# Economic Assessment of Evolving Red Meat Export Market Access Requirements for Traceability of Livestock and Meat

**Project Report Submitted to U.S. Meat Export Federation**

March 2011

**Acknowledgements**

The research team is grateful for financial support provided for this project by the U.S. Meat Export Federation (USMEF). In addition, we appreciate considerable support and assistance from Paul Clayton, Erin Daley Borror, Kevin Smith, and other USMEF staff. Furthermore, the research team thoroughly appreciates the multitude of livestock and meat industry stakeholders and related professionals who shared information and views about traceability systems and important global developments.

**Research Team**

Gary Brester, Professor, Agricultural Economics, Montana State University

Kevin Dhuyvetter, Professor, Agricultural Economics, Kansas State University

Dustin Pendell, Assistant Professor, Agricultural and Resource Economics, Colorado State University

Ted Schroeder, Professor, Agricultural Economics, Kansas State University

Glynn Tonsor, Assistant Professor, Agricultural Economics, Kansas State University

# Table of Contents

# I. EXECUTIVE SUMMARY

### *Purpose*

The international marketplace for red meat is rapidly changing with animal identification (ID) and meat traceability systems becoming widely adopted in many key U.S. meat export destinations. The United States lags behind many countries in adopting livestock and meat traceability systems. As major meat importing and exporting countries adopt animal and meat tracking systems, the United States is becoming less competitive and risks losing market access. The purpose of this study is to provide an economic analysis of impacts of potential changes in U.S. meat access to global markets and costs associated with possible increases in domestic adoption of traceability programs.

### *Procedure*

A host of complementary research activities were conducted including:

1. Reviewing existing published literature associated with ID and tracing;
2. Conducting several personal interviews with industry and government stakeholders;
3. Gathering details on current animal ID and tracing programs in major meat exporting countries and associated requirements in major importing countries;
4. Estimating costs of adopting animal ID and tracing systems that may be required for future exporting of U.S. beef and pork; and
5. Quantifying short-run and long-run net economic impacts of adjustments in international market access and domestic tracing programs using an equilibrium displacement model.

### *Summary of Findings*

Our evaluation of changes in traceability requirements and associated adjustments in international trade focuses on a particular traceability system. In this study, we consider source and age verification programs as a potential requirement for future access to specific beef export markets. Similarly, we consider a comparable pork traceability program that is market based, but specifically focuses on source verification because age verification is not relevant for the pork sector. The economic impact of

adjustments in the U.S. livestock and meat industry is estimated for several scenarios that could represent future realities for industry stakeholders. The impact of costs associated with expanded participation in traceability programs and various responses in export meat demand is assessed. Similarly, the economic impact of maintaining the status quo (i.e., not expanding traceability domestically) and losing access to various export markets is considered.

The loss of access to both beef (7.3%) and pork (6.3%) export markets roughly the size of 2009 volumes sent to South Korea as a result of not expanding domestic traceability in the U.S. beef and pork industries is estimated to harm the beef and pork industries by $1,792 million and $518 million dollars, respectively, while U.S. meat consumers gain $610 million over a ten-year period. Furthermore, losing market access to all countries except Canada and Mexico (48.7% decline in beef; 68.3% decline in pork exports) results in the beef and pork industries incurring damages of $12,582 million and $5,505 million, respectively, versus consumers being better off by $6,094 million. These estimates quantify the potential damage to domestic livestock industries if the United States were to lose access to key target markets.

Export expansion that would be necessary to offset direct costs associated with adopting domestic traceability is also assessed. The increases in 2009 export volumes required to "break even" (i.e., exactly offset costs of traceability program participation) are equivalent to gaining (or losing) access to a single country. For example, to offset costs of 20% participation in cattle and pork traceability programs, an increase in beef exports of 1% (19.5 million lbs.) and pork exports of 0.5% (21.7 million lbs.) would be required. To put this in perspective, the United States exported 140 million lbs. and 258 million lbs. of beef and pork, respectively, to South Korea in 2009.

***Implications and Industry Recommendations***

This study highlights the substantial economic damage that could occur to U.S. livestock industries if export market access is restricted because of comparatively slow responses to global animal ID and traceability standards. Industry leaders are encouraged to weigh the estimated impacts of "doing

nothing" with the associated costs of expanding participation in enhanced traceability programs. This study provides information to help the red meat industries assess tradeoffs of expanding domestic traceability programs versus lagging behind export competitors and importing country requirements. Our assessment is relatively conservative in its consideration of traceability costs and associated impacts. For instance, it is expected that future economies of scale and scope in information technology development will reduce traceability participation costs. Similarly, our export market access simulation results are conservative estimates of industry benefits. The estimates are conservative because we do not consider a variety of potential benefits that could result from expanded traceability programs including possible domestic demand enhancements, improvements in disease surveillance and eradication efforts, better on-farm management capabilities, cost reductions in meeting country of origin and recently passed nutritional labeling regulations, and related efficiencies in developing value-added programs and credence claims.

Targeted industry recommendations reflecting this study's findings and implications include:

1) *Prosperity of the U.S. livestock industries will increasingly depend on expanding international trade of meat products. Industry stakeholders must recognize this fact and carefully consider the corresponding adjustments necessary if they desire to remain competitive in the global meat marketplace.*
2) *A candid and more complete recognition of the United States falling behind competing global meat exporters with respect to evolving world meat trade standards for animal and meat traceability should be a priority for industry leaders. Serious consideration should be given for producer educational programs raising recognition.*
3) *Designing and adopting animal and meat traceability systems that attain current world standards involves differential benefits and costs to individual industry participants. As a result, despite large meat and livestock industry-wide economic benefits from adoption of traceability practices gained through greater global market access, direct benefits for some will be smaller and less obvious. Furthermore, philosophical changes may be necessary to encourage adjustments required to meet world standards. Success will necessitate industry champions to help guide the industry effort to become a world leader in animal and meat traceability.*
4) *Industry leaders and individual producers should start viewing additional traceability as investments in the viability of their industry. This study notes the substantial value of export*

*market maintenance and expansion. Coupled with other recognized benefits omitted from this assessment, we suggest corresponding "investment" should be seriously discussed and considered.*

5) *While economies of size exist resulting in higher per head costs for smaller operations participating in traceability programs, broader recognition is needed of these same operations absorbing a substantial segment of industry economic losses stemming from lost export markets or an inability to gain access to potential markets. Industry leadership that clearly communicates this is needed to facilitate substantial increases in voluntary participation rates in traceability systems.*

## II. BACKGROUND

The international marketplace for red meat is rapidly changing. Increasingly, access to meat importing countries includes sanitary, phytosanitary, and related traceability protocols. Countries that have well-developed mandatory animal Identification and traceability programs enjoy comparative advantages in red meat exports relative to countries without such systems. Animal identification (ID) and meat traceability systems are becoming widely adopted in many key U.S. meat export destinations. Souza-Monteiro and Caswell (2004) noted "four patterns of adoption are evident in the major producing and trading countries: adoption of mandatory systems in response to consumer concerns (EU and Japan), imposition of mandatory traceability to maintain or enhance export shares (Australia, Brazil, and Argentina), industry managed mandatory programs for animal identification (Canada), and voluntary systems (United States)" (p. 7). The United States lags behind many other countries in adopting livestock and meat traceability systems. Smith et al. (2005) reported that the United States is "lagging behind many countries in developing traceability systems for food in general and especially for livestock, and their products" (p. 174). A central reason is that the U.S. cow-calf production sector is characterized by a large number of small, decentralized operations who do not readily see direct benefits associated with the costs of an animal identification system (Tonsor and Schroeder, 2006; Schulz and Tonsor, 2010a,b). Furthermore, the U.S. federal government supports voluntary rather than mandatory animal tracing systems in contrast to many major meat importing and exporting countries. Therefore, the United States is becoming less competitive and could lose access to certain markets (Murphy, Pendell and Smith, 2009). The purpose of this study is to provide an economic analysis of potential changes in U.S. meat access to global markets under various domestic animal traceability adoption rates.

## III. OBJECTIVES

The purpose of this study is to determine economic impacts on U.S. livestock and meat producers and consumers resulting from potential import requirements for meat traceability. The five specific objectives are to:

1. Determine U.S. meat export verification program requirements for ensuring key export market access and document what key competing importing countries require for their own domestic livestock tracing systems.

2. Identify options available for U.S. producers and processors in meeting new requirements for exporting red meat to targeted countries.

3. Estimate costs associated with meeting new requirements for exporting red meat to targeted countries.

4. Identify comparative advantages and disadvantages U.S. producers and processors face in meeting evolving requirements for exporting red meat to targeted destinations relative to other global meat suppliers.

5. Estimate economic impacts in both domestic and foreign markets of varying adoption rates of animal identification and tracing in the U.S. red meat industries.

## IV. PROCEDURES

Several data collection procedures and information assessments were employed in this project. Specifically, our approach included:

1. Reviewing existing published literature associated with animal ID and tracing;

2. Conducting several personal interviews with industry and government stakeholders including personnel at USDA FAS (Foreign Agricultural Service ), USMEF, five industry firms currently providing verification programs complying with USDA's process verification program system, two meat processors, and two retail grocery chains;

3. Documenting details on current animal ID and tracing programs in major meat exporting countries and associated requirements in major importing countries;

4. Developing direct cost estimates for adopting animal ID and tracing systems that may be requirements for future exporting of U.S. beef and pork; and

5. Quantifying short-run and long-run net economic impacts of adjustments in international market access and domestic participation in animal ID and traceability programs using an equilibrium displacement model.

## v. CURRENT U.S. MEAT, EXPORT VERIFICATION PROGRAMS, AND OPTIONS FOR U.S. PRODUCERS AND PROCESSORS

The first step in our analysis was to benchmark the current status of U.S. meat export market access. Tables V.1 and V.2 present U.S. beef and veal exports by destination in total pounds and percentages, respectively, from 2005 to 2010. Tables V.3 and V.4 present comparable information for U.S. pork exports. Export volumes for both red meats have trended upward. In addition to increased export volumes, several changes have occurred among trading partners. For example, the U.S. exported at least 10 million pounds of beef to eight different countries in 2009 compared to only five countries in 2005 (table V.1). Common to both beef and pork export markets is that North American trading partners (i.e., Canada and Mexico) represent a significant proportion of exports. However, North American trading partners accounted for 82% of U.S. beef exports in 2005, but the share declined to 39% in 2010 (table V.2). The share of pork exports to Canada and Mexico has been rather stable (table V.4) over this same period (23-35%).

Conversely, the relative importance of specific Asian markets for beef and pork has varied considerably. For instance, Japan is a significant destination for both products, South Korea is predominant in beef trade, and China is predominant in pork trade. These distinctions among Asian markets are central to our analysis. For example, China (mainland) currently has an agreement with the United States to accept pork imports, but it does not accept beef imports. In contrast, China accepts beef products from Canada, Australia, New Zealand, Uruguay, and Brazil. While a discussion on global comparative advantages in the meat trade marketplace is presented in section VI of this report, divergent access to China demonstrates a fundamental foundation of this project. In particular, evolving requirements for access to major U.S. export markets are identified and economic impacts of meeting these requirements are estimated. In this study, we quantify the impacts of different animal traceability requirements for future global meat market access. More narrowly, we conduct an economic assessment to quantify impacts of different scenarios associated with alternative traceability requirements necessary for future access to global meat markets.

Table V.1. U.S. Beef and Veal Exports by Destination, Carcass Weight (Thousand Pounds)

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|
| Canada | 105,895 | 238,556 | 339,106 | 389,250 | 363,189 | 390,213 |
| China (Taiwan) | 22,394 | 67,364 | 70,684 | 85,397 | 84,399 | 122,916 |
| Hong Kong | 2,034 | 12,624 | 32,223 | 32,363 | 82,226 | 133,388 |
| Japan | 17,496 | 51,639 | 159,411 | 231,070 | 274,341 | 350,991 |
| Mexico | 464,024 | 660,454 | 586,434 | 758,534 | 628,464 | 500,487 |
| Russia | 1,441 | 142 | 114 | 47,725 | 13,435 | 79,997 |
| South Korea | 1,077 | 1,283 | 77,919 | 152,095 | 140,693 | 277,103 |
| Vietnam | 11,058 | 10,383 | 41,869 | 121,925 | 148,332 | 114,460 |
| Others | 71,740 | 102,428 | 126,205 | 177,941 | 199,681 | 330,210 |
| Total | 697,158 | 1,144,875 | 1,433,964 | 1,996,299 | 1,934,759 | 2,299,765 |

Source: Livestock Marketing Information Center.

Table V.2. U.S. Beef and Veal Exports by Destination, Percentage of Total Exports

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|
| Canada | 15% | 21% | 24% | 19% | 19% | 17% |
| China (Taiwan) | 3% | 6% | 5% | 4% | 4% | 5% |
| Hong Kong | 0% | 1% | 2% | 2% | 4% | 6% |
| Japan | 3% | 5% | 11% | 12% | 14% | 15% |
| Mexico | 67% | 58% | 41% | 38% | 32% | 22% |
| Russia | 0% | 0% | 0% | 2% | 1% | 3% |
| South Korea | 0% | 0% | 5% | 8% | 7% | 12% |
| Vietnam | 2% | 1% | 3% | 6% | 8% | 5% |
| Others | 10% | 9% | 9% | 9% | 10% | 14% |

Source: Livestock Marketing Information Center.

Table V.3. U.S. Pork Exports by Destination, Carcass Weight (Thousand Pounds)

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|
| Canada | 302,211 | 324,935 | 367,584 | 422,266 | 406,840 | 433,293 |
| China (Mainland) | 123,222 | 111,943 | 228,021 | 361,562 | 54,039 | 156,582 |
| China (Taiwan) | 62,828 | 59,425 | 33,219 | 56,704 | 75,612 | 64,739 |
| Japan | 1,045,956 | 1,015,423 | 1,072,788 | 1,323,719 | 1,273,628 | 1,284,966 |
| Hong Kong | 23,452 | 49,929 | 127,026 | 489,799 | 300,897 | 203,797 |
| Mexico | 538,227 | 608,937 | 451,407 | 658,144 | 890,179 | 1,037,053 |
| Russia | 94,099 | 208,744 | 244,311 | 429,908 | 284,068 | 153,853 |
| South Korea | 190,085 | 293,416 | 264,854 | 296,967 | 258,288 | 220,245 |
| Caribbean | 20,873 | 27,329 | 33,538 | 47,937 | 69,757 | 74,277 |
| Others | 265,162 | 295,014 | 318,434 | 564,458 | 480,804 | 598,045 |
| Total | 2,666,116 | 2,995,096 | 3,141,181 | 4,651,464 | 4,094,112 | 4,226,850 |

Source: Livestock Marketing Information Center.

Table V.4. U.S. Pork Exports by Destination, Percentage of Total Exports

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|
| Canada | 11% | 11% | 12% | 9% | 10% | 10% |
| China (Mainland) | 5% | 4% | 7% | 8% | 1% | 4% |
| China (Taiwan) | 2% | 2% | 1% | 1% | 2% | 2% |
| Japan | 39% | 34% | 34% | 28% | 31% | 30% |
| Hong Kong | 1% | 2% | 4% | 11% | 7% | 5% |
| Mexico | 20% | 20% | 14% | 14% | 22% | 25% |
| Russia | 4% | 7% | 8% | 9% | 7% | 4% |
| South Korea | 7% | 10% | 8% | 6% | 6% | 5% |
| Caribbean | 1% | 1% | 1% | 1% | 2% | 2% |
| Others | 10% | 10% | 10% | 12% | 12% | 14% |

Source: Livestock Marketing Information Center.

Before examining potential impacts of alternative traceability requirements, current requirements need to be documented. U.S. meat products eligible for export must be produced under an approved USDA AMS (Agricultural Marketing Service) Export Verification program. As of September 2010, USDA's website provides details for meat export requirements to Belize, Cayman Islands, Chile, Colombia, Dominican Republic, Egypt, El Salvador, Hong Kong, Japan, South Korea, Lebanon, Malaysia, Mexico, Peru, Russia, Singapore, St. Lucia, Taiwan, Thailand, Ukraine, United Arab Emirates, and Vietnam.[1] Rather than provide detailed requirements for these 22 countries, we focus on beef exports to Japan, South Korea, and Hong Kong. These three markets represent potentially lucrative meat trade markets and comprise a significant component of politically contentious meat trade negotiations over recent years. Accordingly, these three countries are used as examples of current requirements:

Current requirements of U.S. exporters of beef to South Korea include[2]:

- Beef must be from cattle less than 30 months of age;
- Participation is required in a Quality System Assessment (QSA) that verifies beef being certified is from cattle less than 30 months of age; and
- Eligible products must be produced under an approved AMS Export Verification program.

Current requirements of U.S. exporters of beef to Japan include[3]:

- Beef derived from animals 20 months of age or younger; and
- Eligible products must be produced under an approved AMS Export Verification program.

Current requirements of U.S. exporters of beef to Hong Kong[4]:

- Beef derived from animals less than 30 months of age; and
- Eligible products must be produced under an approved AMS Export Verification program.

Current requirements for beef exports to South Korea, Japan, and Hong Kong each include restrictions on the age of animals from which beef products originate. Accordingly, a core assumption of our

[1] Details on individual country requirements are available at: http://www.fsis.usda.gov/Regulations_&_Policies/Export_Requirements_EV_Countries/index.asp#evcountries.
[2] http://www.fsis.usda.gov/Regulations_&_Policies/Republic_of_Korea_Requirements/index.asp
[3] http://www.fsis.usda.gov/Regulations_&_Policies/Japan_Requirements/index.asp
[4] http://www.fsis.usda.gov/Regulations_&_Policies/Hong_Kong_Requirements/index.asp

analysis is that future beef trade may increasingly require traceability systems capable of documenting animal ages. This assumption can be justified from multiple perspectives. First, the private sector is already facilitating source and age verification (SAV) which provides an opportunity to observe actual participation costs.[5] Second, current market access negotiations indicate that source and age verification will be critical to future trade negotiations. Third, the "source" verification component of an SAV program provides more detailed origination information than "bill of lading" traceability systems that are currently accepted by some countries. However, a "bill of lading" may not be accepted as adequate origin documentation in the future (e.g., South Korea) and, thus, basing costs on SAV programs may be more appropriate. More narrowly, demands for age verification protocols inherently contain a source verification component. Increasing global demands for source verifying traceability systems (see section VI for more details) justifies our approach of using SAV programs as the basis for estimating traceability costs in this study.

Consequently, we explore details of currently available source and age verification programs in this project. More specifically, our estimation of economic impacts stemming from alternative traceability requirements was conducted using current SAV programs as the future requirement for U.S. access to global meat markets. The estimated costs of SAV participation are presented in section VII while corresponding economic impacts of associated livestock and meat market adjustments are discussed in section VIII.

Although source and age verification programs may be a requirement for U.S. access to global beef markets, age verification clearly is not relevant for pork exports (i.e., age verification programs do not exist in the swine industry). Accordingly, swine traceability costs were estimated assuming third-party verification of animal origin without concern for age verification.

[5] Background details on age requirements and associated food safety information on Bovine Spongiform Encephalopathy (BSE) and Specified Risk Material (SRM) are available at: http://www.fsis.usda.gov/regulations_&_Policies/BSE_Resources/index.asp

## VI. INTERNATIONAL CATTLE IDENTIFICATION AND TRACEABILITY PROGRAMS: COMPETITIVE IMPLICATIONS

Animal traceability has developed around the world at a rapid pace. Major beef export countries have developed animal traceability systems to better protect animal health and enhance export market growth. Increasingly, beef importing countries are adopting animal traceability systems for domestic production and such systems are beginning to emerge as requirements for market access. International animal health, food safety, and world trade associations have recognized the value of effective animal traceability systems. Overall, the United States lags behind emerging world standards for animal ID and traceability. This places the United States in a potentially comparative disadvantage for future export market maintenance and growth. This section is intended to document developments in global cattle traceability. The traceability systems/requirements of major importers and exporters are compared and a strategic assessment is made of the United States relative to other major beef export competitors. This assessment serves as a guide for scenarios considered in subsequent sections regarding possible changes in meat export market access associated with animal traceability.

The focus of discussion in this section is cattle identification and traceability systems. In the United States, cattle traceability is a greater concern than hog traceability in large part because production systems make tracking cattle more difficult than tracking hogs. Because hogs are produced and marketed in large groups that typically remain together throughout the production phase, tracking origin by group is relatively simple. Conversely, cattle production systems have considerable co-mingling of cattle from different origins. As such, the majority of U.S. produced pork already has group/lot hog traceability (Blasi et al., 2009). Furthermore, age verification which is an important component of beef trade (but not pork trade) requires individual animal identification because animals are sorted and regrouped frequently under normal production practices.

**Global Guidelines**

Several notable world organizations have established international livestock identification guidelines including the World Organization for Animal Health, the World Trade Organization, the Food and Agriculture Organization of the United Nations, and Codex Alimentarius.

***World Organization for Animal Health (OIE)***

The OIE is an intergovernmental organization founded in 1924. Currently OIE has 175 member countries and territories. Its mission includes ensuring transparency of global animal disease status, collecting and disseminating veterinary scientific information, providing expertise in animal disease control, and safeguarding world trade by publishing health standards for international trade in animals and animal products. OIE has published general principles for animal identification and traceability for disease prevention and control in their *Terrestrial Animal Health Code*.

