Food Demand and Nutrient Elasticities from Household Survey Data." Technical bulletin number 1887, ERS.	Cross-sectional 1987–1988	−0.037	0.021	Not clear whether compensated or uncompensated

(continued)

Table B-2. Cross-Price Demand Elasticities: Beef Quantity WRT Pork Price (continued)

Source	Data Frequency and Time Period	Estimate	Standard Error	Note
Beach, R.H., C. Zhen, N.E. Piggott, M.K. Wohlgenant, C.L. Viator, and S.C. Cates. 2007. *An Economic Analysis of the Effectiveness of the Pork Checkoff Program*. Research Triangle Park, NC: RTI International.	Quarterly 1982–2005	−0.122	NR	Uncompensated, conditional
Brester, G.W., and M.K. Wohlgenant. 1991. "Estimating Interrelated Demands for Meats Using New Measures for Ground and Table Cut Beef." *American Journal of Agricultural Economics* 73:1182-1194.	Annual 1962–1989	0.348 (1) 0.094 (2)	NR	Compensated, unconditional (1) Ground beef (2) Table cut beef
Boetel, B.L., and D.J. Liu. 2003. "Evaluating the Effect of Generic Advertising and Food Health Information within a Meat Demand System." *Agribusiness* 19:345-354.	Quarterly 1976–2000	0.195	NR	Compensated, conditional
		Average	0.045	
		Median	0.002	
		Maximum	0.348	
		Minimum	−0.13	

Table B-3. Cross-Price Demand Elasticities: Poultry Quantity WRT Pork Price

Source	Data Frequency and Time Period	Estimate	Standard Error	Note
Marsh, T.L., T.C. Schroeder, and J. Mintert. 2004. "Impact of Meat Product Recalls on Consumer Demand in the USA." *Applied Economics* 36:897-909.	Quarterly 1982–1998	0.023	0.064	Compensated, unconditional
Piggott, N.E., and T.L. Marsh. 2004. "Does Food Safety Information Impact U.S. Meat Demand?" *American Journal of Agricultural Economics* 86:154-174.	Quarterly 1982–1999	−0.168 (1) −0.103 (2)	NR	(1) Uncompensated, conditional (2) Compensated, conditional

(continued)

Table B-3. Cross-Price Demand Elasticities: Poultry Quantity WRT Pork Price (continued)

Source	Data Frequency and Time Period	Estimate	Standard Error	Note
Brester, G.W., and T.C. Schroeder. 1995. "The Impacts of Brand and Generic Advertising on Meat Demand." *American Journal of Agricultural Economics* 77:969-979.	Quarterly 1970–1993	0.07	0.07	Compensated, unconditional
Mazzocchi, M. 2006. "No News Is Good News: Stochastic Parameters Versus Media Coverage Indices in Demand Models after Food Scares." *American Journal of Agricultural Economics* 88:727-741.	Quarterly 1982–1999	−0.38	0.58	Long-run uncompensated, conditional
Sarmiento, C. 2005. "A Varying Coefficient Approach to Global Flexibility in Demand Analysis: A Semiparametric Approximation." *American Journal of Agricultural Economics* 87:38-47.	Annual 1950–2000	NR	NR	
Moschini, G., and K.D. Meilke. 1989. "Modeling the Pattern of Structural Change in U.S. Meat Demand." *American Journal of Agricultural Economics* 71:253-261.	Quarterly 1967–1987	−0.068	0.084	Uncompensated, conditional
Eales, J.S., and L.J. Unnevehr. 1993. "Simultaneity and Structural Change in U.S. Meat Demand." *American Journal of Agricultural Economics* 75:259-268.	Annual 1962–1989	NR	NR	
Kinnucan, H.W., H. Xiao, C.J. Hsia, and J.D. Jackson. 1997. "Effects of Health Information and Generic Advertising on U.S. Meat Demand." *American Journal of Agricultural Economics* 79:13-23.	Quarterly 1976–1993	−0.102	NR	Compensated, conditional

(continued)

Table B-3. Cross-Price Demand Elasticities: Poultry Quantity WRT Pork Price (continued)