The 2010 *Terrestrial Animal Health Code* recognizes:

> *"1. Animal identification and animal traceability are tools for addressing animal health (including zoonoses) and food safety issues. These tools may significantly improve the effectiveness of activities such as: the management of disease outbreaks and food safety incidents, vaccination programmes, herd/flock husbandry, zoning/compartmentalisation, surveillance, early response and notification systems, animal movement controls, inspection, certification, fair practices in trade and the utilisation of veterinary drugs, feed and pesticides at farm level.*
>
> *2. There is a strong relationship between animal identification and the traceability of animals and products of animal origin."* http://www.oie.int/eng/normes/mcode/en_chapitre_1.4.1.htm

OIE suggests that no single identification system or method fits all needs. However, the organization recognizes animal ID and traceability as tools for addressing animal health *and* food safety issues. OIE recommends procedures that will, among other things:

a. Provide for unique animal or group lot identification;
b. Provide for animal traceability;
c. Establish birth time periods;
d. Determine when an animal was introduced into an establishment; and
e. Arrange for retiring identification devices.

The OIE suggests that animal identification, animal movement, and changes in numbers of livestock or livestock establishments should be reported to a central authority. A significant component of livestock and meat trade is conditional on certification of animal health status to reduce the likelihood of disease transmission through meat or animal trade. Animal ID and movement traceability facilitates the certification of animal health.

OIE leadership has taken a strong stance on animal identification and product traceability. An editorial by the Director General on July 2008 states:

> *"Animal identification and product traceability from the farm to the fork must be progressively implemented worldwide … As a tool for controlling disease in animals and food safety, a traceability system should enable an animal product to be traced back to the animal's farm of origin, and to be identified throughout the food production chain. Traceability constitutes the link between animal health, food safety and the organoleptic characteristics of food linked to its origin."* (Vallat, 2008).

***Codex Alimentarius***

The Codex Alimentarius Commission (Codex) was launched in 1963 by the Food and Agriculture Organization of the United Nations (FAO) and World Trade Organization (WTO) to develop codes of practice for global food standards. The Codex is comprised of 183 member countries. The organization was established to protect human health, facilitate fair trade practices, and promote improved and consistent world food standards.

The Codex *Code of Hygienic Practice for Meat (Code)* indicates that a principle of meat hygiene involves animal identification practices that "allow trace-back to the place of origin to the extent practicable, to allow regulatory investigation where necessary" (p. 9). The *Code* stresses the importance of animal or group identification capable of tracing back from abattoirs and dressing plants to the place of origin. The focus of the *Code* is to develop hygiene provisions for meat from live animal production systems through retail.

The FAO (2004) published *Good Practices for the Meat Industry* as a guide to the meat industry for implementing rising quality and safety standards for trade. The document details animal identification and traceability system mechanisms as a new standard that is becoming a norm in animal health management and consumer assurances. Barcos (2001) provides similar information detailing an animal identification system.

***World Trade Organization***

The World Trade Organization (WTO), launched in 1995 from the General Agreement on Tariffs and Trade (GATT), is comprised of 153 members. The main purposes of WTO are to facilitate fair trade negotiations, establish rules of trade, and settle trade disputes.

WTO supports a position on trade, in accordance with GATT rules, that allow governments to impose trade restrictions or requirements to protect human, animal, or plant life or health. Such standards cannot be used as protection from import competition, but rather, must be based on science. Member countries are encouraged under the Sanitary and Phytosanitary Measures Agreement (SPS) to employ international standards, guidelines, and recommendations in their trade policies. WTO recognizes OIE as the international organization establishing guidelines for protecting animal health and Codex as the basis for food safety standards.

Important components of the WTO SPS include:

> *"The WTO SPS Agreement provides member countries with a right to implement traceability as an SPS measure. However, this right is accompanied by certain obligations. The measures must be based on an assessment of the risks and be scientifically justified, appropriate to the circumstances, no more restrictive of trade than required and applied consistently, including between the country imposing the measure and other countries."* (Wilson and Beers, 2001, p. 383).

> *"If an exporting country can demonstrate that the measures it applies to its exports achieve the same level of health protection as in the importing country, then the importing country is expected to accept the exporting country's standards and methods."*
> http://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm4_e.htm

These statements indicate that if a country adopts an animal traceability system for their domestic livestock production sector to protect animal or human health, they may also apply the same standards to imports if appropriate justifications are made. For example, if Korea adopted an animal identification and traceability system for domestic bovine production, they could impose similar standards on countries importing beef into Korea.

***Synthesis***

Information from FAO, WTO, OIE, and Codex provides a clear signal of the need for individual animal identification, traceability, and global meat trade standards. Although differences in identification and traceability systems are apparent across countries and even across species within a single country, the underlying theme is that farm-to-retail traceability is rapidly becoming an international requirement for protecting human and animal health and providing consumer assurances.

**Comparisons of Identification Systems**

Many countries have developed animal identification and traceability systems. The systems differ in characteristics, protocols, technologies, implementation, depth, breadth, and precision (Golan et al., 2004).

***Past Studies***

Several studies have compared animal identification and traceability systems across countries. We summarize findings of four such studies (table VI.1). A caveat in interpreting the information contained in table VI.1 is that we have categorized the results based on the authors' interpretations of the status of animal ID and traceability systems at the time each study was completed. Certainly, the precision of some cell entries are subject to debate. However, the important issue is that, over time, trade rules have changed. For example, even the most current study (New Zealand MAF, 2009) is already out-of-date in several respects because of the rapid evolution of global animal traceability requirements.

The findings of previous studies in table VI.1 are:

1. The studies illustrate that animal traceability systems are becoming widespread around the world with 18 different countries, including 7 of the 8 currently largest beef exporters, evaluated across the studies.

2. Animal traceability systems are largely mandatory across the countries reviewed with the United States and Mexico being the most notable exceptions. As illustrated later, in the near future the United States may be one of only a few major producing countries with fully voluntary traceability.

3. Animal movement recording is common among countries with mandated tracing systems. Canada and New Zealand, the only two countries that do not currently record animal movement besides the United States, are currently designing such systems for implementation in 2011 (New Zealand MAF, 2009).

**Table VI.1. Summary of Studies Comparing Cattle Traceability Systems Across Selected Countries**

| Authors & Year | Country | Primary Production Establishments Identified | Individual ID Animals Leaving Premises | Herd ID Animals Leaving Premises | Record Animal Movement |
|---|---|---|---|---|---|
| Barcos 2001 | Argentina | M | no | M | |
| | Australia | M | M | M | |
| | Canada | M | V | M | |
| | Cyprus | M | no | M | |
| | Egypt | M | no | M | |
| | European Union | M | M | M | |
| Souza-Monteiro & Caswell 2004 | European Union | | M | M | |
| | Japan | | M | no | |
| | Australia | | M | M | |
| | Brazil | | M | M | |
| | Argentina | | M | M | |
| | Canada | | M | M | |
| | **United States** | | no | no | |
| Bowling et al. 2008 | Australia | M | M | | M |
| | Botswana | V | M | | M |
| | Brazil | M | M | | M |
| | Canada | V | M | | V |
| | European Union | M | M | | M |
| | Japan | M | M | | M |
| | Mexico | V | V | | V |
| | Nambia | M | M | | M |
| | New Zealand | V | V | | V |
| | South Korea | M | M | | M |
| | Uruguay | M | M | | M |
| | **United States** | V | V | | V |
| New Zealand MAF 2010 | Great Britain | M | M | | M |
| | Australia | M | M | | M |
| | Canada | M | M | | no |
| | Netherlands | M | M | | M |
| | Switzerland | M | M | | M |
| | Japan | V | M | | M |
| | South Korea | M | M | | M |
| | Argentina | | M | | |
| | Brazil | M | | | M |
| | New Zealand | M | V | | no |
| | **United States** | V | V | | V |

Note: M=mandatory, V=voluntary, no=not capable, blank means not studied or unknown

***Current Comparison***

Many countries are at various stages of adopting animal traceability systems. Furthermore, adoption is on-going, so that even recent studies are already dated. The discussion below updates what is often outdated information from previous studies summarized in table VI.1. Therefore, this report represents an update on the current status of animal traceability. We compare systems that currently exist in major meat exporting and importing countries. The major exporters are selected because they represent key international competitors in the global export market. The major import countries are selected because, as discussed earlier, each could impose their own domestic standards on countries from which they import without WTO challenges. Each country imposes their own system based on specific goals while employing different technologies. We attempt to identify salient characteristics of each traceability system that are likely most relevant for trade competitiveness and market access for the United States.

***Major Beef Export and Import Countries***

Leading meat export countries (excluding variety meats) are identified in table VI.2. The major beef exporters in 2010 are expected to be Brazil with about a 23% share of total world exports, Australia with an 18% share, and the United States with a 14% share.

**Table VI.2. Leading World Beef Exporters, 2007 - 2010 (Forecasted in October 2010)**

| | Year | | | | Market Share |
|---|---|---|---|---|---|
| Exporter | 2007 | 2008 | 2009 | 2010 | 2010 |
| | Thousand Metric Tons (carcass weight) | | | | |
| Brazil | 2,189 | 1,801 | 1,596 | 1,675 | 23% |
| Australia | 1,400 | 1,407 | 1,364 | 1,325 | 18% |
| **United States** | 650 | 856 | 878 | 1,036 | 14% |
| India | 678 | 672 | 609 | 700 | 10% |
| New Zealand | 496 | 533 | 514 | 510 | 7% |
| Canada | 457 | 494 | 480 | 525 | 7% |
| Argentina | 534 | 423 | 655 | 300 | 4% |
| Uruguay | 385 | 361 | 376 | 380 | 5% |
| Others | 782 | 943 | 638 | 755 | 10% |
| World Total | 7,571 | 7,490 | 7,110 | 7,206 | 100% |

Source: Foreign Ag Service, USDA

Leading beef import countries (excluding variety meats) are summarized in table VI.3. The United States is the world's leading beef importer in 2010 followed by Russia, Japan, European Union, Mexico, and South Korea. The most rapidly growing import countries are Vietnam and Hong Kong.

**Table VI.3. Leading World Beef Importers, 2007 - 2010 (Forecasted in October 2010)**

| | Year | | | | Market Share |
|---|---|---|---|---|---|
| Importer | 2007 | 2008 | 2009 | 2010 | 2010 |
| | Thousand Metric Tons (carcass weight) | | | | |
| **United States** | 1,384 | 1,151 | 1,191 | 1,126 | 16% |
| Russia | 1,030 | 1,137 | 895 | 940 | 14% |
| Japan | 686 | 659 | 697 | 695 | 10% |
| European Union | 642 | 466 | 495 | 490 | 7% |
| Mexico | 403 | 408 | 322 | 335 | 5% |
| South Korea | 308 | 295 | 315 | 345 | 5% |
| Vietnam | 90 | 200 | 250 | 275 | 4% |
| Canada | 242 | 230 | 247 | 235 | 3% |
| Egypt | 293 | 166 | 180 | 190 | 3% |
| Hong Kong | 90 | 118 | 154 | 200 | 3% |
| Others | 1,990 | 2,069 | 1,950 | 2,047 | 30% |
| World Total | 7,158 | 6,899 | 6,696 | 6,878 | 100% |

Source: Foreign Ag Service, USDA

## Traceability Systems of Major Exporters (Including Some Major Importers)

Table VI.4 presents a summary of cattle traceability systems in major exporting and importing countries.

### *Brazil*

Brazil developed a bovine traceability system with the creation of SISBOV (Brazilian Bovine and Bubaline Identification and Certification System). When SISBOV was originally designed, the intent was to require participation by all producers that supply cattle to meatpackers who produce beef for export (Lima, Bornstein, and Cukierman, 2006). SISBOV 's main function was to identify, register, and certify animals on farms. Under SISBOV, producers are required to report various production protocols including how an animal was bred, its principal diet, vaccinations, etc. Any incoming, outgoing, or animal deaths must also be reported (OIA, 2010). SISBOV is intended to be a full traceability system. Once a producer complies with SISBOV requirements, the production site is considered an ERAS (Cadastro do

Estabelecimento Rural Aprovado). An ERAS must pass an inspection every six months to maintain export status. The primary motivation for SISBOV was to increase access to the European Union and other export markets. One of the key drivers of SISBOV was better control of foot-and-mouth disease (FMD) in the Brazilian bovine herd, a long standing and recurring disease issue in Brazil. However, the system also cites food safety as a motivating driver.

***Australia***

Australia's NLIS (National Livestock Identification System) is a very advanced animal traceability system. Launched in 1999, NLIS became mandatory nationally in July 2005. NLIS uses a single national centralized database maintained by Meat and Livestock Australia. All animals are identified and movement traced across properties using RFID technologies.

> "*NLIS is a permanent whole-of-life individual animal identification system allowing an individual animal to be traced from its property of birth to its slaughter destination. NLIS has been designed to improve traceability, enhance food safety, ensure beef product integrity, to allow and sustain international market access, and to provide progressive livestock producers with enhanced managerial opportunities.*" (Tonsor and Schroeder, 2006, p.110).

***United States***

In February 2010, the United States decided to change directions and abandon the National Animal Identification System (NAIS) that it had been designing since 2002. A new animal identification system is being developed that will only apply to animals crossing state lines. Such animals need to be identified, but the modes of identification are left to individual states to decide. Whether the requirements will involve only breeding animals or if calves and yearlings will also be part of the system is unclear. The program is currently set to be launched in 2013. The motivation for the animal identification system is animal disease surveillance and control for animals crossing state lines.

***India***

India exports to emerging markets such as Malaysia, Philippines, the Middle East, Vietnam, and Africa (USDA – FAS, 2004). A large portion of India's exports are buffalo meat. We could find no information suggesting that an animal identification system is present in India. OIE does not consider India to be a FMD free zone.

***New Zealand***

A voluntary animal identification system has been present in New Zealand since 1999. Though generally voluntary, animal identification was mandatory for tuberculosis-infected herds. However, New Zealand recently launched the National Animal Identification and Tracing (NAIT) system that is set to become a mandatory ID and traceability system for all cattle in mid-2011.

> *"The National Animal Identification and Tracing (NAIT) project aims to develop and implement a system that will enable New Zealand to better manage biosecurity and food safety risks, ensure continued successful competition in premium livestock product markets, and will allow farmers [to] realise on-farm benefits through more efficient stock management."* (MAF, 2009, p. 1).

The purpose of NAIT is to

> "*...safeguard the New Zealand brand and farmers' income by protecting market access...through enhancing regulatory and consumer confidence in New Zealand's ability to manage biosecurity and food safety risks.*" (MAF, 2009, p. ii).

***Canada***

In 2001, the Canadian Cattle Identification Agency (CCIA) implemented a mandatory animal identification system. By 2002 all animals leaving their farm of origin had to be tagged with an official ID tag. Starting in 2010, the tags had to be RFID tags. Currently, CCIA is designing an animal movement

tracking system that will require animal movement recording in 2011. CCIA has added an age verification program to enable producers to easily age verify cattle through the ID system. The age verification system can be accessed based upon the individual animal tag number, by feedlots, auction markets, producers, and abattoirs (though downstream firms cannot determine the herd of origin from this information). The motivations for CCIA to adopt animal identification and traceability were controlling animal disease and assuring domestic and export market confidence. As a major importer, the status of Canada is also important for U.S. beef export opportunities.

***Argentina***

Foot-and-mouth disease has been a recurring problem in Argentina. The country's major beef trading partners (e.g., the United States and EU) have been encouraging Argentina to eradicate this disease. Certifications with respect to FMD are required for Argentine beef exports to the United States and the EU. To address these concerns, Argentina has adopted an animal traceability program. In 2007, a mandatory program was initiated requiring calves born after September 2007 to carry official ID tags. The entire herd is expected to be tagged by 2017 (McConnell and Mathews, 2008).

***Uruguay***

Similar to Argentina, Uruguay has had problems with FMD. They developed a national animal ID program to control the disease. In 1973, Uruguay launched a program to track the origin of animals through the government-created Division de Controlar de Semovientes (DICOSE) (McConnell and Mathews, 2008). In 2006, Uruguay began requiring two tags (a visible tag and an electronic tag) to identify cattle before an animal reached six months of age or is moved from its origin. All cattle are expected to be tagged in 2010. Traceability from individual beef cuts back to specific animals and their origins will be required beginning in 2010 (McConnell and Mathews, 2008).

### *Summary of Major Exporters*

The United States is clearly behind major competing beef export countries in the adoption of animal identification and traceability systems that are rapidly becoming international standards. Of the world's eight largest exporters, six have mandatory cattle animal identification and traceability systems. Only the United States and India have not adopted mandatory national ID and traceability systems. These systems are dynamic and rapidly evolving with several countries moving from simple animal ID to animal movement tracking within the next year. Motivations for launching and building upon animal ID and traceability programs frequently reference animal health management, export market access, food safety and assurances, and producer profitability. Improved supply chain coordination, animal biosecurity, and enhanced producer management opportunities are also frequently noted secondary benefits of animal ID programs. If the United States continues with its current animal ID program strategy, it will be increasingly difficult to demonstrate the same level of assurances major competing countries offer.

## Traceability Systems of Selected Major Importers

In general, identifying animal identification system information for major meat importers was a larger challenge than for major exporters. Therefore, we focus on a few select importers in this discussion. Arguably, the requirements of major importers are the most important as they establish the minimum standards that exporters will need for access to any single market. That is, major importers with ID and traceability systems could establish similar WTO-compliant standards for access to their domestic markets.

### *Japan*

In 2001 following discovery of BSE in Japan, the Ministry of Agriculture, Forestry, and Fisheries launched a pilot project to label beef products with information consumers could use to identify farms of origin (Marchant, 2002). In 2003, the Law for Special Measures Concerning the Management and Relay of Information for Individual Identification of Cattle (the beef traceability law) was enacted requiring all domestically produced beef to be traceable from consumers back to farms of origin (U.S. International

Trade Commission (USITC), 2008). All cattle are required to be tagged and animal movement must be reported to the government who maintains the database. The database includes information related to animal birth date, sex, breed, name and address of producer, location of fattening, and slaughter date (Pendegrass, 2007). The focus of beef marketing in Japan is to gain consumer confidence in products through making them "feel good". For example, some outlets provide photographs of beef producers who supply some retail programs (Clemens, 2003). By entering a unique 10-digit number of the individual animal identification code on the package label, a Japanese consumer can quickly access information about where an animal was raised, its sex, breed, birth date, locations where the animal lived throughout its lifetime, and slaughter location (e.g., see https://www.id.nlbc.go.jp/english/). Gaining trust of skeptical Japanese consumers is critical to assuring product safety. Animal traceability is a significant part of this assurance.

***European Union***

In 1997, in response to the BSE outbreak in Europe, the Council of the European Union launched an animal traceability system. The main motivations were improvements in animal and public health. Bovine are required to have a permanent unique individual identification to enable traceability from birth to slaughter. In addition to registering two ear tags per animal in a national database, a passport for each animal is also required. All animal movements across establishments are required to be reported to a central authority in each state.

***South Korea***

The principal concern for South Korea relative to U.S. beef imports is food safety issues related to BSE. Korean consumers want to know if beef products are from Hanwoo (Korean beef cattle breed) relative to Jeotso (Korean dairy cattle breed). In addition, consumers are especially concerned if beef products are from a country that has had cases of BSE (Smith et al., 2005). USITC (2008) reported that by June 2009, all beef produced in Korea (including beef and dairy breeds) would be included in a national beef traceability system. Similar to Japan, Korean consumers can enter bar code numbers from individual beef packages into computers at retail outlets to retrieve information about cattle age, where an animal was raised, producer names, and where an animal was slaughtered. South Korea announced it will

impose requirements that imported beef must also be traceable beginning in December 2010 (Johnston, 2010). All imports will be required to have identification numbers registered with the Ministry for Food, Agriculture, Forestry and Fisheries through the National Veterinary Research and Quarantine Service. The "bill of lading" currently used for U.S. beef shipments to South Korea are reported to already meet the traceability requirements back to U.S. suppliers (Farms.com, 2010).

***Mexico***

In 2003, Mexico launched a federal animal ID system administered by the federal Department of Agriculture. The National Livestock Individual Animal Identification System (SINIGA) goals were to provide a better cattle census, manage animal health, and provide traceability. The program is voluntary and includes an estimated 19% of Mexican cattle currently tagged with SINIGA tags (Ortega and Peel, 2010). SINIGA tags are issued with information cards that contain owner, type of cattle, and location information. The cards are intended to be updated and follow cattle when they are sold. The system was designed with bar codes, but they have not been used and only about 30% of officially SINIGA tagged animals have actually been entered into the central governmental database (Ortega and Peel, 2010).

The United States is a major market for Mexican feeder cattle. However, concerns with bovine tuberculosis have motivated development of an electronic animal traceability system for cattle exported to the United States from the state of Chihuahua. The system, referred to as SICOMORA, was designed to identify the herd of origin, protect against illegal entrance into Chihuahua of cattle from other Mexican states, and provide traceability of animals back to the herd of origin. Cattle that have passed brucellosis and tuberculosis tests have herd origin and zoosanitary certificates, are spayed (if heifers), and have a cattle movement permit are eligible for export to the United States (Ramírez, 2010).

***Summary of Selected Major Importers***

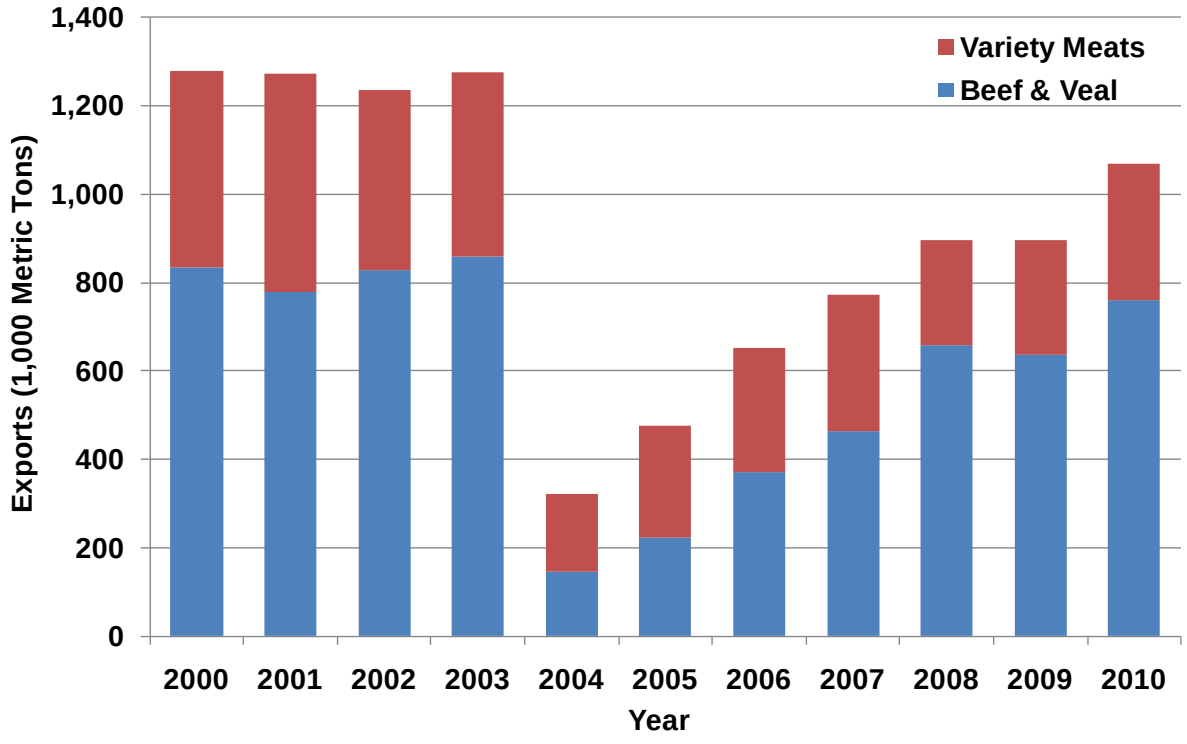
Importing countries are adopting animal traceability systems similar to those of major exporters. Animal disease control and food safety assurances highlight the main goals of these systems. Consumers in European and Asian markets increasingly require traceability protocols. In some cases, consumers are demanding access to animal movements and the identification of animal owners as elements of beef product safety assurances. As such, these countries likely will continue to add traceability requirements to importers. Access to these markets will depend upon demonstrated individual animal traceability.

| **Table VI.4. Summary of Cattle Traceability Systems as of August 2010, Selected Major Exporters** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | National | ID | Animal | |
| | System | Launch | | Individual | System | Movement | |
| Country (*web location*) | Name | Date | Mandatory | Animal ID | | Tracking | Motivation |
| Brazil | ERAS & SISBOV | 2002-03 | For export animals, unclear for rest | Yes? | Various forms | Yes | Control FMD and Market access to EU |
| *(http://www.oiabrasil.com.br/prog-sisbov-1.htm)* | | | | | | | |
| Australia | NLIS (National Livestock Identification System) | 1999, mandatory in 2005 | Yes | Yes | RFID | Yes | Export Market access, food safety, animal disease |
| *(http://www.mla.com.au/Meat-safety-and-traceability/Livestock-identification)* | | | | | | | |
| **United States** | None | ~2013 | For animals crossing state lines only | No | Various forms | No | Control diseases for animals crossing states |
| *(http://www.aphis.usda.gov/traceability/)* | | | | | | | |
| India | None | | No | No | | No | |
| | | | | | | | |
| New Zealand | NAIT (National Animal Identification and Tracing) | 2006 | Yes beginning mid-2011 | Yes | RFID | To begin 2011 | Market access and TB management |
| *(http://www.nait.co.nz/)* | | | | | | | |
| Canada | CCIA, Canadian Cattle Identification Agency | 2002 | Yes | Yes | RFID | To begin 2011 | Market access accelerated with BSE |
| *(http://www.canadaid.com/index.html)* | | | | | | | |
| Argentina | Argentina Animal Health Information System - Sistema de Gestion Sanitaria (SGS) | 2007 | Expected by 2017 | Yes? | Various | ? | Control FMD and market access |
| *(http://www.senasa.gov.ar/indicadores.php?in=1)* | | | | | | | |
| Uruguay | Division de Controlar de Semovientes (DICOSE) | 2006 mandatory | Yes | Yes | RFID | Yes | Control FMD and market access |
| *(http://www.mgap.gub.uy/DGSG/DICOSE/dicose.htm)* | | | | | | | |

| **Table VI.4. Summary of Cattle Traceability Systems as of August 2010, Selected Major Importers** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | National | ID | Animal | |
| | System | Launch | | Individual | System | Movement | |
| Country (*web location*) | Name | Date | Mandatory | Animal ID | | Tracking | Motivation |
| Japan | Law for Special Measures Concerning the Management and Relay of Information for Individual Identification of Cattle (the beef traceability law) | 2003 | Yes | Yes | ear tag | Yes | Response to BSE discovery to restore consumer confidence |
| *(https://www.id.nlbc.go.jp/english/)* | | | | | | | |
| European Union | Each member state has own system name | 1997 current law 2000 | Yes | Yes | No, under review | Yes | Animal health and BSE response |
| *(http://ec.europa.eu/food/animal/identification/bovine/legislation_en.htm)* | | | | | | | |
| Mexico | National Livestock Individual Animal Idenficiation System (SINIGA) | 2003 | No | Yes | Bar code tags | Yes | Animal health, census, traceability |
| *(http://www.sagarpa.gob.mx/ganaderia/Paginas/default.aspx)* | | | | | | | |
| South Korea | South Korea Beef Traceability System | 2004 and updated in 2009 | Yes | Yes | RFID | Yes | Consumer food safety assurance and animal healh management |

U.S. beef, veal, and beef variety meat exports have been an important component of overall beef demand. During the early 2000s, beef exports (including veal and variety meats) exceeded 1.2 million metric tons annually (figure VI.1). Beef exports (excluding variety meats) averaged about 9-10% of total beef production during the early part of the decade. However, following the first U.S. BSE infected cow discovery in December 2003, beef and beef variety meat exports dramatically declined in 2004 to about one-quarter of their pre-BSE level. Since then, recovery of beef exports has been slow and stalled in 2009 during the global economic recession. By 2009, six years after the BSE discovery, total U.S. exports of beef and variety meats were at approximately 70% of their pre-BSE level. Preliminary data suggest beef exports will increase in 2010 relative to 2009.

**Figure VI.1. US Exports of Beef & Veal and Beef Variety Meats, 2000-2010.**




Source: Department of Commerce, U.S. Census Bureau, Foreign Trade Statistics (FATUS)

Beef exports are driven by a large number of interrelated factors. Important determinants of exports include:

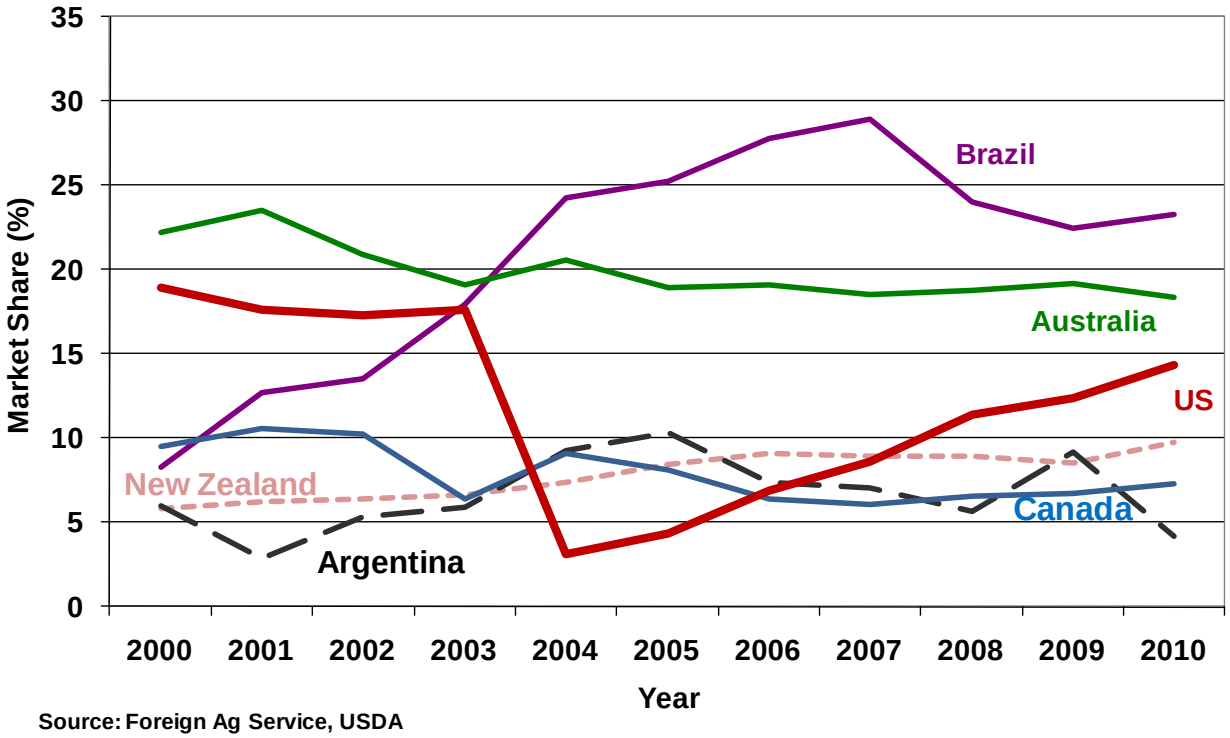
1. Export country beef prices;
2. Competing export countries' beef prices;
3. Import country beef prices;
4. Relative exchange rates;
5. Sanitary and phytosanitary conditions;
6. Consumer preferences in importing countries;
7. Trade barriers; and
8. Political relations.

Because many factors affect trade, isolating the impact of animal and meat traceability on trade is difficult. One way to assess the impact of animal traceability on trade is to consider a variety of potential trade scenarios. Traceability could have a marginal impact on trade in cases where some customers demand it and others do not. That is, the presence of a traceability system might increase exports to certain markets. However, beef traceability, or lack thereof, is likely to have a larger affect because it might limit access to a particular country. The likely larger impact of traceability is that its presence might cause temporarily-closed markets to re-open more quickly. In addition, such systems may allow market access to a particular import country in the event of either a U.S. food-safety or animal disease occurrence. Similarly, if an import country imposes traceability as a necessary condition for beef imports, only products that are traceable would have access.

To understand the strategic position of the United States relative to major competing export and import countries, information was collected regarding the status of market access. Table VI.5 summarizes the trade status for selected major export and import countries. The United States, Canada, and Brazil share the same BSE status of *controlled risk* in OIE classification whereas; Australia, New Zealand, and Argentina enjoy *negligible risk*. The United States petitioned for reclassification as *negligible risk* in 2010, but was denied the upgraded status by OIE. BSE is a substantial market access issue. As is shown in figure VI.2, the U.S. share of world beef exports declined from 17% in 2003 to 3% in 2004 following the first case of BSE in December 2003. Nearly every U.S. export market closed in early 2004.

Furthermore, recovery from this reduction in market access has been slow with U.S. market share increasing only to 11% in 2009. Other major exporters face similar market access problems in specific markets because of BSE (e.g., Canada) or FMD (e.g., Brazil and Argentina).

**Figure VI.2. Market Shares of Selected Leading World Beef Exporters, 2000-2010 (Forecast in October 2010)**




Source: Foreign Ag Service, USDA

The United States faces a number of restrictions relative to specific importing countries including animal age requirements, required country-specific USDA Export Verification programs for product to be eligible for export, traceability requirements, required affidavits that beef is not from cattle imported into the United States directly for slaughter from Mexico or Canada, or non-hormone treated cattle (NHTC) requirements. The myriad of restrictions across countries is especially pertinent to the export of edible and inedible offal and variety meats as the United States does not consume these products in large amounts domestically. For example, beef variety meats comprised about 30% of total beef and variety meat export volume in 2009. Typically, more than 35% of beef variety meat production and more than 50% of beef liver production is exported. Although variable over time, more than 50% of

beef tongues are exported. As such, when exports are curtailed, impacts are large because many beef products that are exported in large volumes have much lower values in the domestic market.

Several implications of the export market access status for U.S. beef are noteworthy:

1. Following the 2003 U.S. BSE discovery, loss of Asian export market access was particularly costly. In 2003, Japan and South Korea represented about 60% of U.S. beef exports (table VI.5). In 2009, these two countries still only comprise about 20% of U.S. exports. The Asian markets are substantial strategic markets for U.S. beef. However, access to Japan is challenging because of stringent age requirements. As such, beef exported from the United States to Japan requires producer participation in USDA source and age verification programs. Animal identification and traceability facilitates source and age verification programs. Canada, with its mandatory ID system and available source and age verification program, has a comparative advantage relative to the United States for meeting the Japanese requirements.

2. Overall, access for U.S. beef exports to major importers is complicated by a large number of varying access requirements. For example, various maximum age requirements are common and country-specific export verification programs are often required. Different requirements and definitions exist across countries relative to specified risk material (SRM). Some programs require tracing to farm of origin, and the EU requires NHTC verification. The various market access requirements make sourcing beef products a challenge that would be reduced with animal identification and traceability. Certainly, Australia and New Zealand have comparative advantages in meeting cumbersome export market access requirements. Grain finishing in Australia has gained in popularity, though it still represents a small portion of their overall production. If grain finishing in Australia grows, this will increasingly be a direct challenge to the U.S.

3. Countries that grass finish cattle have a comparative advantage in serving the EU market given NHTC requirements. However, a market niche does exist for NHTC grain fed beef. Canada and the United States are about equally suited for supplying this market, with Canada possibly facing a relative disadvantage given transportation of products from Western Canada.

4. Relative to the other major exporters in table VI.5, the United States has the least developed animal identification system. As such, additional export market access constraints that include ID and traceability protocols would place the U.S. industry at a competitive disadvantage.

**Table VI.5. Comparison of Export Country Market Access to Selected Import Countries as of September 1, 2010.**

| | National | OIE | OIE | Dominant | Import Country Sanitary and Phytosanitary Restrictions on Beef Imports | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Export Country | Animal Traceability | BSE Status | FMD Status | Cattle Finishing | Japan | China | South Korea | Taiwan | Hong Kong | Europe (EU-27) | Russia | Canada | Mexico |
| Share of US Exports 2003 (FAS) | | | | | 34.7% | 0.4% | 24.8% | 1.9% | 1.8% | 0.2% | 0.4% | 9.4% | 22.4% |
| Share of US Exports 2009 (FAS) | | | | | 12.8% | 0.0% | 8.3% | 4.2% | 3.6% | 2.2% | 0.7% | 20.5% | 31.7% |
| Share of Imports from US 2009 (Global Trade Atlas) | | | | | 14.0% | 0.0% | 26.5% | 29.7% | 16.0% | 2.3% | 0.5% | 65.7% | 80.2% |
| US | No | Controlled | Free | Grain | <21 mo, EV Required | Not Eligible | <30 mo, EV Required | <30 mo, EV Required, | <30 mo, EV Required, Traceable to farm of origin | NHTC Required | <30 mo, EV Required | No Restrictions, No EV | < 30 mo, EV Required |
| Canada | Yes | Controlled | Free | Grain | Age verfication CCIA | boneless, <30 mo, full traceability | Not Eligible | <30 mo | <30 mo, Traceable to farm of origin | < 30 mo, NHTC Required | <30 mo, or boneless 30 mo + | | <30 mo |
| Australia | Yes | Negligble | Free | Grass | No Restrictions | No Restrictions | No Restrictions | No Restrictions | No Restrictions | No Restrictions | No Restrictions | No Restrictions | No Restrictions |
| New Zealand | Yes | Negligble | Free | Grass | No Restrictions | No Restrictions | No Restrictions | No Restrictions | No Restrictions | No Restrictions | No Restrictions | No Restrictions | No Restrictions |
| Brazil | Yes? | Contolled | Mixed / Vaccinate | Grass | FMD Restrictions | No Restrictions | Not Eligible | Not Eligible | No Restrictions | Inspection, Traceability | No Restrictions | No Restrictions | |
| Argentina | Yes? | Negligble | Free / Vaccinate | Grass | FMD Restrictions | Not Eligible | Not Eligible | Not Eligible | No Restrictions | Inspection, Traceability | No Restrictions | No Restrictions | Not Eligible |

Sources:

USDA, FSIS, Export Requirements for Meat and Poultry Products: Available at http://www.fsis.usda.gov/regulations/index_of_import_requirements_by_country/index.asp#meat&poultry

http://www.inspection.gc.ca/english/fssa/meavia/man/ch11/11.7e.shtml

USDA, FAS, Global Agricultural Trade System Online. Available at: http://www.fas.usda.gov/gats/ExpressQuery1.aspx

Global Trade Atlas, data provided by Erin Daley, USMEF.

Thanks to Kevin Smith UMSEF for assistance with import country status data collection

## VII. DIRECT COSTS OF MEETING RED MEAT EXPORT REQUIREMENTS

Personal interviews were conducted with companies overseeing five process verified programs that include source and age verification (SAV) protocols and related production practice verification services. To protect the confidentiality of information shared by these companies, specific details on individual firms will not be presented. However, our discussions included conversations with firms holding significant market shares in the current provision of source and age verification as well as firms that have recently experienced notable growth. Accordingly, we are confident that the assumed direct costs of participation are reasonable and consistent with current service offerings present in the market. The participation cost and qualitative information offered by these firms are core inputs in our analysis. This information was combined with insights from the team's experience in conducting a benefit-cost analysis of the National Animal Identification System (NAIS) to develop baseline industry cost estimates of adopting traceability systems to meet evolving export market access requirements.

Because the companies interviewed either require, or highly recommend, producers identify cattle with radio frequency identification (RFID) tags, this technology serves as the basis for the cost estimates for the beef and dairy industries. While there is not a direct SAV counterpart for the swine industry, it was assumed that swine producers would participate in a third-party verification program similar to that of the cattle industry except that individual animal identification would not be needed. The approach used in this study for estimating direct costs at the producer and packer levels follows that of the NAIS benefit-cost (B-C) study (Blasi et al., 2009) with several notable exceptions. Direct costs associated with registering premises, reading RFID tags, and storing ID data that were estimated in the NAIS B-C study were excluded from this analysis because they are not applicable. However, the costs of participating in an SAV program (or similar source verification program for the swine industry) as administered by a private company were included. That is, the costs of recording, reading, storing data, and tracing back to producers are assumed to be incorporated into program fees (i.e., enrollment fees) paid to a third party. The other change is that the NAIS B-C data reflected costs, inventories and number of operations in 2007, which have been updated to 2009 in this analysis. Finally, while the NAIS B-C study included direct cost estimates for the bovine, porcine, ovine, and poultry industries, this study focuses strictly on the bovine and porcine industries.

The NAIS B-C study provided a thorough explanation of the many assumptions required to complete the analysis and provided numerous tables of information that supported the results. Because readers can refer to the NAIS B-C study for details, they are not reported here. Rather, the focus of this report is on the results and any major assumptions that might differ from the NAIS B-C report.

**Direct Cost Estimates: Cattle/Beef**

Costs were estimated by segmenting the cattle industry into five main groups (referred to as operation types and sectors): 1) Beef Cow/Calf, 2) Dairy, 3) Backgrounder (also referred to as Stocker), 4) Feedlot, and 5) Packing Plant. Estimating costs separately for these different operations makes it possible to see how each segment of the cattle industry would be impacted by adopting source and age verification practices.[6] For each of the different "operation types," costs were also estimated for different sized operations based on USDA reported size categories (with the exception of Backgrounder operations where size categories were estimated).

The Beef Cow/Calf and the Dairy groups were split into two subcategories: operations that currently identify calves individually and those that do not. Operations currently identifying calves individually use various methods of identification (e.g., plastic ear tags, metal tags, branding, tattoos, etc.). Of the various methods, plastic ear tags are the most common with 80.7% of operations identifying calves individually using this form of ID (USDA, 2008a). For this report, all operations that currently identify calves individually are referred to as "tagging operations" and incremental costs associated with RFID are based on the use of a "second tag". The taxonomy of tagging operations for Cow/Calf producers was based on information reported in the National Animal Health Monitoring System (NAHMS) publication titled *Part 1: Reference of Beef Cow-Calf Management Practices in the United States, 2007-08* (USDA, 2008a). Similarly, the categorization of tagging operations for Dairy producers was based on information found in the NAHMS report *Dairy 2007 Part I: Reference of Dairy Cattle Health and Management Practices in the United States* (USDA, 2007). The methods of estimating costs apply to both subcategories (those who already tag and those who do not) unless stated otherwise.