Source	Data Frequency and Time Period	Estimate	Standard Error	Note
Alston, J.M., and J.A. Chalfant. 1993. "The Silence of the Lambdas: A Test of the Almost Ideal and Rotterdam Models." *American Journal of Agricultural Economics* 75:304-313.	Quarterly 1967–1988	−0.09 (1) −0.10 (2)	NR	(1) Uncompensated, conditional, Rotterdam Demand System (2) Uncompensated, conditional, Almost Ideal Demand System
Huang, K.S., and B.H. Lin. 2000. "Estimation of Food Demand and Nutrient Elasticities from Household Survey Data." Technical bulletin number 1887, ERS.	Cross-sectional 1987–1988	−0.008	0.028	Not clear whether compensated or uncompensated
Beach, R.H., C. Zhen, N.E. Piggott, M.K. Wohlgenant, C.L. Viator, and S.C. Cates. 2007. *An Economic Analysis of the Effectiveness of the Pork Checkoff Program*. Research Triangle Park, NC: RTI International.	Quarterly 1982–2005	−0.179	NR	Uncompensated, conditional
Brester, G.W., and M.K. Wohlgenant. 1991. "Estimating Interrelated Demands for Meats Using New Measures for Ground and Table Cut Beef." *American Journal of Agricultural Economics* 73:1182-1194.	Annual 1962–1989	0.062	NR	Compensated, unconditional
Boetel, B.L., and D.J. Liu. 2003. "Evaluating the Effect of Generic Advertising and Food Health Information within a Meat Demand System." *Agribusiness* 19:345-354.	Quarterly 1976–2000	0.104	NR	Compensated, conditional
		Average	−0.072	
		Median	−0.09	
		Maximum	0.104	
		Minimum	−0.38	

Table B-4. Cross-Price Demand Elasticities: Fish Quantity WRT Pork Price

Source	Data Frequency and Time Period	Estimate	Standard Error	Note
Kinnucan, H.W., H. Xiao, C.J. Hsia, and J.D. Jackson. 1997. "Effects of Health Information and Generic Advertising on U.S. Meat Demand." *American Journal of Agricultural Economics* 79:13-23.	Quarterly 1976–1993	0.315	NR	Compensated, conditional
Boetel, B.L., and D.J. Liu. 2003. "Evaluating the Effect of Generic Advertising and Food Health Information within a Meat Demand System." *Agribusiness* 19:345-354.	Quarterly 1976–2000	0.106	NR	Compensated, conditional
Huang, K.S., and B.H. Lin. 2000. "Estimation of Food Demand and Nutrient Elasticities from Household Survey Data." Technical bulletin number 1887, ERS.	Cross-sectional 1987–1988	0.0018	0.1415	Not clear whether compensated or uncompensated
Yen, S.T., B Lin, and D.M. Smallwood. 2003. "Quasi- and Simulated-Likelihood Approaches to Censored Demand Systems: Food Consumption by Food Stamp Recipients in the United States." *American Journal of Agricultural Economics* 85:458-478.	Cross-sectional, June 1996-January 1997	0.11 (1) 0.11 (2) 0.00 (3) 0.00 (4) 0.01 (5) –0.10 (6)	0.08 (1) 0.09 (2) 0.10 (3) 0.08 (4) 0.09 (5) 0.10 (6)	(1) Compensated, quasi-maximum likelihood (2) Compensated, simulated maximum likelihood (3) Compensated, two-step procedure (4) Uncompensated, quasi-maximum likelihood (5) Uncompensated, simulated-maximum likelihood (6) Uncompensated, two-step procedure
Moschini, G., and K.D. Meilke. 1989. "Modeling the Pattern of Structural Change in U.S. Meat Demand." *American Journal of Agricultural Economics* 71:253-261.	Quarterly 1967–1987	0.012	0.077	Uncompensated, conditional
		Average	0.056	
		Median	0.011	
		Maximum	0.315	
		Minimum	–0.1	

Table B-5. Export Demand Elasticities

Source	Data Frequency and Time Period	Estimate	Standard Error	Note
Lemieux, C.M., and M.K. Wohlgenant, 1989, "'Ex ante'" Evaluation of the Economic Impact of Agricultural Biotechnology: The Case of Porcine Somatotropin." *American Journal of Agricultural Economics* 71:903-914.	NA	–3	NR	Assumed value, not estimated in the original article
Beach, R.H. et al. 2007. *An Economic Analysis of the Effectiveness of the Pork Checkoff Program*. research Triangle Park, NC: RTI International.	Quarterly 1982–2005	–1.497	0.636	Single-equation, linear demand, uncompensated
Fabiosa, J.F., and Y.S. Ukhova. 2000. "New Aggregate and Source-Specific Pork Import Demand Elasticity for Japan: Implications to U.S. Exports." Working paper 00-WP 253, October, Center for Agricultural and Rural Development, Iowa State University.	Monthly 1993–1998	–1.837 (1) –1.666 (2)	NR	Conditional Almost Ideal Demand System, elasticities of demand for U.S. pork by Japanese consumers (1) Uncompensated (2) Compensated
Yang, S-R, and W.W. Koo. 2004. "Japanese Meat Import Demand Estimation with the Source Differentiated AIDS Model." *Journal of Agricultural and Resource Economics* 19:396-408	Annual 1973–1990	–1.097	NR	Conditional Almost Ideal Demand System, elasticities of demand for U.S. pork by Japanese consumers
		Average	–1.819	
		Median	–1.666	
		Maximum	–1.097	
		Minimum	–3	