[6] In the NAIS B-C study Auction Yards were also included as another operation type; however, this group is not relevant in this study because the costs they incurred in the earlier study would be part of the SAV program costs absorbed by other sectors.

The following discussion of cattle industry costs is partitioned into the five operation types. The costs for each operation type are based on total direct costs associated with all cattle in the industry being identified and participating in an SAV program as administered by a third party. Costs with less than 100% participation will be discussed in a later section. These five group subtotals were summed to obtain the total final cost for the cattle (bovine) industry.

***Cow/Calf Sector***

Tables VII.1 and VII.2 summarize costs of participating in an SAV program for beef cow/calf operations that currently do and do not tag, respectively, by operation size. Tagging costs consist of the following: RFID tags, tag applicator, labor, chute charge, cattle shrink, and injury (both animal and human) and were calculated in the same manner as the NAIS B-C study. Tag costs ranged from $2.25/tag for small volumes (less than 25) to $1.75/tag for large volumes (500 or more) based on quotes from various companies. These costs were slightly lower than the NAIS B-C study because this technology is becoming more common and costs have fallen. SAV participation costs were based on cost "schedules" developed from information obtained from five companies currently offering SAV programs. These schedules reflect a combination of fixed annual costs and per head charges based on operation size.

The smallest operations have higher costs per head than larger operations, regardless of whether they are currently tagging (table VII.1) or not (table VII.2). Economies of size are much more related to SAV program participation costs than tagging costs because of fixed enrollment fees charged by SAV programs. The costs for operations currently not tagging are higher because of custom tagging costs as opposed to the marginal cost of tagging a calf with a second tag. From a cost standpoint, a traceability program that requires individual cattle to be tagged will create larger burdens for operations that are not currently tagging. Also, regardless of whether an operation currently tags or not, very small operations (i.e., those with less than 50 cows) would have significantly higher costs. This is not unexpected because the total cost for a third party to verify the source and age of calves from a small operation are similar to a large operation. Thus, per head costs are much higher. The costs per operation range from $185 ($14.51/head sold) for small operations currently tagging calves to $29,012 ($5.39/head sold) for very large operations not currently tagging calves. However, the costs per head

sold range from $15.83/head ($202/operation) for small operations not currently tagging their calves to $2.75/head ($14,784/operation) for very large operations currently tagging calves.

***Dairy Sector***

Tables VII.3 and VII.4 summarize the costs of participating in an SAV program for dairy operations that currently tag and not tag, respectively, by operation size. Unlike the beef cow/calf sector, a much higher percentage of operations currently ID cattle (86.5% of operations compared to only 44.6% of beef cow/calf operations). As expected, the costs follow a similar pattern as the beef cow/calf sector, i.e., costs per head are higher for small compared to large operations. However, a difference with dairy is that small operations not currently tagging do not have higher costs than those that tag. This is because it was assumed that operations currently tagging would enroll all calves in an SAV program at birth (and buy RFID tags). Conversely, operations not currently tagging would make this decision as calves are sold and, thus, would only enroll calves (and buy RFID tags) for those that survive and are marketed. The other difference between dairy operations and beef cow/calf is that costs per animal sold are generally higher because dairies tend to market fewer calves annually per cow (i.e., a large proportion of heifers are retained). Costs per operation range from about $190 for the smallest operations (regardless of whether currently identifying calves individually) to $7,500-$9,900 for the largest operations (with the higher costs being for operations not currently identifying animals individually).

***Backgrounding and Feedlot Sectors***

Tables VII.5 and VII.6 summarize the costs of participating in an SAV program for backgrounding and feedlot operations, respectively, by operation size. Because it is assumed that calves were tagged prior to this stage of production, tagging costs are confined to the replacement of lost tags. Thus, most of the costs are attributed to the fees for participating in a traceability program (i.e., SAV enrollment fees). However, for very large feedlots, this cost is small on a per head basis because the costs are spread over a large number of cattle. Thus, as was seen with the cow/calf and dairy sectors, the costs per head are significantly higher for very small operations, but decrease rapidly as operation size increases because of the fixed costs of SAV enrollment. The estimated costs per operation are fairly constant across operation size for backgrounding operations – ranging from $709 to $1,137. For feedlots, the annual

costs range from an average of slightly less than $800 per operation for the smallest feedlots to an annual average of over $13,000 for the largest feedlots.

**Table VII.1. Summary of SAV Participation Costs for Beef Cow/Calf Operations that Currently Tag Cattle by Size of Operation**

| | Size of Operation, number of head | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1-49 | 50-99 | 100-499 | 500-999 | 1000-1999 | 2000-4999 | 5,000+ |
| Costs per head sold | | | | | | | |
| Tags and tagging cost | $4.21 | $2.90 | $2.73 | $2.43 | $2.42 | $2.43 | $2.40 |
| SAV participation cost | $10.30 | $2.38 | $0.91 | $0.53 | $0.45 | $0.39 | $0.35 |
| Total annual cost | $14.51 | $5.28 | $3.65 | $2.96 | $2.86 | $2.82 | $2.75 |
| Costs per operation | | | | | | | |
| Tags and tagging cost | $54 | $163 | $416 | $1,326 | $2,637 | $4,905 | $12,903 |
| SAV participation cost | $131 | $134 | $139 | $289 | $487 | $797 | $1,881 |
| Total annual cost | $185 | $296 | $555 | $1,614 | $3,124 | $5,702 | $14,784 |
| Total number of operations | 233,818 | 51,086 | 46,939 | 3,106 | 793 | 200 | 43 |
| Total industry cost, thousand $ | $43,221 | $15,146 | $26,046 | $5,014 | $2,476 | $1,140 | $633 |

**Table VII.2. Summary of SAV Participation Costs for Beef Cow/Calf Operations Currently Not Tagging Cattle by Size of Operation**

| | Size of Operation, number of head | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1-49 | 50-99 | 100-499 | 500-999 | 1000-1999 | 2000-4999 | 5,000+ |
| Costs per head sold | | | | | | | |
| Tags and tagging cost | $5.54 | $5.29 | $5.20 | $5.04 | $5.04 | $5.04 | $5.04 |
| SAV participation cost | $10.29 | $2.37 | $0.90 | $0.52 | $0.44 | $0.39 | $0.34 |
| Total annual cost | $15.83 | $7.66 | $6.10 | $5.57 | $5.49 | $5.43 | $5.39 |
| Costs per operation | | | | | | | |
| Tags and tagging cost | $71 | $297 | $791 | $2,747 | $5,505 | $10,185 | $27,160 |
| SAV participation cost | $131 | $133 | $138 | $285 | $481 | $786 | $1,852 |
| Total annual cost | $202 | $430 | $929 | $3,032 | $5,986 | $10,971 | $29,012 |
| Total number of operations | 364,182 | 30,914 | 20,261 | 1,244 | 317 | 80 | 17 |
| Total industry cost, thousand $ | $73,465 | $13,288 | $18,824 | $3,772 | $1,900 | $879 | $498 |

**Table VII.3. Summary of SAV Participation Costs for Dairy Operations that Currently Tag Cattle by Size of Operation**

| | Size of Operation, number of head | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1-49 | 50-99 | 100-199 | 200-499 | 500-999 | 1,000-1,999 | 2000+ |
| Costs per head sold | | | | | | | |
| Tags and tagging cost | $5.57 | $4.06 | $4.03 | $3.69 | $3.43 | $3.39 | $3.34 |
| SAV participation cost | $11.77 | $3.34 | $1.88 | $1.69 | $0.79 | $0.67 | $0.49 |
| Total annual cost | $17.34 | $7.40 | $5.91 | $5.38 | $4.23 | $4.06 | $3.83 |
| Costs per operation | | | | | | | |
| Tags and tagging cost | $62 | $162 | $291 | $591 | $1,238 | $2,429 | $6,601 |
| SAV participation cost | $131 | $133 | $136 | $271 | $286 | $483 | $970 |
| Total annual cost | $193 | $296 | $427 | $862 | $1,525 | $2,912 | $7,571 |
| Total number of operations | 27,594 | 14,965 | 7,439 | 3,330 | 1,471 | 787 | 640 |
| Total industry cost, thousand $ | $5,337 | $4,423 | $3,180 | $2,871 | $2,242 | $2,292 | $4,846 |

**Table VII.4. Summary of SAV Participation Costs for Dairy Operations Currently Not Tagging Cattle by Size of Operation**

| | Size of Operation, number of head | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1-49 | 50-99 | 100-199 | 200-499 | 500-999 | 1,000-1,999 | 2,000+ |
| Costs per head sold | | | | | | | |
| Tags and tagging cost | $5.04 | $4.87 | $4.79 | $4.70 | $4.62 | $4.55 | $4.55 |
| SAV participation cost | $11.74 | $3.32 | $1.85 | $1.66 | $0.77 | $0.65 | $0.47 |
| Total annual cost | $16.79 | $8.19 | $6.64 | $6.37 | $5.38 | $5.20 | $5.02 |
| Costs per operation | | | | | | | |
| Tags and tagging cost | $56 | $194 | $346 | $753 | $1,665 | $3,262 | $8,987 |
| SAV participation cost | $131 | $132 | $134 | $267 | $276 | $466 | $926 |
| Total annual cost | $187 | $327 | $480 | $1,020 | $1,941 | $3,728 | $9,913 |
| Total number of operations | 4,307 | 2,336 | 1,161 | 520 | 230 | 123 | 100 |
| Total industry cost, thousand $ | $807 | $763 | $558 | $530 | $446 | $458 | $990 |

**Table VII.5. Summary of SAV Participation Costs for Backgrounding Operations by Size of Operation**

| | Size of Operation Size, number of head | | | | | | |
|---|---|---|---|---|---|---|---|
| | 31 | 104 | 345 | 496 | 722 | 1,453 | 2,963 |
| Costs per head sold | | | | | | | |
| Tags and tagging cost | $0.75 | $0.43 | $0.22 | $0.19 | $0.20 | $0.16 | $0.14 |
| SAV participation cost | $22.76 | $6.71 | $2.01 | $1.40 | $0.96 | $0.48 | $0.25 |
| Total annual cost | $23.51 | $7.14 | $2.24 | $1.59 | $1.16 | $0.64 | $0.39 |
| Costs per operation | | | | | | | |
| Tags and tagging cost | $23 | $44 | $76 | $94 | $141 | $224 | $396 |
| SAV participation cost | $686 | $686 | $686 | $686 | $686 | $687 | $741 |
| Total annual cost | $709 | $731 | $763 | $780 | $827 | $911 | $1,137 |
| Total number of operations | 21,438 | 11,334 | 6,333 | 4,333 | 3,329 | 2,316 | 1,787 |
| Total industry cost, thousand $ | $15,197 | $8,280 | $4,829 | $3,381 | $2,753 | $2,109 | $2,032 |

**Table VII.6. Summary of SAV Participation Costs for Feedlot Operations by Size of Operation**

| | Size of Operation, feedlot capacity (head) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1-999 | 1000-1999 | 2000-3999 | 4000-7999 | 8000-15999 | 16000-31999 | 32000+ |
| Costs per head sold | | | | | | | |
| Tags and tagging cost | $0.50 | $0.16 | $0.14 | $0.12 | $0.12 | $0.12 | $0.12 |
| SAV participation cost | $15.39 | $0.79 | $0.44 | $0.36 | $0.17 | $0.09 | $0.03 |
| Total annual cost | $15.89 | $0.96 | $0.58 | $0.48 | $0.29 | $0.21 | $0.15 |
| Costs per operation | | | | | | | |
| Tags and tagging cost | $25 | $157 | $356 | $660 | $1,620 | $3,799 | $10,389 |
| SAV participation cost | $769 | $771 | $1,097 | $1,903 | $2,337 | $2,992 | $3,015 |
| Total annual cost | $794 | $928 | $1,453 | $2,563 | $3,958 | $6,791 | $13,404 |
| Total number of operations | 80,000 | 810 | 575 | 340 | 185 | 132 | 128 |
| Total industry cost, thousand $ | $63,555 | $752 | $835 | $871 | $732 | $896 | $1,716 |

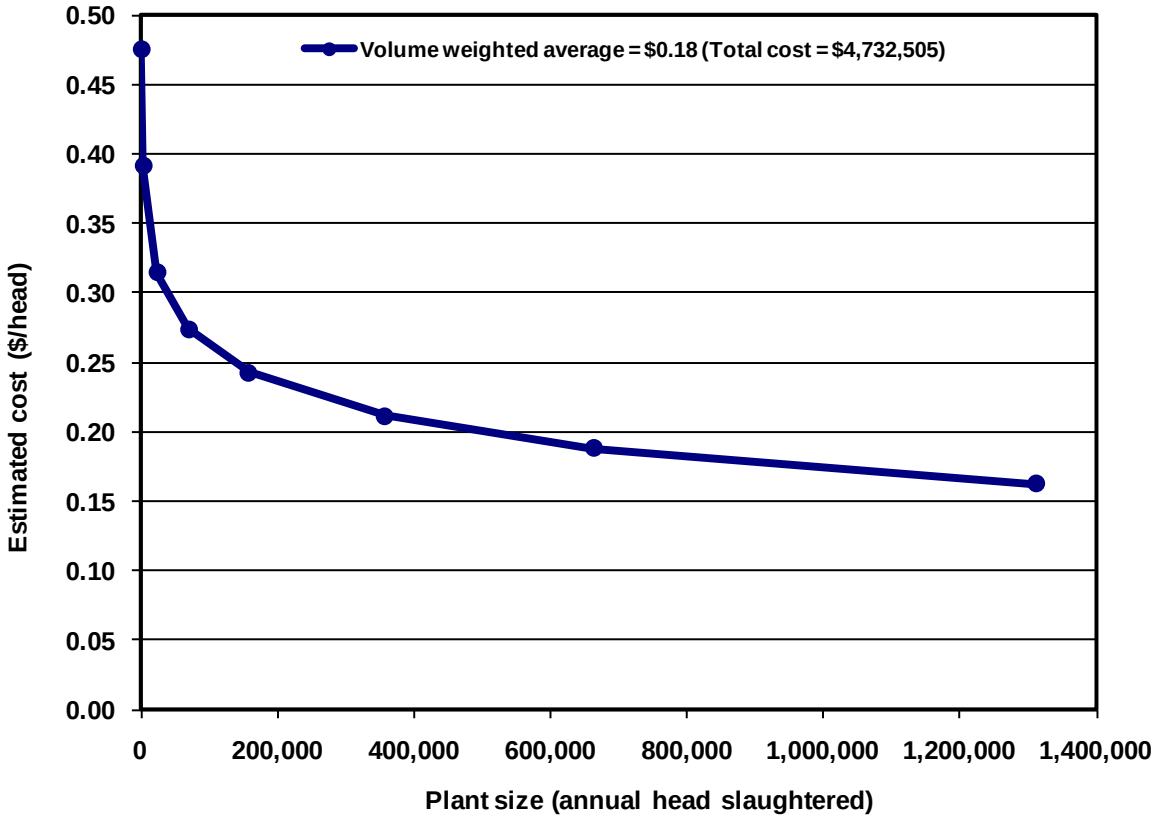
***Packing Plant Sector***

Traceability costs incurred by cattle packing plants depend on numerous factors, but primarily on plant size. For this analysis, packing plant SAV costs were based on reduced plant efficiencies associated with tracking cattle. To determine how enrollment in SAV programs might impact packing plants of various sizes, a distribution of plant sizes was required. Information on the number and size of steer and heifer, cow and bull, and calf packing plants was obtained from USDA GIPSA (USDA, 2008b). Average values for 2002-2006 were used to identify the distribution of plant sizes and then adjusted to 2009 marketings.

Costs associated with traceability programs in packing plants were based on an estimate of kill floor downtime. Based on interviews with personnel from two large packing plants, it was estimated that traceability would result in an average of six additional minutes of downtime per week.[7] Non-animal costs for packing plants of various size categories were estimated using a published cost function (RTI International, 2007a) and data relevant for 2009. Based on the average estimate of downtime costs for large packing plants and predicted non-animal costs, it was estimated that costs would increase 0.12% on a weekly basis for large plants ($0.16/head processed). This percentage was applied to estimated non-animal costs for packing plants of all sizes to obtain estimates of per head cost increases by plant size. Cost increases associated with a traceability program for steer and heifer slaughter plants ranged from a low of $0.16/head for the largest plants (average of approximately 1.3 million head per plant per year) to a high of $0.47/head for the smallest plants (average of slightly over 300 head per year). Figure VII.1 presents estimated packing plant costs associated with SAV programs by plant size and the volume weighted average value of $0.18/head identified for the packing plant sector.

[7] The average cost of downtime on the kill floor ($/minute) from the two plants is used to estimate costs, but specific values are not reported here for confidentiality reasons.

**FIGURE VII.1. COSTS ASSOCIATED WITH SAV PARTICIPATION IN STEER AND HEIFER PACKING PLANTS (BASED ON 2009 VOLUMES AND COSTS).**



***Summary of Cattle/Beef Industry***

Table VII.7 reports the total estimated cost to the cattle/beef industry by sector and by various levels of adoption/participation. At 100% participation, the total estimated cost to the industry would be approximately $350 million with almost 60% of that cost being incurred at the cow-calf level. This is due principally to the costs of RFID tags. Assuming that early adopters of traceability (i.e., SAV) programs are those producers with the lowest costs, table VII.7 (far right column) indicates how industry costs increase with adoption rates. That is, the "Uniform" adoption method reflects costs increasing linearly as adoption rate increases. However, with a voluntary program we would expect lower cost operations (i.e., large operations currently tagging calves) to be early adopters. Thus, the more likely scenario (and that used in our analysis) is where costs increase at an increasing rate at higher adoption rates as depicted in the "Low Cost" column of table VII.7. Personal interviews suggest that about 10% of the industry is already involved in SAV programs. Thus, the added cost of increasing 10 percentage points to reach an industry level of 20% would be approximately $13 million (or 20% adoption costs of $24.3 million, minus 10% adoption costs of $11.3 million). For comparison, note that the added cost of increasing adoption rate 10 percentage points going from 90% to 100% adoption is over $115 million. The marginal cost of increasing adoption or participation in traceability programs increases because of the disparity between costs of operations within the industry and largely reflects why sub-sets of the industry are notably less likely to voluntarily participate.

We believe the total estimated cost to the industry of approximately $350 million is a conservative estimate in that it likely represents an upper bound to what costs might actually be for several reasons. First, we assume that producers would use RFID tags. However, this is not a requirement and producers could use bright visual tags. At current costs, bright visual tags would be about 50% of the cost of RFID tags. If this change were made (all else equal), the $350 million estimate of total industry costs (with 100% participation) would drop by $38.7 million. Likewise, the "cost schedules" used in third-party verified SAV programs likely would decline with higher levels of participation. That is, as program participation increases, these companies could spread fixed costs over more producers and, thus, their rates likely would fall. If the fixed fees and per head charges decreased 20% from their current values (annual audit charges held constant), this would reduce the total industry cost by $41.3 million. While these adjustments may well develop with additional SAV participation, we chose to take a conservative approach and utilize current cost estimates for this analysis.

**Table VII.7. Total Cattle Industry Cost versus Adoption Rate Under 100% SAV Enrollment**

***100% SAV Enrollment Industry Costs (thousand dollars)***

| | Total Annual | Percent | | Adoption | Adoption Method | |
|---|---|---|---|---|---|---|
| Industry Sector | Industry Cost | of Total | | rate | Uniform | Low Cost |
| Beef cow-calf | $ 206,303 | 58.8% | | 10% | $ 35,065 | $ 11,309 |
| Dairy | $ 29,743 | 8.5% | | 20% | $ 70,130 | $ 24,305 |
| Background | $ 38,581 | 11.0% | | 30% | $ 105,195 | $ 37,707 |
| Feedlot | $ 69,357 | 19.8% | | 40% | $ 140,260 | $ 52,339 |
| Packers | $ 6,665 | 1.9% | | 50% | $ 175,325 | $ 70,909 |
| TOTAL COST | $ 350,649 | 100.0% | | 60% | $ 210,390 | $ 92,522 |
| | | | | 70% | $ 245,454 | $ 117,565 |
| | | | | 80% | $ 280,519 | $ 161,676 |
| | | | | 90% | $ 315,584 | $ 235,414 |
| | | | | 100% | $ 350,649 | $ 350,649 |

**Direct Cost Estimates: Swine/Pork**

Direct costs were estimated for the swine/pork industry based on six operation types: 1) Farrow-to-Wean, 2) Farrow-to-Feeder, 3) Farrow-to-Finish, 4) Wean-to-Feeder (Nursery), 5) Feeder-to-Finish (Grow/Finish), and 6) Packing Plants. As with the bovine industry, costs were estimated following the approach of the NAIS B-C study with several modifications. First, all costs related to individual tags associated with cull sows and boars were eliminated as it was assumed traceability was pertinent only to market hogs. Additionally, costs associated with storing ID data and registering premises were eliminated. An enrollment fee for participating in a third-party verification program was included. Enrollment fees were estimated such that they were consistent with SAV programs for the cattle industry in terms of fixed annual fees. The costs associated with managing and reporting data (i.e., computer, software, office labor, etc.) were included in the same manner as the NAIS B-C study to reflect producers' in-house costs that were not covered by fees paid to a third party.

Table VII.8 summarizes the costs of participating in third-party verified traceability programs for the different swine production operations by size. Costs are reported in two categories – those associated with enrolling in a third-party program and in-house costs associated with data collection, recording, and reporting (see NAIS B-C study for details related to this cost). The costs for enrolling in a third party traceability program were greater than the sum of data collection, recording, and reporting costs because most operations already have systems in place for recording/reporting data. Thus, only additional costs were included. Because costs are based on groups of animals rather than individual animals in the swine industry, per head costs are much lower for large operations as total costs per operation are similar to those of smaller operations. Depending on type and size of operation, annual cost per operation ranged from a low of approximately $200 to a high of slightly over $500. However, the cost per pig sold ranged from $0.01 for large farrow-to-wean operations to over $2/head for the smallest feeder-to-finish operations. Thus, as was the case for the bovine industry, large economies of size in costs per head exist because of the fixed cost associated with providing ID data for tracing animals.

**Table VII.8. Summary of Traceability Costs for Swine Operations by Type and Size of Operation**

| | Size of Operation, number of head | | | | Industry |
|---|---|---|---|---|---|
| | < 500 | 500-1999 | 2000-4999 | 5000+ | Total/Avg |
| *Farrow-to-Wean* | | | | | |
| Data recording/reporting costs | $95 | $128 | $179 | $205 | $976,400 |
| Third party traceability program costs | $176 | $176 | $307 | $307 | $1,476,259 |
| Total cost, $/operation | $270 | $303 | $486 | $512 | $2,452,659 |
| Total cost, $/pig sold | $0.72 | $0.09 | $0.03 | $0.01 | $0.04 |
| *Farrow-to-Feeder* | | | | | |
| Data recording/reporting costs | $92 | $107 | $173 | $193 | $561,909 |
| Third party traceability program costs | $176 | $176 | $307 | $307 | $974,863 |
| Total cost, $/operation | $267 | $282 | $480 | $500 | $1,536,772 |
| Total cost, $/pig sold | $0.76 | $0.11 | $0.04 | $0.02 | $0.05 |
| *Farrow-to-Finish* | | | | | |
| Data recording/reporting costs | $89 | $89 | $102 | $103 | $2,051,719 |
| Third party traceability program costs | $176 | $176 | $307 | $307 | $4,648,258 |
| Total cost, $/operation | $264 | $264 | $410 | $410 | $6,699,977 |
| Total cost, $/pig sold | $1.57 | $0.39 | $0.20 | $0.12 | $0.32 |
| *Wean-to-Feeder* | | | | | |
| Data recording/reporting costs | $49 | $49 | $62 | $101 | $404,495 |
| Third party traceability program costs | $176 | $176 | $307 | $307 | $1,561,565 |
| Total cost, $/operation | $225 | $225 | $369 | $408 | $1,966,060 |
| Total cost, $/pig sold | $0.31 | $0.06 | $0.04 | $0.02 | $0.03 |
| *Feeder-to-Finish* | | | | | |
| Data recording/reporting costs | $22 | $22 | $22 | $52 | $907,608 |
| Third party traceability program costs | $176 | $176 | $307 | $307 | $7,956,902 |
| Total cost, $/operation | $198 | $198 | $329 | $359 | $8,864,510 |
| Total cost, $/pig sold | $2.07 | $0.28 | $0.14 | $0.04 | $0.10 |

***Packing Plant Sector***

Traceability costs incurred by hog packing plants will depend on numerous factors, but primarily on plant size. However, because of the nature of the industry (i.e., highly consolidated), the added costs to the packing industry are likely minimal. That is, the ability to trace pork back to individual production operations already exists throughout most of the industry. However, some additional costs would likely occur if the entire industry was required to adopt a traceability system. Because a cost function, such as was used for the beef industry, does not exist and several packers indicated their costs would not change, costs in the packing plant sector were estimated with the methodology used in the NAIS B-C study with values updated to reflect 2009 slaughter numbers. Costs per head were estimated to be $0.19/head for the smallest plants (processing 375 head per year) to less than $0.01/head for the largest plants (processing an average of over 3 million hogs per year). Although economies of size exist, costs are low even for the smallest packing plants.

***Summary of Swine/Pork Industry***

Table VII.9 presents total costs to the swine/pork industry by sector for various levels of adoption/participation. At 100% participation, the total industry costs would be approximately $21.67 million with almost all costs occurring at the production level. Over 70% of these costs are incurred by operations that sell market hogs, as opposed to those selling weaned or feeder pigs. Although similar costs are incurred per operation, there are more operations of this type. Assuming that early adopters of traceability programs are producers with the lowest adoption costs table VII.9 (far right column) indicates how industry costs will increase with adoption rates. While the marginal cost of increasing adoption or participation in traceability programs increases at higher adoption rates, the effect is more linear than with the cattle/beef industry. The reason for this result is that there is less disparity between costs of operations within the swine industry relative to the beef industry.

**Table VII.9. Total Swine Industry Cost versus Adoption Rate Under 100% SAV Enrollment**

***100% SAV Enrollment Industry Costs (thousand dollars)***

| | Total Annual | Percent | | Adoption | Adoption Method | |
|---|---|---|---|---|---|---|
| Industry Sector | Industry Cost | of Total | | rate | Uniform | Low Cost |
| Farrow-to-Wean | $ 2,453 | 11.3% | | 10% | $ 2,167 | $ 1,715 |
| Farrow-to-Feeder | $ 1,537 | 7.1% | | 20% | $ 4,334 | $ 3,431 |
| Farrow-to-Finish | $ 6,700 | 30.9% | | 30% | $ 6,502 | $ 5,165 |
| Farrow-to-Feeder | $ 1,966 | 9.1% | | 40% | $ 8,669 | $ 7,045 |
| Feeder-to-Finish | $ 8,865 | 40.9% | | 50% | $ 10,836 | $ 9,070 |
| Packers | $ 152 | 0.7% | | 60% | $ 13,003 | $ 11,130 |
| TOTAL COST | $ 21,672 | 100.0% | | 70% | $ 15,170 | $ 13,234 |
| | | | | 80% | $ 17,338 | $ 15,861 |
| | | | | 90% | $ 19,505 | $ 18,744 |
| | | | | 100% | $ 21,672 | $ 21,672 |

# VIII. NET ECONOMIC IMPACTS OF RED MEAT EXPORT REQUIREMENTS

The previous chapter presented cost estimates for expanding traceability in the U.S. bovine and porcine industries. These species-specific costs depend upon the degree of program adoption. A variety of effects are caused by adding costs to a marketing system. In general, added costs are dispersed throughout a vertically-related marketing chain and prices and quantity exchanged in the market are impacted. Furthermore, changes in prices for one meat commodity influences the demand for substitute meat products. Expansion of traceability programs could also positively influence demand for meat products. However, the extent of these potential changes is difficult to forecast.

This chapter addresses various combinations of these issues. An equilibrium displacement model (EDM) was used to simulate the effects of industry costs incurred through adoption of traceability programs on meat/livestock prices, quantities exchanged, and producer/consumer surplus. This modeling technique has been well developed and is widely used in economic research to assess net societal impacts of a variety of private technology adoption and/or public policy regulations and initiatives. Throughout this chapter we evaluate economic impacts of traceability adoption following the evaluated programs as discussed in previous chapters. In particular, the assumed traceability programs are SAV for the bovine industry and a similar, third-party verification program (without age or individual animal identification) for the porcine industry. In subsequent discussion, the general term traceability refers to these programs. Our analysis is also conducted at an aggregate industry level using prices and quantities describing live animals and carcasses. While a cut-level analysis would be appealing given the divergent trade patterns of different meat cuts, limitations in both required data (e.g., cut-level own- and cross-price elasticities) and peer-reviewed studies important for keeping our study in context currently prohibit a cut-level approach.

Changes in producer and consumer surplus are estimated because these metrics measure changes in producer and consumer well-being. Consumer surplus is a measure of the difference between what consumers are *willing* to pay for a product and the price that they *actually* pay for a product. That is, at any given product price, some consumers are just willing to pay that price for a product. However, many other consumers are willing to pay more for the product than the current market price. This

concept is clearly illustrated by increases in the price of any food product. Suppose the price of a food product increases because poor weather has reduced the supply of an important ingredient. The resulting price increase certainly reduces the quantity sold, but some consumers will continue to purchase the product despite the price increase. Clearly, these consumers were willing to pay more for the product prior to its price increase. This difference between willingness to pay for a product and the amount actually paid is a measure of a consumer's gain. Increases in consumer surplus represent improvements in the collective well-being of consumers in general. This does not mean that every consumer benefits when consumer surplus increases. Rather, consumers in aggregate are better-off when consumer surplus increases.

Producer surplus represents an analog to consumer surplus. That is, at any given market price, some (but not all) producers would be *willing* to produce a product even if prices were lower than the market. Essentially, aggregate producer surplus is the difference between an industry's total revenue and the total variable costs of producing a product. This is not synonymous with profit because measures of profit also include costs which do not vary with output (i.e., fixed costs). Increases in producer surplus represent an aggregate improvement in the economic well-being of producers within a sector of an industry. However, as with consumer surplus, an aggregate improvement does not mean that every individual producer is necessarily better off.

An EDM can be used to effectively measure *changes* in consumer and producer surplus associated with changing economic conditions. The model measures these changes in response to changes in demand for products, supply of products, or both. Consumer demand changes occur for a variety of reasons (e.g., changes in income, prices of substitute goods, tastes and preferences, product attributes). The supply of products may also change for a variety of reasons (e.g., changes in input costs, technology, government regulations). The EDM is used to simulate impacts caused by the potential expansion of traceability programs. By adopting such a program, producers will incur direct costs, but adoption could also increase consumer demand if consumers value this attribute. Hence, we simulate the export demand increases necessary to offset increased costs of animal identification/tracking programs. We are unable to forecast consumer responses to such programs. Therefore, we evaluate the size of potential demand changes needed so that the meat production sectors would be indifferent with

respect to the expansion of domestic traceability programs. We evaluate these impacts in the aggregate. That is, while an entire livestock sector may be indifferent (in terms of producer surplus generation) to such programs, individual producers within a sector may not be indifferent. We also evaluate various combinations of export demand changes on prices, quantities, and producer/consumer surplus.

Price and quantity data for 2009 were used in the model. Domestic price and quantity data were obtained from the Livestock Marketing Information Center (LMIC, 2010). Import and export prices and quantities were obtained from the USDA FAS (USDA FAS, 2010). For additional discussion and details of the multi-market equilibrium displacement simulation model of the U.S. meat industry, utilized data, and assumed elasticity estimates see Appendix A.

**Simulation Scenarios**

Several simulation scenarios are presented below to illustrate the impacts of potential combinations of traceability policies, associated additional enrollment and participation costs, and corresponding potential export demand responses. These scenarios assume no domestic demand benefit, nor any on-farm management or other synergistic benefits related to increased traceability. Accordingly, we consider the simulation results for each scenario to be conservative as several potential benefits are assumed to be zero in our calculations. The scenarios are separated into three general areas:

***1. Loss of Export Beef and Pork Demand if Traceability is Not Implemented***

Traceability systems are rapidly developing throughout the world (see section VI). As previously discussed, the United States could lose access to international beef export markets if it falls behind world standards regarding animal identification/tracing systems.

Murphy et al. (2008) states that animal identification systems "are becoming prerequisites to international trade" (page 284). As a result, maintaining the status quo with respect to the adoption of traceability program in the United States could reduce U.S. access to specific international markets. To

estimate how reduced export market access would impact the U.S. livestock and meat markets, we simulate scenarios in which the United States loses beef and/or pork export market access to South Korea and other export markets. This first scenario is consistent with the recent announcement that South Korea will require expanded traceability of imported beef (Johnston, 2010). The second scenario represents a more detrimental situation in which only Canada and Mexico allow beef and pork imports from the United States. This expands the first situation to the case of other markets possibly following the lead of South Korea (or the like) in enforcing stricter requirements on U.S. producers. These scenarios demonstrate potential losses of not adopting traceability as it becomes the international standard. More narrowly, these scenarios include:

i. Scenario 1A: No expansion in traceability and loss of beef exports to South Korea (7.3% decline in total beef exports);
ii. Scenario 1B: No expansion in traceability and loss of pork exports to South Korea (6.3% decline in total pork exports);
iii. Scenario 1C: No expansion in traceability and loss of both beef and pork exports to South Korea (7.3% decline in total beef exports and 6.3% decline in total pork exports);
iv. Scenario 1D: No expansion in traceability and loss of all non-North American beef exports (48.7% decline in total beef exports);
v. Scenario 1E: No expansion in traceability and loss of all non-North American pork exports (68.3% decline in total pork exports); and
vi. Scenario 1F: No expansion in traceability and lose all non-North American beef and pork exports (48.7% decline in total beef exports and 68.3% decline in total pork exports).

In each scenario, decreases in export volume are simple percentage declines based upon 2009 trade levels.

### *2. Increases in Export Beef and Pork Demand Needed to Offset Increases in Traceability Costs*

As previously discussed, enhanced traceability programs will increase costs for U.S. livestock producers. However, such systems may increase foreign consumer confidence in the U.S. meat system. Hence, the size of an increase in beef and pork export demand needed to just offset the increase in costs is simulated. These simulations provide insight regarding the feasibility of expanding exports to cover costs associated with traceability. These simulations involve adjusting the size of the increase in beef [pork] export demand such that wholesale, slaughter cattle, and feeder cattle (which includes cow/calf

producers) sectors [wholesale and slaughter hogs sectors] do not lose any (10-year discounted present value) producer surplus. In essence, these scenarios measure how much of a beef and pork export demand enhancement would be needed (assuming constant domestic demand) to encourage producer adoption. These scenarios include:

i. Scenario 2A: 20% traceability in the U.S. beef industry;
ii. Scenario 2B: 20% traceability in the U.S. pork industry;
iii. Scenario 2C: Full traceability in the U.S. beef industry; and
iv. Scenario 2D: Full traceability in the U.S. pork industry.

Our consideration of "20% traceability" in scenarios 2A and 2B warrants clarification. These scenarios reflect the possible, voluntary expansion in traceability program participation by some U.S. producers. This expansion could correspond to a subset of producers responding to increasing global standards required for exporting red meat. These scenarios assume 20% of animals in the U.S. bovine or porcine industry enroll in the evaluated traceability programs. This should not be confused as 20% of operations being enrolled or 20% success in tracing product/animals through the supply chain. In contrast, we assume a segment (20%) of the domestic bovine or porcine production participates in expanded traceability programs. Furthermore, we assume complete traceability of animals and meat products is obtained for the 20% of the industry voluntarily participating. Moreover, we assume the lowest cost producers lead in adoption; as opposed to assuming uniform adoption across operations. In contrast, the "Full traceability" in scenarios 2C and 2D reflects complete (100%) enrollment by domestic industries and hence complete ability to track animals and meat products. While complete voluntary traceability is likely not feasible, we consider the possibility as U.S. producers may face a similar situation in the future.

### *3. Effects of Increased Traceability Costs without Export Expansion*

The impacts of increased costs of traceability programs are also simulated assuming that neither export nor domestic consumer demand is enhanced by the adoption of tracing programs. In essence, these scenarios estimate the impacts of traceability costs assuming that no demand benefits accrue to the industries. These scenarios include:

i. Scenario 3A: 20% traceability in both the U.S. beef and pork industries (no increase in trade); and
ii. Scenario 3B: Full traceability in both the U.S. beef and pork industries (no increase in trade).

**Traceability Cost Estimates**

Changes in direct benefits (i.e., expanded export market access) and costs (i.e., additional traceability participation) are required to determine resulting changes in prices and quantities. The costs of increased traceability in the beef and pork industries are presented in chapter VII. For instance, annual cost estimates resulting from achieving 20% traceability participation in the beef and pork industries are $13.00 million and $3.43 million, respectively (tables VII.7 and VII.9).

The annual beef industry traceability costs of $13 million are distributed as: $0.61 million to the wholesale beef sector (packers), $2.91 million to the slaughter cattle production sector (backgrounders and feedlots), and $9.47 million to the feeder cattle production sector. Using 2009 average prices and quantities for each market level, these cost estimates represent the following percentage increases in costs relative to total value: 0.002% at the wholesale beef level, 0.008% at the slaughter cattle level, and 0.04% at the farm level (table VIII.1). Smaller total annualized costs of investing in a tracing program are incurred in the swine industry (table VIII.1).

The percentage changes in costs for the alternate scenarios (described below) at each market level are estimated in a similar manner. For instance, percentage increases in costs are presented in table VIII.1 for the scenarios discussed above.

**Table VIII.1. Exogenous (Percentage) Supply Changes Used in the Multi-Market Simulation Model**

| | Percentage Change | | | | | |
|---|---|---|---|---|---|---|
| | Scenario 2A[a] | Scenario 2B[b] | Scenario 2C[c] | Scenario 2D[d] | Scenario 3A[e] | Scenario 3B[f] |
| **Beef Sector** | | | | | | |
| Retail | 0 | 0 | 0 | 0 | 0 | 0 |
| Wholesale | 0.0017 | 0 | 0.0165 | 0 | 0.0017 | 0.0165 |
| Slaughter | 0.0081 | 0 | 0.3754 | 0 | 0.0081 | 0.3754 |
| Feeder | 0.0367 | 0 | 0.7686 | 0 | 0.0367 | 0.7686 |
| **Pork Sector** | | | | | | |
| Retail | 0 | 0 | 0 | 0 | 0 | 0 |
| Wholesale | 0 | 0.0002 | 0 | 0.0011 | 0.0002 | 0.0011 |
| Slaughter | 0 | 0.0268 | 0 | 0.1697 | 0.0268 | 0.1697 |
| **Lamb Sector** | | | | | | |
| Retail | 0 | 0 | 0 | 0 | 0 | 0 |
| Wholesale | 0 | 0 | 0 | 0 | 0 | 0 |
| Slaughter | 0 | 0 | 0 | 0 | 0 | 0 |
| Feeder | 0 | 0 | 0 | 0 | 0 | 0 |
| **Poultry Sector** | | | | | | |
| Retail | 0 | 0 | 0 | 0 | 0 | 0 |
| Wholesale | 0 | 0 | 0 | 0 | 0 | 0 |

*a* Scenario 2A: 20% traceability in the U.S. beef industry.
*b* Scenario 2B: 20% traceability in the U.S. pork industry.
*c* Scenario 2C: Full traceability in the U.S. beef industry.
*d* Scenario 2D: Full traceability in the U.S. pork industry.
*e* Scenario 3A: 20% traceability in both the U.S. beef and pork industries (no increase in trade).
*f* Scenario 3B: Full traceability in both the U.S. beef and pork industries (no increase in trade).

## Results

The results for each of the aforementioned simulation scenarios are presented in this section. The impacts of "doing nothing" and losing export market access, increasing costs on the livestock and meat industry, and various export demand scenarios are considered. In each case, percentage changes in prices and quantities for livestock and meat prices are presented for both short-run (1-year) and long-run (10-year) time horizons. Each percentage change is relative to 2009 average prices and quantities. In addition, changes in producer surplus at each market level and for each species are presented as are changes in consumer surplus. Ten-year cumulative changes in producer and consumer surplus are also presented. Changes in prices, quantities, and producer and consumer surplus estimated for the various scenarios considered can be found in Appendices B and C.

### *Simulated Effects of Various Loss in Export Market Scenarios (No Costs)*

Table VIII.2 presents median percentage changes in prices and quantities resulting from a 7.3% decrease (representing loss of access to South Korea) in export market access for U.S. beef (Scenario 1A). The first column shows the short-run (1-year) results. Retail and wholesale beef prices decrease by 0.22% and 0.29%, respectively, while domestic quantities increase by 0.18% and 0.36%. Prices and quantities for imported wholesale beef, slaughter cattle, and feeder cattle all decline. Retail, wholesale, imported, and slaughter pork prices and quantities all decrease slightly (but by less than 0.03%). This occurs because the demand for pork decreases as the retail price of beef decreases. Lower domestic pork prices encourage export expansion by 0.1%. Similar to pork, all lamb and poultry prices and quantities decrease slightly, except for small increase in poultry exports. In the long run, most of these relationships are similar. However, all of the long-run estimates are small, consistent with the meat industry adjusting to the loss of export markets over time.

Table VIII.3 presents changes in producer and consumer surplus due to a 7.3% decrease in U.S beef exports. The short-run impacts are larger than the long-run effects, as expected. In the short run, the slaughter and feeder cattle sectors lose $132 million and $55 million, respectively, while the retail and wholesale sectors gain $118 million and $178 million. The reduction in U.S. beef exports causes an increase in the supply of beef at the wholesale level and, ultimately, at the retail level. This increase in

quantity decreases the price for both wholesale and retail level beef. The increase in quantity of wholesale beef reduces the demand for live cattle, thus decreasing the prices at both the slaughter and farm levels. In year 10, the entire beef industry loses $70 million of producer surplus. Over the entire 10-year period, the discounted present value of producer surplus losses for the beef industry totals $1,639 million or about 0.4% of the discounted present value of the 10-year total surplus for the industry.

The pork industry realizes a small loss in producer surplus of $19.3 million in year 1 as lower beef prices cause consumer to substitute away from pork to relatively cheaper beef. Over the entire 10-year period, the pork industry loses only about 0.01% of discounted total producer surplus. Similar to pork, the lamb and poultry industries lose about $0.19 million and $58.8 million of producer surplus in year 1, respectively, and a discounted present value of $0.24 million and $75.3 million over the entire 10 years. The latter values represent a 0.003% and 0.04% decline, respectively.

With the loss of beef export markets and increased quantities of retail beef, beef consumer surplus increases by 0.06%, pork consumer surplus decreases by 0.003%, and domestic lamb consumer surplus increases by 0.002%. Imported lamb consumer surplus declines by 0.005% and poultry consumer surplus decreases by 0.006%. In terms of all U.S. meat consumers, consumer surplus increases by $154 million over the 10-year period which represents an increase of 0.01%. These increases in consumer surplus primarily stem from reductions in retail meat prices.

Figure VIII.1 presents changes in the total discounted present value of producer and consumer surplus for Scenarios 1A – 1C. The net societal effects (adding consumer and producer surplus changes together) of losing market access to South Korea ranges from declines of $283 million to $1,839 million. The largest losses result from losing market access for beef.

A loss of the U.S. export pork market to South Korea (scenario 1B), or a decrease by 6.3%, has similar but smaller overall impacts as losing access to the beef export market in South Korea. The loss in producer

surplus for the pork industry is naturally larger than the beef industry as discounted present value losses for the pork industry are $499.9 million or 0.21% of the discounted present value of the 10-year total surplus for the industry. Over the entire 10-year period, the discounted present value of producer surplus losses for the beef industry totals $153.2 million or about 0.04% of the discounted present value of the 10-year total surplus for the industry (table C-2). The 10-year discounted present value of producer surplus losses for the lamb and poultry industries total $0.3 million and $47.6 million, respectively. The loss of the U.S. pork export market causes the supply of wholesale pork to increase, thus decreasing the price for retail pork. The decrease in the retail pork price causes consumer to substitute away from beef, poultry, and lamb to pork. Consumer surplus for U.S. meat consumers increases by $467 million over the 10-year period which represents an increase of 0.04% (table C-2).

If the United States loses market access to South Korea for both beef and pork (scenario 1C), the reductions in total discounted present value of producer surplus for beef, pork, lamb, and poultry industries are $1,792 million, $518 million, $58 million, and $126 million, respectively, with the largest losses falling on the slaughter and feeder cattle and slaughter hog sectors (table C-3). As in the two previous scenarios, total consumer surplus increases. In particular, loss of both beef and pork market access in South Korea increases consumer surplus by $610 million over the 10-year period.

If the United States was denied access to all non-North American beef export markets (scenario 1D), reductions in total discounted present value of producer surplus for beef, pork, lamb, and poultry industries are $10,990 million, $164 million, $2 million, and $505 million, respectively (table C-4). These losses are about seven times as large as the case of losing only South Korean markets and document implications of countries possibly following the lead of South Korea or other key export target market countries. The slaughter and feeder cattle sectors lose $8,466 million and $5,409 million, respectively, while the retail and wholesale beef sectors each gain $1,126 million and $1,699 million. Total consumer surplus increases by $1,074 million or 0.09%.

If the United States loses access to all non-North American pork export markets (scenario 1E), the changes in total discounted present value surplus to the meat industry is $7,658 million with losses to

the beef and pork industries totaling $1,658 million and $5,398 million, respectively (table C-5). Consumers gain $5,109 million in additional surplus over the 10-year period with the largest gain to the pork consumers ($5,632 million).

If the United States simultaneously lost access to all non-North American beef and pork export markets (scenario 1F), the entire meat industry would experience a $19,304 million (2.6%) decline in total producer surplus (table C-6). The beef, pork, lamb, and poultry sectors lose $12,582 million, $5,505 million, $5 million, and $1,046 million, respectively, while total meat consumer surplus increases by $6,094 million over the 10-year period.

***Simulated Effects of Increases in Export Demand Needed to Offset Additional Traceability Costs***

A large and growing body of research suggests that foreign consumers value food traceability or attributes made available through traceability of food products. Many consumers demand and demonstrate a willingness-to-pay for food products that are traceable to farms and ranches. For example, Pouliot and Sumner (2008) note "The improved food safety from increased traceability increases consumers' willingness to pay for the (safer) product. This creates an additional incentive to improve the food safety reputation of the industry." (p. 25). Many other research projects indicate that international consumers demand traceability and/or product attributes that may be verified by traceability programs (e.g., Buhr, 2003; Cuthbertson and Marks, 2007; Gracia and Zeballos, 2005; Hobbs, 1996; Hobbs et al., 2005; Schroeder et al., 2007; Tonsor et al., 2005). Dickinson and Bailey (2005) concluded that consumers in Japan, Canada, United States, and the UK were willing to pay on average from 7% to 25% more for beef and pork sandwiches containing traceable meat. Japanese consumers, a very important market for U.S. beef and pork, were the highest at 25%. Results from the literature reveal that the U.S. livestock industries lag behind other major producing regions in animal identification and traceability (as documented in section VI), reducing its competitiveness and demand for its product relative to other major exporters in the global market.

Regardless of adoption rates, increases in the use of traceability programs will certainly increase production and marketing costs. However, it is possible that such systems may increase foreign

consumer confidence in the U.S. meat system. Hence, the size of an increase in beef and pork export demand needed to just offset these costs are simulated for several scenarios (scenarios 2A-2D). These simulations involve adjusting the size of the increase in beef [pork] export demand to the point where the wholesale, slaughter cattle, and feeder cattle (which includes cow/calf producers) [wholesale, slaughter hogs] sectors do not lose any (10-year discounted) producer surplus.

Assuming the U.S. cattle industry achieves 20% traceability participation, a permanent 1.01% increase in export beef demand would be needed so the three beef producer sectors would not lose any producer surplus. If the U.S. swine industry obtains 20% traceability participation, a permanent 0.53% increase in pork exports would be required to offset the costs incurred by wholesale pork and slaughter hog levels. If the U.S. cattle and hog industries each have full traceability participation, 29.5% and 3.4% increases in beef and pork exports are needed so that the three beef producer sectors and two pork producer sectors would not lose any surplus, respectively.

To put such increases into perspective, Hong Kong's beef export market share in 2009 was 4% and all of East Asia's (Taiwan, Hong Kong, Japan, South Korea, and Vietnam) combined export market share for U.S. beef was almost 38% (see table V.2 in section V). With 20% traceability participation in the beef industry, the costs can easily be offset by gaining access, or not losing access, to a single country. Full traceability costs could be offset in the beef industry by gaining or maintaining access to a few countries. Similarly, to offset the costs of full traceability participation in the pork industry, having market access to a country like South Korea which held 6% export market share in 2009 (see table V.4 in section V) would suffice. Traceability adoption rates and export demand are likely positively correlated.

***Simulated Effects of Effects of Increased Costs Traceability (No Benefits)***

These scenarios consider the impacts on the U.S. livestock and meat sector of the adoption of traceability programs in the absence of corresponding export expansion (scenarios 3A and 3B). Assuming 20% participation in both cattle and hog industries, the 10-year impact on meat producers is a decline of $346 million or 0.05% for total producer surplus (table C-11).

With increased costs resulting from 100% enrollment in traceability programs, total meat producer surplus declines by $9,384 million (table C-12). The beef industry loses $10,360 million while the pork, lamb and poultry industries gain $139 million, $3 million, and $733 million, respectively. Consumer surplus for beef, pork, and domestic lamb declines by $3,179 million, $11 million, and $0.3 million, respectively. The imported lamb and poultry consumers gain $4 million and $399 million, respectively.

***Conclusions***

An equilibrium displacement model of the beef, pork, lamb, and poultry sectors was used to evaluate the impacts on producers and consumers from beef and pork export market losses as a result of falling further behind international standards with respect to animal traceability programs. Additional scenarios consider impacts of increased costs resulting from enhanced traceability and various impacts on export demand.

If the United States does not adopt traceability programs, it could possibly lose access to certain export markets. For example, the loss of South Korea as a market for beef exports would cause a 10-year discounted present value loss of beef industry producer surplus of $1,639 million (0.38% reduction). Over the entire 10-year period, the pork, lamb and poultry industries would lose about 0.01%, 0.003%, and 0.04% of discounted total producer surplus, respectively. The losses occur because the export market losses would cause additional beef to remain in the United States which would lower retail beef prices and reduce the demand for pork, lamb, and poultry. In terms of all U.S. meat consumers, consumer surplus increases by $154 million over the 10-year period which represents a 0.01% increase.

If the United States does not expand traceability programs and loses access to the South Korean pork market, the impacts are also negative but smaller relative to the loss of beef exports. A 10-year discounted present value loss of total meat industry producer surplus of $710 million results when pork exports decline by 6.3%. Consumer surplus for all U.S. meat consumers increases by $467 million over the 10-year period. If the United States loses market access to South Korea for both beef and pork, the impacts are much larger, with producers losing $2,448 million while consumers gain $610 million.

If the United States experiences beef export losses to all non-North American markets, the slaughter cattle and feeder cattle sectors, the entire swine, lamb, and poultry industries lose economic surplus while the retail and wholesale beef sectors gain. Consumers of beef and lamb gain economic surplus while pork and poultry consumer surplus declines. The overall societal loss under this scenario (producer plus consumer surplus) is a 10-year cumulative net present value of $10,704 million. If the United States were to lose pork exports to all non-North American markets, the overall net loss is much smaller with a 10-year cumulative net present value of $2,549 million. Combining the two previous scenarios (losing both beef and pork exports to all non-North American markets), the 10-year cumulative net present value losses to meat producers is $19,304 million while meat consumers gain $6,094 million in surplus.

Export demand for U.S. meat could increase as a result of enhanced traceability systems. With enhanced beef traceability, the simulation model determined the magnitude of an increase in beef export demand increase necessary so that the wholesale beef, slaughter cattle, and feeder cattle sectors would lose no producer surplus. A 1.01% increase in beef export demand would completely pay for achieving a 20% traceability participation in the U.S. beef herd over a 10-year period. Similarly for pork, a 0.53% increase in pork export demand would be needed to completely pay for obtaining 20% traceability enrollment. If the United States had a 20% traceability program for beef and pork, the increases in export demand needed to offset the increase in costs would be 1% (or 19.5 million lbs.) and 0.5% (or 21.7 million lbs.), respectively. To put such increases into perspective, the United States exported 141 million lbs. of beef and 258 million lbs. of pork to South Korea in 2009. With a full (100%) traceability participation in the beef and pork industry, the costs can be offset by increasing beef exports by 29.5% (571 million lbs.) and pork exports by 3.4% (139 million lbs). In 2009, the United States exported over 625 million lbs. of beef to Mexico. To make full traceability investment economically viable, the United States would need to gain market access to one country such as Mexico for beef or South Korea for pork.

Finally, simulations were conducted to evaluate the costs of enhanced traceability systems in the beef and pork industries without any direct benefits. Producer surplus losses for obtaining 20% participation

in tracing are $346 million, which compares to losses of $9,384 million for a full (100%) traceability programs in both the beef and pork industries if there were no benefits. With no benefits, consumers lose $124 million for the 20% tracing scenario compared to $2,785 million for the full tracing scenario.

**Table VIII.2. Median Percentage Changes from No Expansion in Traceability and Losing Beef Exports to South Korea (7.3% Decline in Total Beef Exports)**

| Endogenous Variables | Short Run[a] | Long Run[a] |
|---|---|---|
| Retail Beef Quantity | 0.184% | -0.017% |
| Retail Beef Price | -0.217% | 0.014% |
| Wholesale Beef Quantity | 0.356% | -0.108% |
| Wholesale Beef Price | -0.286% | 0.098% |
| Imported Wholesale Beef Quantity | -0.156% | -0.599% |
| Imported Wholesale Beef Price | -0.085% | -0.060% |
| Exported Wholesale Beef Quantity | -7.154% | -7.567% |
| Slaughter Cattle Quantity | -0.058% | -0.642% |
| Slaughter Cattle Price | -0.262% | -0.041% |
| Feeder Cattle Quantity | -0.022% | -0.482% |
| Feeder Cattle Price | -0.214% | -0.171% |
| Retail Pork Quantity | -0.030% | 0.002% |
| Retail Pork Price | -0.014% | 0.000% |
| Wholesale Pork Quantity | -0.019% | 0.002% |
| Wholesale Pork Price | -0.013% | 0.000% |
| Imported Wholesale Pork Quantity | -0.012% | 0.002% |
| Imported Wholesale Pork Price | -0.009% | 0.000% |
| Exported Wholesale Pork Quantity | 0.012% | 0.000% |
| Slaughter Hog Quantity | -0.008% | 0.001% |
| Slaughter Hog Price | -0.020% | 0.001% |
| Domestic Retail Lamb Quantity | -0.004% | 0.001% |
| Domestic Retail Lamb Price | -0.017% | 0.000% |
| Imported Retail Lamb Quantity | -0.024% | 0.001% |
| Imported Retail Lamb Price | -0.002% | 0.000% |
| Wholesale Lamb Quantity | -0.001% | 0.000% |
| Wholesale Lamb Price | -0.004% | 0.000% |
| Slaughter Lamb Quantity | 0.000% | 0.000% |
| Slaughter Lamb Price | -0.002% | 0.000% |
| Feeder Lamb Quantity | 0.000% | 0.000% |
| Feeder Lamb Price | -0.002% | 0.000% |
| Retail Poultry Quantity | -0.032% | 0.002% |
| Retail Poultry Price | -0.029% | 0.000% |
| Wholesale Poultry Quantity | -0.013% | 0.002% |
| Wholesale Poultry Price | -0.091% | 0.000% |
| Exported Retail Poultry Quantity | 0.009% | 0.000% |

Note: Percentage changes are based upon average 2009 prices and quantities for livestock and meat.
[a]Short-run is year 1 and long-run is year 10.

**Table VIII.3. Producer and Consumer Surplus Changes from No Expansion in Traceability and Losing Beef Exports to South Korea (7.3% Decline in Total Beef Exports)**

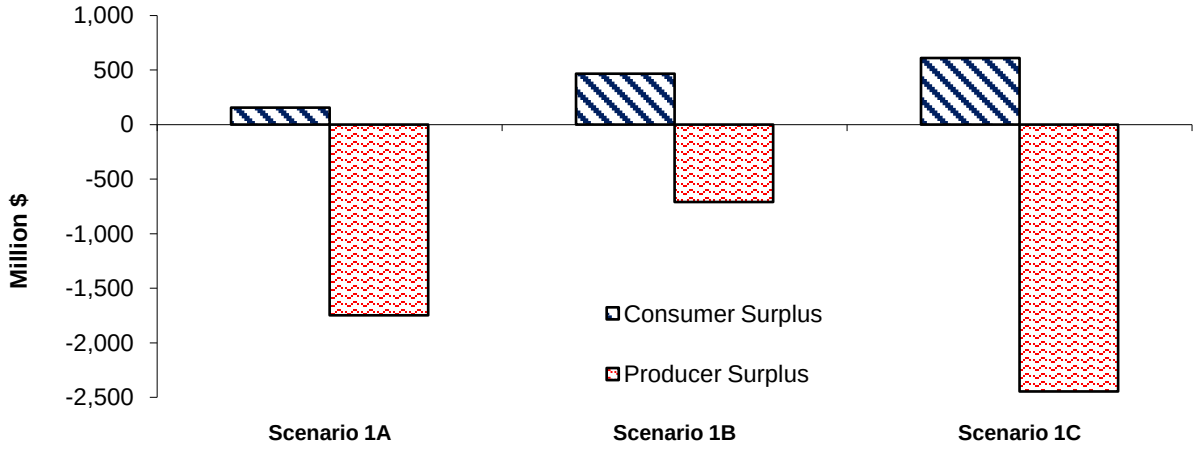
| Surplus Measure | Short Run[a] | Long Run[a] | Cumulative | Cumulative Present Value | Cumulative As A Percent Of Total |
|---|---|---|---|---|---|
| | million dollars | | | | |
| Producer Surplus | | | | | |
| Retail Beef | 118.10 | 4.23 | 204.44 | 183.05 | 0.063% |
| Wholesale Beef | 177.82 | 12.27 | 300.85 | 270.77 | 0.177% |
| Slaughter Cattle | -132.10 | -42.64 | -1,578.69 | -1,276.95 | -0.725% |
| Feeder Cattle | -55.36 | -44.00 | -1,058.59 | -826.45 | -0.614% |
| Total Beef Producer Surplus | 113.36 | -70.38 | -2,138.11 | -1,638.51 | -0.377% |
| Retail Pork | -12.26 | 0.15 | -16.64 | -16.28 | -0.013% |
| Wholesale Pork | -3.89 | 0.09 | -4.55 | -4.62 | -0.008% |
| Slaughter Hog | -2.52 | 0.09 | -2.42 | -2.59 | -0.004% |
| Total Pork Producer Surplus | -19.29 | 0.34 | -24.73 | -24.44 | -0.010% |
| Retail Domestic Lamb | -0.15 | 0.00 | -0.21 | -0.20 | -0.006% |
| Wholesale Lamb | -0.02 | 0.00 | -0.02 | -0.02 | -0.002% |
| Slaughter Lamb | -0.01 | 0.00 | -0.01 | -0.01 | -0.001% |
| Feeder Lamb | -0.01 | 0.00 | 0.00 | 0.00 | 0.000% |
| Total Lamb Producer Surplus | -0.19 | 0.00 | -0.24 | -0.24 | -0.003% |
| Retail Poultry | -54.63 | 0.06 | -74.08 | -70.68 | -0.037% |
| Wholesale Poultry | -3.82 | 0.01 | -5.06 | -4.84 | -0.029% |
| Total Poultry Producer Surplus | -58.78 | 0.07 | -79.35 | -75.34 | -0.037% |
| Total Meat Producer Surplus | 35.33 | -69.94 | -2,248.13 | -1,750.52 | -0.233% |
| Consumer Surplus | | | | | |
| Retail Beef | 172.22 | -11.35 | 164.39 | 184.69 | 0.060% |
| Retail Pork | -6.11 | 0.52 | -4.44 | -5.38 | -0.003% |
| Retail Domestic Lamb | 0.04 | 0.00 | 0.08 | 0.07 | 0.002% |
| Retail Imported Lamb | -0.22 | 0.00 | -0.28 | -0.28 | -0.005% |
| Retail Poultry | -21.44 | 0.65 | -24.07 | -25.45 | -0.006% |
| Total Meat Consumer Surplus | 142.01 | -10.11 | 132.63 | 154.16 | 0.013% |

Note: Surplus is calculated using average 2009 prices and quantities for livestock and meat.

[a]Short-run is year 1 and long-run is year 10.

[b]Totals are not identical to sums of individual surpluses because they are medians of simulations.

**Figure VIII.1. Cumulative present value of 10-year total consumer and producer surplus changes with varying export market losses and no change in demand**




Scenario 1A: No expansion in traceability and lose beef exports to South Korea (7.3% decline in total beef exports).
Scenario 1B: No expansion in traceability and lose beef exports to South Korea (6.3% decline in total beef exports).
Scenario 1C: No expansion in traceability and lose both beef and pork exports to South Korea (7.3% decline in total beef export and 6.3% decline in total pork exports).
Data for the corresponding figure can be found in tables C-1 through C-3.

## IX. LIMITATIONS

As in any economic analysis, this study is limited by its assumptions, available resources, and related constraints. Given the "what if" nature of this study, a few limitations are worth highlighting. Specifically, a conservative approach was used in this analysis as presented costs may be over-estimated and potential benefits may be under-stated. For example, the costs of expanding traceability are based on what is available today, reflective of current enrollment rates, and are based on existing costs schedules faced by U.S. livestock producers. As noted in chapter VII, the direct costs of expanding traceability may be overestimated as technology improves and verification firms realize scale economies and additional competition.

The benefits of expanding traceability are considered within the context of maintaining or expanding export market access. However, domestic demand may be positively affected as well. Given the predominance of domestic consumption (i.e., historically 0-10% of beef has been exported) this is a noteworthy restriction. Furthermore, expanded traceability would likely enhance animal health surveillance and eradication efforts, reduce the extent and/or duration of animal disease outbreaks, increase efficiency in meeting labeling requirements such as country of origin and nutritional information, and improve the efficacy of meeting value-added programs. Given these potential additional benefits, we believe that our analysis is conservative in that we understate the "return" to expanding traceability in the U.S. beef and pork industries.

As more information becomes available, future additional research may center on reducing the key limitations of the current study. For instance, our approach quantifies economic impacts at an aggregate industry level. However, deeper insights regarding differential impacts associated with economies of scale of traceability adoption are worthy of future work. Similarly, in the future a more detailed meat product cut-level analysis may be possible as data limitations are addressed. Furthermore, when target export markets enact specific requirements on traceability of importing countries, this analysis could be updated to provide a more targeted assessment of resulting economic impacts. Moreover, if global trade negotiations result in traceability systems that differ from those

modeled in this analysis, additional research could focus on the specifics of such systems. Finally, while beyond the purpose of this study, additional work is needed to compare the economic impacts associated with implementing market-based traceability systems (such as the source and age verification assumed in this study) relative to government-sponsored programs (such as the discontinued NAIS program) that are primarily focused on improving animal disease control and eradication efforts. The total and distributional impacts within the U.S. livestock and meat marketing chain likely vary across these two approaches. Identification of these differences may assist stakeholders in future discussions regarding domestic animal identification and traceability.

## x. REFERENCES


Balagtas, J.V., and S. Kim. 2007. "Measuring the Effects of Generic Dairy Advertising in a Multi-Market Equilibrium." *American Journal of Agricultural Economics* 89:932-946.

Barcos, L.O. 2001. "Recent developments in animal identification and the traceability of animal products in international trade." *Rev. Sci. Tech. Off. Int. Epiz*., 2001, 20 (2), 640-651. Available at: http://www.oie.int/boutique/extrait/barcos.pdf

Blasi, D., G. Brester, C. Crosby, K. Dhuyvetter, J. Freeborn, D. Pendell, T. Schroeder, G. Smith, J. Stroade, and G. Tonsor. 2009. *Benefit-Cost Analysis of the National Animal Identification System.* Final Report submitted to USDA-APHIS on January 14, 2009. Available at: http://www.naiber.org/Publications/NAIBER/BC.analysis.NAIS.pdf (accessed May 18, 2009).

Bowling, M.B, D.L. Pendell, D.L. Morris, Y. Yoon, K. Katoh, K.E. Belk, and G.C. Smith. 2008. "Review: Identification and Traceability of Cattle in Selected Countries Outside of North America." *Professional Animal Scientist* 24:287-294.

Brester, G.W. 1996. "Estimation of the U.S. Import Demand Elasticity for Beef: The Importance of Disaggregation." *Review of Agricultural Economics* 18:31-42.

Brester, G.W., J.M. Marsh, and J.A. Atwood. 2004. "Distributional Impacts of Country-of-Origin Labeling in the U.S. Meat Industry." *Journal of Agricultural and Resource Economics* 29:206-227.

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.

Brester, G.W., and M.K. Wohlgenant. 1997. "Impacts of the GATT/Urugay Round Trade Negotiations on U.S. Beef and Cattle Prices." *Journal of Agricultural and Resource Economics* 22:145-156.

Buhr, B.L. 2003. "Traceability, Trade and COOL: Lessons from the EU Meat and Poultry Industry." International Agricultural Trade Research Consortium, Working Paper #03-5, Department of Applied Economics, University of Minnesota, April.

Clemens, R. 2003. "Meat Traceability and Consumer Assurance in Japan." MATRIC Briefing Paper 03-MBP-5, Iowa State University, September. Available at: http://www.card.iastate.edu/publications/DBS/PDFFiles/03mbp5.pdf

Codex Alimentarius Commission. *Code of Hygienic Practice for Meat.* CAC/RCP 58-2005. Available at:

http://www.codexalimentarius.net/download/standards/10196/CXP_058e.pdf

Cuthbertson, B., and N. Marks. 2007. "Beyond Credence: Emerging Consumer Trends in International Markets." Published by the Victorian Government Department of Primary Industries Melbourne, May.

Dickinson, D.L., and D. Bailey. 2005. "Experimental Evidence on Willingness to Pay for Red Meat Traceability in the United States, Canada, United Kingdom, and Japan." *Journal of Agricultural and Applied Economics* 37:537-548.

Edwards, G. 2010. "Traceability Deployment Australia and Internationally." Presented at the International Livestock Identification International Conference, Calgary, Alberta, July 20. Available at: http://www.internationallivestockid.com/files/Session-05-Edwards.pdf

Farms.com. 2010. "USMEF: South Korea Proceeds with Hog Traceability System." July 29. Available at: http://www.meatingplace.com/MembersOnly/webNews/details.aspx?item=15780

Food and Agriculture Organization of the United Nations (FAO). 2004. *Good Practices for the Meat Industry*. FAO Animal Production and Health Manual. Available at: http://www.fao.org/docrep/007/y5454e/y5454e00.htm

Foreign Agricultural Service, USDA. 2010. *Livestock and Poultry: World Markets and Trade.* April. Available at: http://www.fas.usda.gov/psdonline/circulars/livestock_poultry.pdf

Gracia, A., and G. Zeballos. 2005. "Attitudes of Retailers and Consumers toward the EU Traceability and Labeling System for Beef." *Journal of Food Distribution Research* 36:45-56.

Golan, E., B. Krissoff, F. Kuchler, L. Calvin, K. Nelson, and G. Price. 2004. *Traceability in the U.S. Food Supply: Economic Theory and Industry Studies*. United States Department of Agriculture, Economic Research Service, Agricultural Economic Report Number 830, Washington, DC, March.

Hobbs, J.E. 1996. "A Transaction Cost Analysis of Quality, Traceability and Animal Welfare Issues in UK Beef Retailing." *British Food Journal* 98:16-26.

Hobbs, J.E., D. Bailey, D.L. Dickinson, and M. Haghiri. 2005. "Traceability in the Canadian Red Meat Sector: Do Consumers Care?" *Canadian Journal of Agricultural Economics* 53:47-65.

Johnston, T. 2010. "S. Korea Starts Tracking Imported Beef." *Meatingplace.com,* March 9. Available at: http://www.meatingplace.com/MembersOnly/webNews/details.aspx?item=15780

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.

Lima, V.M.B., C.T. Bornstein, and H.L. Cukierman. 2006. "The Brazilian Bovine Traceability System – A Critical Appraisal." *Estudos Sociedade e Agricultura* 14:49-87.

Livestock Marketing Information Center. 2010. LMIC, Lakewood, CO. Available at: http://lmic.info/

Lusk, J.L, and J.D. Anderson. 2004. "Effects of Country-Origin-Labeling on Meat Producers and Consumers." *Journal of Agricultural and Resource Economics* 29:185-205.

Marchant, J. 2002. "Secure Animal Identification and Source Verification." JM Communications, UK. Copyright Optibrand Ltd., LLC. Available at: http://www.optibrand.com/uploadedfiles/Animal_ID.pdf

Marsh, J.M. 1994. "Estimating Intertemporal Supply Response in the Fed Beef Market." *American Journal of Agricultural Economics* 76:444-453.

Marsh, J.M. 2003. "Impacts of Declining U.S. Retail beef Demand on Farm-Level Beef Prices and Production." *American Journal of Agriculture Economics* 85:902-913.

McConnell, M. and K. Mathews, Jr. 2008. "Global Market Opportunities Drive Beef Production Decisions in Argentina and Uruguay." *Amber Waves,* April. Available at: http://www.ers.usda.gov/AmberWaves/April08/Features/GlobalMarket.htm

Ministry of Agriculture and Forestry (MAF) Biosecurity New Zealand. 2009. *Review of Selected Cattle Identification and Tracing Systems Worldwide: Lessons for the New Zealand National Animal Identification and Tracing (NAIT) Project.* MAF Biosecurity New Zealand Information Paper No: 2009/03. Available at: http://www.maf.govt.nz/mafnet/review-cattleident-systems-worldwide.pdf

Murphy, R.G.L, D.L. Pendell, D.L. Morris, J.A. Scanga, K.E. Belk, and G.C. Smith. 2008. "Review: Animal Identification Systems in North America." *Professional Animal Scientist* 24:277-286.

Murphy, R.G.L., D.L. Pendell, and G.C. Smith. 2009. "Lessons from the Canadian Industry for Developing the National Animal Identification System." *International Food and Agribusiness Management Review* 12:1-18.

Organização Internacional Agropecuária (OIA). http://www.oiabrasil.com.br/prog-sisbov-1.htm

Ortega, C. and D.S. Peel. 2010. "The Mexican Animal Identification System: Current Situation, Problems, and Potential." *Journal of Agricultural and Applied Economics* 42:551-557.

Paarlberg, P.L., A.H. Seitzinger, J.G. Lee, and K.H. Mathews, Jr. 2008. *Economic Impacts of Foreign Animal Disease.* ERR-57. USDA-ERS, May.

Pendegrass, E. 2007. *A Comparison of International Animal Identification Programs.* The National Agricultural Law Center, University of Arkansas School of Law. April.

Pendell, D.L., G.W. Brester, T.C. Schroeder, K.C. Dhuyvetter, and G.T. Tonsor. 2010. "Animal Identification and Tracing in the United States." *American Journal of Agricultural Economics*. 92:927-940.

Pouliot, S., and D. A. Sumner. 2008. "Traceability, Liability, and Incentives for Food Safety and Quality." *American Journal of Agricultural Economics* 90: 15–27.

Ramírez, A. 2010. "SINCOMORA A Traceability Electronic System for Beef Cattle Exported from Chihuahua to the U.S." Presented at the International Livestock Identification International Conference,

Calgary, Alberta, July 20. Available at: http://www.internationallivestockid.com/files/Session-01-Ramirez.pdf

Rickard, B.J., and D.A. Sumner. 2008. "Domestic Support and Border Measures for Processed Horticultural Products." *American Journal of Agricultural Economics* 90:55-68.

RTI International. 2007a. "GIPSA Livestock and Meat Marketing Study. Volume3: Fed Cattle and Beef Industries Final Report." Research report prepared for GIPSA (Contract No. 53-32KW-4-028) by RTI International (RTI Project Number 0209230), Research Triangle Park, NC.

RTI International. 2007b. "GIPSA Livestock and Meat Marketing Study. Volume5: Lamb and Lamb Meat Industries Final Report." Research report prepared for GIPSA (Contract No. 53-32KW-4-028) by RTI International (RTI Project Number 0209230), Research Triangle Park, NC.

Schroeder, T.C., G.T. Tonsor, J.M.E. Pennings, and J. Mintert. 2007. "Consumer Food Safety Risk Perceptions and Attitudes: Impacts on Beef Consumption across Countries." *The B.E. Journal of Economic Analysis and Policy Contributions* 7:1-29.

Schulz, L. and G.T. Tonsor. 2010a. "Cow-Calf Producer Perceptions Regarding Individual Animal Traceability." *Journal of Agricultural and Applied Economics* 42:659-677.

Schulz, L. and G.T. Tonsor. 2010b. "Cow-Calf Producer Preferences for Voluntary Traceability Systems." *Journal of Agricultural Economics* 61:138-162.

Souza-Monteiro, D.M. and Caswell, J.A. "The Economics of Implementing Traceability in Beef Supply Chains: Trends in Major Producing and Trading Countries." University of Massachusetts Amherst Working Paper No. 2004-6. June 2004.

Smith, G.C., J.D. Tatum, K.E. Belk, J.A. Scanga, T. Grandin, and J.N. Sofos. 2005. "Traceability from a U.S. Perspective." *Meat Science* 71:174-193.

Tomek, W.G., and K.L. Robinson. 1990. *Agricultural Product Prices*. 3rd ed. Ithaca, New York: Cornell University Press.

Tonsor, G.T. and T. C. Schroeder. 2006. "Livestock Identification: Lessons for the U.S. Beef Industry from the Australian System." *Journal of International Food and Agribusiness Marketing* 18, 3/4:103-118.

Tonsor, G., T.C. Schroeder, J.A. Fox, and A. Biere. 2005. "European Preferences for Beef Steak Attributes." *Journal of Agricultural and Resource Economics* 30:367-380.

United States Department of Agriculture, Foreign Agricultural Service. 2004. World Beef Trade Overview. Available at: http://www.fas.usda.gov/dlp2/circular/2003/03-10LP/beefoverview.html

U.S. Department of Agriculture. 2007. Dairy 2007, Part I: Reference of Dairy Cattle Health and Management Practices in the United States, 2007. USDA-APHIS-VS, CEAH. Fort Collins, CO #N480.1007

U.S. Department of Agriculture. 2008a. Part I: Reference of Beef Cow-Calf Management Practices in the United States, 2007-08. USDA:APHIS:VS, CEAH, National Animal Health Monitoring System. Fort Collins, CO.

U.S. Department of Agriculture. 2008b. Packers and Stockyards Statistical Report, 2006 Reporting Year. USDA-GIPSA, SR-08-1. Washington D.C. Available at http://archive.gipsa.usda.gov/pubs/2006_stat_report.pdf.

U.S. Department of Agriculture. 2010. Quick Stats. USDA-NASS. Washington D.C. Available at http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/index.asp.

United States International Trade Commission. 2008. *Global Beef Trade: Effects of Animal Health, Sanitary, Food Safety, and Other Measures on U.S. Beef Exports.* Investigation No. 332-488, USITC Publication 4033, September. Available at: http://www.usitc.gov/publications/332/pub4033.pdf

Vallat, B. 2008. "Animal identification and product traceability from the farm to the fork must be progressively implemented worldwide." World Organization for Animal Health, Editorials from the Director General, July 15. Available at: http://www.oie.int/eng/Edito/en_edito_apr08.htm

Wilson, D.W. and P.T. Beers. 2001. "Global trade requirements and compliance with World Trade Organization agreements: the role of tracing animals and animal products." *Rev. Sci. Tech. Off. Int. Epiz.*, 20(2):379-384. Available at: http://www.chicucthuyhcm.org.vn/Download/KHKT/1-%20Kha%20nang%20truy%20cap%20nguon%20goc.pdf

Wohlgenant, M.K. 1989. "Demand for Farm Output in a Complete System of Demand Functions." *American Journal of Agricultural Economics* 71:241-252.

Wohlgenant, M.K. 1993. "Distribution of Gains from Research and Promotion in Multi-Stage Production Systems: The Case of the U.S. Beef and Pork Industries." *American Journal of Agricultural Economics* 75:642-651.

Wohlgenant, M.K. 2005. "Market Modeling of the Effects of Adoption of New Swine Waste Management Technologies in North Carolina." Unpublished, North Carolina State University.

World Organization for Animal Health (OIE). *Terrestrial Animal Health Code 2010.* Available at: http://www.oie.int/eng/normes/mcode/en_sommaire.htm

World Trade Organization (WTO). http://www.wto.org/index.htm

Zhao, Z., T.I. Wahl, and T.L. Marsh. 2006. "Invasive Species Management: Foot-and-Mouth Disease in the U.S. Beef Industry." *Agricultural and Resource Economics Review* 35:98-115

# XI. APPENDICES

## Appendix A: Structural and Equilibrium Displacement Models of the U.S. Meat Industry

The beef and lamb marketing chains are modeled by considering four distinct sectors: retail (consumer), wholesale (processor), slaughter (feedlot), and farm (feeder and cow/calf). The pork and poultry industries are modeled with fewer market levels than the beef and lamb industries because of higher degrees of vertical market integration. The pork industry includes three sectors: retail, wholesale, and slaughter, while the poultry industry consists of only the retail and wholesale sectors. International trade is included for each industry at various sectors depending upon market structures. Specifically, beef and pork imports and exports are considered at the wholesale level. Likewise, poultry exports are considered at the retail level while poultry imports are not modeled because they are virtually nonexistent. Lamb imports are considered at the retail level because most imported lamb retains its country-of-origin branding. Consequently, domestic lamb and imported lamb are considered distinctly different products at the retail level. Although country-of-origin labeling has been mandated in the United States, there have not been noticeable increases in demand for U.S. beef and pork to warrant separate demand and supply curves at the retail levels like lamb. Hence, imports of beef and pork are additions to U.S. wholesale supplies of each. Beef, pork, imported lamb, domestic lamb, and poultry are considered meat substitutes in the primary demand functions. The structural model of demand and supply relationships for the U.S. livestock and meat industry is presented in the supplementary appendix online.

In general terms, the structural supply and demand model is given by the following equations (error terms have been omitted):

**BEEF SECTOR:**

*Retail Beef Sector:*

Retail beef primary demand:

$$Q_B^{rd} = f_1\left(P_B^{rd}, P_K^{rd}, P_{Ld}^{rd}, P_{Li}^{rd}, P_Y^{rd}, \boldsymbol{Z}_B^{rd}\right) \quad \text{(A.1)}$$

Retail beef derived supply:

$$Q_B^{rs} = f_2\left(P_B^{rs}, Q_B^{ws}, \boldsymbol{W}_B^{rs}\right) \quad \text{(A.2)}$$

*Wholesale Beef Sector:*

Wholesale beef derived demand:

$$Q_B^{wd} = f_3\left(P_B^{wd}, Q_B^{rd}, \boldsymbol{Z}_B^{wd}\right) \quad \text{(A.3)}$$

Wholesale beef derived supply:

$$Q_B^{ws} = f_4\left(P_B^{ws}, Q_B^{ss}, Q_{Bi}^{ws}, Q_{Be}^{wd}, \boldsymbol{W}_B^{ws}\right) \quad \text{(A.4)}$$

Imported wholesale beef derived demand:

$$Q_{Bi}^{wd} = f_5\left(P_{Bi}^{wd}, Q_B^{wd}, \boldsymbol{Z}_{Bi}^{wd}\right) \quad \text{(A.5)}$$

Imported wholesale beef derived supply:

$$Q_{Bi}^{ws} = f_6\left(P_{Bi}^{ws}, \boldsymbol{W}_{Bi}^{ws}\right) \quad \text{(A.6)}$$

Exported wholesale beef derived demand:

$$Q_{Be}^{wd} = f_7\left(P_{Be}^{wd}, \boldsymbol{Z}_{Be}^{wd}\right) \quad \text{(A.7)}$$

*Slaughter Cattle Sector:*

Slaughter cattle derived demand:

$$Q_B^{sd} = f_8\left(P_B^{sd}, Q_B^{wd}, \boldsymbol{Z}_B^{sd}\right) \quad \text{(A.8)}$$

Slaughter cattle derived supply:

$$Q_B^{ss} = f_9\left(P_B^{ss}, Q_B^{fs}, \boldsymbol{W}_B^{ss}\right) \quad \text{(A.9)}$$

*Feeder Cattle Sector:*

Feeder cattle derived demand:

$$Q_B^{fd} = f_{10}\left(P_B^{fd}, Q_B^{sd}, \boldsymbol{Z}_B^{fd}\right) \quad \text{(A.10)}$$

Feeder cattle primary supply:

$$Q_B^{fs} = f_{11}\left(P_B^{fs}, \boldsymbol{W}_B^{fs}\right) \quad \text{(A.11)}$$

**PORK SECTOR:**

*Retail Pork Sector:*

Retail pork primary demand:

$$Q_K^{rd} = f_{12}\left(P_K^{rd}, P_B^{rd}, P_{Ld}^{rd}, P_{Li}^{rd}, P_Y^{rd}, \boldsymbol{Z}_K^{rd}\right) \quad \text{(A.12)}$$

Retail pork derived supply:

$$Q_K^{rs} = f_{13}\left(P_K^{rs}, Q_K^{ws}, \boldsymbol{W}_K^{rs}\right) \quad \text{(A.13)}$$

*Wholesale Pork Sector:*

Wholesale pork derived demand:

$$Q_K^{wd} = f_{14}\left(P_K^{wd}, Q_K^{rd}, \boldsymbol{Z}_K^{wd}\right) \quad \text{(A.14)}$$

Wholesale pork derived supply:

$$Q_K^{ws} = f_{15}\left(P_K^{ws}, Q_K^{ss}, Q_{Ki}^{ws}, Q_{Ke}^{wd}, \boldsymbol{W}_K^{ws}\right) \quad \text{(A.15)}$$

Imported wholesale pork derived demand:

$$Q_{Ki}^{wd} = f_{16}\left(P_{Ki}^{wd}, Q_K^{wd}, \boldsymbol{Z}_{Ki}^{wd}\right) \quad \text{(A.16)}$$

Imported wholesale pork derived supply:

$$Q_{Ki}^{ws} = f_{17}\left(P_{Ki}^{ws}, \boldsymbol{W}_{Ki}^{ws}\right) \quad \text{(A.17)}$$

Exported wholesale pork derived demand:

$$Q_{Ke}^{wd} = f_{18}\left(P_{Ke}^{wd}, \boldsymbol{Z}_{Ke}^{wd}\right) \quad \text{(A.18)}$$

*Slaughter Hog Sector:*

Slaughter hog derived demand:

$$Q_{K}^{sd} = f_{19}\left(P_{K}^{sd}, Q_{K}^{wd}, \boldsymbol{Z}_{k}^{sd}\right) \quad \text{(A.19)}$$

Slaughter hog primary supply:

$$Q_{K}^{ss} = f_{20}\left(P_{K}^{ss}, \boldsymbol{W}_{K}^{ss}\right) \quad \text{(A.20)}$$

**LAMB SECTOR:**

*Retail Lamb Sector:*

Domestic retail lamb primary demand:

$$Q_{Ld}^{rd} = f_{21}\left(P_{Ld}^{rd}, P_{Li}^{rd}, P_{B}^{rd}, P_{K}^{rd}, P_{Y}^{rd}, \boldsymbol{Z}_{Ld}^{rd}\right) \quad \text{(A.21)}$$

Domestic retail lamb derived supply:

$$Q_{Ld}^{rs} = f_{22}\left(P_{Ld}^{rd}, Q_{L}^{ws}, \boldsymbol{W}_{Ld}^{rs}\right) \quad \text{(A.22)}$$

Imported retail lamb primary demand:

$$Q_{Li}^{rd} = f_{23}\left(P_{Li}^{rd}, P_{Ld}^{rd}, P_{B}^{rd}, P_{K}^{rd}, P_{Y}^{rd}, \boldsymbol{Z}_{Li}^{rd}\right) \quad \text{(A.23)}$$

Imported retail lamb derived supply:

$$Q_{Li}^{rs} = f_{24}\left(P_{Li}^{rs}, \boldsymbol{W}_{Li}^{rs}\right) \quad \text{(A.24)}$$

*Wholesale Lamb Sector:*

Wholesale lamb derived demand:

$$Q_{L}^{wd} = f_{25}\left(P_{L}^{wd}, Q_{Ld}^{rd}, \boldsymbol{Z}_{L}^{wd}\right) \quad \text{(A.25)}$$

Wholesale lamb derived supply:

$$Q_{L}^{ws} = f_{26}\left(P_{L}^{ws}, Q_{L}^{ss}, \boldsymbol{W}_{L}^{ws}\right) \quad \text{(A.26)}$$

*Slaughter Lamb Sector:*

Domestic slaughter lamb derived demand:

$$Q_{L}^{sd} = f_{27}\left(P_{L}^{sd}, Q_{L}^{wd}, \boldsymbol{Z}_{L}^{sd}\right) \quad \text{(A.27)}$$

Domestic slaughter lamb derived supply:

$$Q_{L}^{ss} = f_{28}\left(P_{L}^{ss}, Q_{L}^{fs}, \boldsymbol{W}_{L}^{ss}\right) \quad \text{(A.28)}$$

*Feeder Lamb Sector:*

Domestic feeder lamb derived demand:

$$Q_{L}^{fd} = f_{29}\left(P_{L}^{fd}, Q_{L}^{sd}, \boldsymbol{Z}_{L}^{fd}\right) \quad \text{(A.29)}$$

Domestic feeder lamb primary supply:

$$Q_{L}^{fs} = f_{30}\left(P_{L}^{fs}, \boldsymbol{W}_{L}^{fs}\right) \quad \text{(A.30)}$$

**POULTRY SECTOR:**

*Retail Poultry Sector:*

Retail poultry primary demand:

$$Q_{Y}^{rd} = f_{31}\left(P_{Y}^{rd}, P_{B}^{rd}, P_{K}^{rd}, P_{Ld}^{rd}, P_{Li}^{rd}, \boldsymbol{Z}_{Y}^{rd}\right) \quad \text{(A.31)}$$

Retail poultry derived supply:

$$Q_{Y}^{rs} = f_{32}\left(P_{Y}^{rs}, Q_{Y}^{ws}, Q_{Ye}^{rd}, \boldsymbol{W}_{Y}^{rs}\right) \quad \text{(A.32)}$$

Exported retail poultry derived demand:

$$Q_{Ye}^{rd} = f_{33}\left(P_{Ye}^{rd}, \boldsymbol{Z}_{Ye}^{rd}\right) \quad \text{(A.33)}$$

*Wholesale Poultry Sector:*

Wholesale poultry derived demand:

$$Q_{Y}^{wd} = f_{34}\left(P_{Y}^{wd}, Q_{Y}^{rd}, \boldsymbol{Z}_{Y}^{wd}\right) \quad \text{(A.34)}$$

Wholesale poultry primary supply:

$$Q_{Y}^{ws} = f_{35}\left(P_{Y}^{ws}, \boldsymbol{W}_{Y}^{ws}\right) \quad \text{(A.35)}$$

Each of the endogenous price (*P*) and quantity (*Q*) variables, as well as the exogenous vectors, are presented in the form of $X_{kl}^{ij}$ for which *i* represents a market level (i.e., *r* = retail, *w* = wholesale (processor/packer), *s* = slaughter (feeding), and *f* = feeder (farm level)). In each case, the superscript *j* indicates either a demand function (*d*) or a supply function (*s*). The subscript *k* represents the species being considered (i.e., *B* = beef, *K* = pork, *L* = lamb, and *Y* = poultry). Finally, the subscript *l* represents either an import (*i*) or export (*e*) function where appropriate. This subscript is omitted for domestic market variables. Within each species, market levels are linked by downstream quantity variables among the demand equations and upstream quantity variables among the supply equations (Wohlgenant, 1993). The vectors $Z_{kl}^{i}$ and $W_{kl}^{i}$ represent demand and supply shifters, respectively.

***Equilibrium Displacement Model***

A general structural model of supply and demand relationships in the U.S. meat industry provides the framework for an equilibrium displacement model (EDM). The meat industry is modeled as a series of primary and derived demand and supply relations for the beef, pork, lamb, and poultry industries. The model uses quantity transmission elasticities between the supply and demand sectors to reflect variable input proportions among live animals and marketing service inputs (Brester, Marsh, and Atwood, 2004; Tomek and Robinson, 1990; Wohlgenant, 1993). The transmission elasticities incorporate variable input

proportion technologies by allowing production quantities to vary across market levels as input substitution occurs in response to changing output and input prices (Wohlgenant, 1989).

EDMs have been widely used in agricultural settings for determining the impacts of an exogenous shock on vertically-related marketing chains. Recent studies using an EDM include: Pendell et al. (2010) which study the impacts of various animal identification and traceability programs; Rickard and Sumner (2008) which assess the effects of trade barriers and domestic support reforms on global processing tomato markets; Balagtas and Kim (2007) analyzed the effectiveness of producer-funded advertising across dairy product and milk markets; and Brester, Marsh, and Atwood (2004) and Lusk and Anderson (2004) evaluated the distributional impacts of country-of-origin-labeling on livestock and meat markets. This study uses the EDM developed by Pendell et al. (2010).

An EDM is a linear approximation to a set of underlying and unknown demand and supply functions. The model's accuracy depends on the degree of nonlinearity of the true demand and supply functions and the magnitude of deviations from equilibrium being considered. If these deviations are relatively small, then a linear approximation of the true demand and supply functions should be relatively accurate (Brester, Marsh, and Atwood, 2004; Brester and Wohlgenant, 1997; Wohlgenant, 1993). Although total producer surplus measurements obtained from linear supply functions may or may not reflect actual values, changes in producer surplus caused by shifts in linear supply or demand functions should approximate actual changes provided that such shifts are relatively small.

An EDM of the U.S. livestock and meat industry is developed by totally differentiating structural supply and demand equations (A.1) to (A.35), and converting to elasticity form yields the linear elasticity model in equations (A.36) to (A.70).

**BEEF SECTOR:**

$$EQ_B^r = \eta_B^r EP_B^r + \eta_{BK}^r EP_K^r + \eta_{BLd}^r EP_{Ld}^r + \eta_{BLi}^r EP_{Li}^r + \eta_{BY}^r EP_Y^r + Ez_B^r \quad \text{(A.36)}$$

$$EQ_B^r = \varepsilon_B^r EP_B^r + \gamma_B^{wr} EQ_B^w + Ew_B^r \quad \text{(A.37)}$$

$$EQ_B^w = \eta_B^w EP_B^w + \tau_B^{rw} EQ_B^r + Ez_B^w \quad \text{(A.38)}$$

$$EQ_B^w = \varepsilon_B^w EP_B^w + \gamma_B^{sw}(Q_B^s / Q_B^w)EQ_B^s + (Q_{Bi}^w / Q_B^w)EQ_{Bi}^w - (Q_{Be}^w / Q_B^w)EQ_{Be}^w + Ew_B^w \quad \text{(A.39)}$$

$$EQ_{Bi}^w = \eta_{Bi}^w EP_{Bi}^w + \tau_B^{rw} EQ_B^w + (Q_{Bi}^w / Q_B^w)Ez_{Be}^w + Ez_{Bi}^w \quad \text{(A.40)}$$

$$EQ_{Bi}^w = \varepsilon_{Bi}^w EP_{Bi}^w + Ew_{Bi}^w \quad \text{(A.41)}$$

$$EQ_{Be}^w = \eta_{Be}^w EP_{Be}^w + Ez_{Be}^w \quad \text{(A.42)}$$

$$EQ_B^s = \eta_B^s EP_B^s + \tau_B^{ws} EQ_B^w + (Q_{Be}^w / Q_B^w) Ez_{Be}^w + Ez_B^s \quad \text{(A.43)}$$

$$EQ_B^s = \varepsilon_B^s EP_B^s + \gamma_B^{fs} EQ_B^f + Ew_B^s \quad \text{(A.44)}$$

$$EQ_B^f = \eta_B^f EP_B^f + \tau_B^{sf} EQ_B^s + Ez_B^f \quad \text{(A.45)}$$

$$EQ_B^f = \varepsilon_B^f EP_B^f + Ew_B^f \quad \text{(A.46)}$$

**PORK SECTOR:**

$$EQ_K^r = \eta_K^r EP_K^r + \eta_{KB}^r EP_B^r + \eta_{KLd}^r EP_{Ld}^r + \eta_{KLi}^r EP_{Li}^r + \eta_{KY}^r EP_Y^r + Ez_K^r \quad \text{(A.47)}$$

$$EQ_K^r = \varepsilon_K^r EP_K^r + \gamma_K^{wr} EQ_K^w + Ew_K^r \quad \text{(A.48)}$$

$$EQ_K^w = \eta_K^w EP_K^w + \tau_K^{rw} EQ_K^r + Ez_K^w \quad \text{(A.49)}$$

$$EQ_K^w = \varepsilon_K^w EP_K^w + \gamma_K^{sw}(Q_K^s / Q_K^w)EQ_K^s + (Q_{Ki}^w / Q_K^w) EQ_{Ki}^w - (Q_{Ke}^w / Q_K^w)EQ_{Ke}^w + Ew_K^w \quad \text{(A.50)}$$

$$EQ_{Ki}^w = \eta_{Ki}^w EP_{Ki}^w + \tau_K^{rw} EQ_K^w + (Q_{Ki}^w / Q_K^w) Ez_{Ke}^w + Ez_{Ki}^w \quad \text{(A.51)}$$

$$EQ_{Ki}^w = \varepsilon_{Ki}^w EP_{Ki}^w + Ew_{Ki}^w \quad \text{(A.52)}$$

$$EQ_{Ke}^w = \eta_{Ke}^w EP_{Ke}^w + Ez_{Ke}^w \quad \text{(A.53)}$$

$$EQ_K^s = \eta_K^s EP_K^s + \tau_K^{ws} EQ_K^w + (Q_{Ke}^w / Q_K^w) Ez_{Ke}^w + Ez_K^s \quad \text{(A.54)}$$

$$EQ_K^s = \varepsilon_K^s EP_K^s + Ew_k^s \quad \text{(A.55)}$$

**LAMB SECTOR:**

$$EQ_{Ld}^r = \eta_{Ld}^r EP_{Ld}^r + \eta_{LdLi}^r EP_{Li}^r + \eta_{LdB}^r EP_B^r + \eta_{LdK}^r EP_K^r + \eta_{LdY}^r EP_Y^r + Ez_{Ld}^r \quad \text{(A.56)}$$

$$EQ_{Ld}^r = \varepsilon_{Ld}^r EP_{Ld}^r + \gamma_L^{wr} EQ_L^w + Ew_{Ld}^r \quad \text{(A.57)}$$

$$EQ_{Li}^r = \eta_{Li}^r EP_{Li}^r + \eta_{LiLd}^r EP_{Ld}^r + \eta_{LiB}^r EP_B^r + \eta_{LiK}^r EP_K^r + \eta_{LiY}^r EP_Y^r + Ez_{Li}^r \quad \text{(A.58)}$$

$$EQ_{Li}^r = \varepsilon_{Li}^r EP_{Li}^r + Ew_{Li}^r \quad \text{(A.59)}$$

$$EQ_L^w = \eta_L^w EP_L^w + \tau_L^{rw} EQ_{Ld}^r + Ez_L^w \quad \text{(A.60)}$$

$$EQ_L^w = \varepsilon_L^w EP_L^w + \gamma_L^{sw} EQ_L^s + Ew_L^w \quad \text{(A.61)}$$

$$EQ_L^s = \eta_L^s EP_L^s + \tau_L^{ws} EQ_L^w + Ez_L^s \quad \text{(A.62)}$$

$$EQ_L^s = \varepsilon_L^s EP_L^s + \gamma_L^{fs} EQ_L^f + Ew_L^s \quad \text{(A.63)}$$

$$EQ_L^f = \eta_L^f EP_L^f + \tau_L^{sf} EQ_L^s + Ez_L^f \quad \text{(A.64)}$$

$$EQ_L^f = \varepsilon_L^f EP_L^f + Ew_L^f \quad \text{(A.65)}$$

**POULTRY SECTOR:**

$$EQ_Y^r = \eta_Y^r EP_Y^r + \eta_{YB}^r EP_B^r + \eta_{YK}^r EP_K^r + \eta_{YLd}^r EP_{Ld}^r + \eta_{YLi}^r EP_{Li}^r + Ez_Y^r \quad \text{(A.66)}$$

$$EQ_Y^r = \varepsilon_Y^r EP_Y^r + \gamma_Y^{wr} EQ_Y^w + Ew_Y^r \quad \text{(A.67)}$$

$$EQ_{Ye}^r = \eta_{Ye}^r EP_{Ye}^r + Ez_{Ye}^r \quad \text{(A.68)}$$

$$EQ_Y^w = \eta_Y^w EP_Y^w + \tau_Y^{rw} EQ_Y^r + Ez_Y^w \quad \text{(A.69)}$$

$$EQ_Y^w = \varepsilon_Y^w EP_Y^w - (Q_{Ye}^r / Q_Y^w) EQ_{Ye}^r + Ew_Y^w \quad \text{(A.70)}$$

The term *E* represents a relative change operator, that is, $EP_k^r = dP_k^r / P_k^r = d\ln(P_k^r)$. Table A-1 provides definitions and estimates for all parameters. In addition, each $z_B^i$ and $w_B^i$ represent single elements of the demand $(Z_k^i)$ and supply $(W_k^i)$ shifters, respectively. Specifically, these elements represent percentage supply or demand changes from initial equilibria caused by a traceability program. That is, $z_k^i$ represents potential changes in demand for meat products resulting from a traceability program. Similarly, $w_k^i$ represents costs that shift supply which may result from a traceability program. All other elements of $(Z_k^i)$ and $(W_k^i)$ are assumed to be unchanged by implementation of a traceability program.

The elasticity form of the model can be expressed in matrix notation as:

$$\mathbf{AY} = \mathbf{BX}, \quad \text{(A.71)}$$

where **A** is a 35x35 nonsingular matrix of elasticities; **Y** is a 35x1 vector of changes in the endogenous price and quantity variables; **B** is a 35x35 matrix of parameters associated with exogenous variables; and **X** is a 35x1 vector of percentage changes in exogenous demand and supply variables. Changes in the

endogenous variables (**Y**) caused by changes in benefits and costs associated with animal identification (**X**) are calculated by solving equation (A.71) as:

$$\mathbf{Y} = \mathbf{A}^{-1}\mathbf{B}\mathbf{X}\,. \tag{A.72}$$

Changes in consumer and producer surplus created by introducing a traceability program can be measured in terms of changes in prices and quantities from equation (A.72) as:

$$\Delta CS_k = -P_k^r Q_k^r (EP_k^r - z_k^r)(1 + 0.5EQ_k^r) \tag{A.73}$$

$$\Delta PS_k^i = P_k^i Q_k^i (EP_k^i + w_k^i)(1 + 0.5EQ_k^i) \tag{A.74}$$

where consumer and producer surplus are denoted by CS and PS, respectively. All other variables have previously been defined.

Change in total producer surplus in species *k* is the sum of the change in producer surplus from each market level, $\Delta PS_k = \sum^i (\Delta PS_k^i)$, and the change in total meat producer surplus is the sum of the change in producer surplus for each species, $\Delta PS = \sum (\Delta PS_k)$. Similarly, the change in the total meat consumer surplus is the sum of the change in consumer surplus across each commodity, $\Delta CS = \sum (\Delta CS_k)$.

***Model Parameterization***

Solutions for **Y** in equation (A.72) require elasticity estimates for the elements of **A** and parameter estimates for the elements of **B**. All short-run (1 year) and long-run (10 year) simulations are based on published supply and demand elasticities. In addition, the quantity transmission elasticities were estimated from publically-available data (see Pendell et al. (2010) for more discussion on the estimation procedures). In all cases, Monte Carlo simulations are conducted using random sampling from a range of these elasticities. The Monte Carlo simulations allow the construction of empirical probability

distributions for changes in endogenous price and quantity variables and surplus measures. The Monte Carlo simulations are conducted assuming that elasticity estimates are correlated among vertical demand and supply sectors within each species. Discussion on the Monte Carlo simulations can be found in the appendix of the Blasi et al. (2009). All elasticity estimates used in the study are reported in table A-1.

**Table A-1. Elasticity Definitions, Estimates, and Sources for the Log Differential Equilibrium Displacement Model**

| Symbol | Definition | Estimate | |
|---|---|---|---|
| | | Short Run | Long Run |
| $\eta_B^r$ | Own-price elasticity of demand for retail beef | -0.86[b] | -1.17[b] |
| $\eta_{BK}^r$ | Cross-price elasticity of demand for retail beef with respect to the price of retail pork | 0.10[a] | |
| $\eta_{BLd}^r$ | Cross-price elasticity of demand for retail beef with respect to the price of domestic retail lamb | 0.05[c] | |
| $\eta_{BLi}^r$ | Cross-price elasticity of demand for retail beef with respect to the price of imported retail lamb | 0.05[c] | |
| $\eta_{BY}^r$ | Cross-price elasticity of demand for retail beef with respect to the price of retail poultry | 0.05[a] | |
| $\varepsilon_B^r$ | Own-price elasticity of supply for retail beef | 0.36[d] | 4.62[d] |
| $\eta_B^w$ | Own-price elasticity of demand for wholesale beef | -0.58[b] | -0.94[b] |
| $\varepsilon_B^w$ | Own-price elasticity of supply for wholesale beef | 0.28[d] | 3.43[b] |
| $\eta_{Bi}^w$ | Own-price elasticity of demand for wholesale beef imports | -0.58[c] | -0.94[c] |
| $\varepsilon_{Bi}^w$ | Own-price elasticity of supply for wholesale beef imports | 1.83[c] | 10.00[c] |
| $\eta_{Be}^w$ | Own-price elasticity of demand for wholesale beef exports | -0.42[e] | -3.00[e] |
| $\eta_B^s$ | Own-price elasticity of demand for slaughter cattle | -0.40[b] | -0.53[b] |
| $\varepsilon_B^s$ | Own-price elasticity of supply for slaughter cattle | 0.26[f] | 3.24[f] |
| $\eta_B^f$ | Own-price elasticity of demand for feeder cattle | -0.14[b] | -0.75[b] |
| $\varepsilon_B^f$ | Own-price elasticity of supply for feeder cattle | 0.22[g] | 2.82[g] |
| $\eta_K^r$ | Own-price elasticity of demand for retail pork | -0.69[a] | -1.00[c] |
| $\eta_{KB}^r$ | Cross-price elasticity of demand for retail pork with respect to the price of retail beef | 0.18[h] | |
| $\eta_{KLd}^r$ | Cross-price elasticity of demand for retail pork with respect to the price of domestic retail lamb | 0.02[c] | |
| $\eta_{KLi}^r$ | Cross-price elasticity of demand for retail pork with respect to the price of imported retail lamb | 0.02[c] | |
| $\eta_{KY}^r$ | Cross-price elasticity of demand for retail pork with respect to the price of retail poultry | 0.02[h] | |
| $\varepsilon_K^r$ | Own-price elasticity of supply for retail pork | 0.73[d] | 3.87[d] |
| $\eta_K^w$ | Own-price elasticity of demand for wholesale pork | -0.71[d] | -1.00[c] |
| $\varepsilon_K^w$ | Own-price elasticity of supply for wholesale pork | 0.44[d] | 1.94[d] |

**Table A-1. Elasticity Definitions, Estimates, and Sources for the Log Differential Equilibrium Displacement Model, Cont.**

| Symbol | Definition | Estimate | |
|---|---|---|---|
| | | Short Run | Long Run |
| $\eta_{Ki}^{w}$ | Own-price elasticity of demand for wholesale pork imports | -0.71[c] | -1.00[c] |
| $\varepsilon_{Ki}^{w}$ | Own-price elasticity of supply for wholesale pork imports | 1.41[c] | 10.00[c] |
| $\eta_{Ke}^{w}$ | Own-price elasticity of demand for wholesale pork exports | -0.89[i] | -1.00[c] |
| $\eta_{K}^{s}$ | Own-price elasticity of demand for slaughter hogs | -0.51j | -1.00[c] |
| $\varepsilon_{K}^{s}$ | Own-price elasticity of supply for slaughter hogs | 0.41k | 1.80[k] |
| $\eta_{Ld}^{r}$ | Own-price elasticity of demand for domestic retail lamb | -0.52[b] | -1.11[b] |
| $\eta_{LdLi}^{r}$ | Cross-price elasticity of demand for domestic retail lamb with respect to the price of imported retail lamb | 0.29[b] | |
| $\eta_{LdB}^{r}$ | Cross-price elasticity of demand for domestic retail lamb with respect to the price of retail beef | 0.05[c] | |
| $\eta_{LdK}^{r}$ | Cross-price elasticity of demand for domestic retail lamb with respect to the price of retail pork | 0.02[c] | |
| $\eta_{LdY}^{r}$ | Cross-price elasticity of demand for domestic retail lamb with respect to the price of retail poultry | 0.02[c] | |
| $\varepsilon_{Ld}^{r}$ | Own-price elasticity of supply for domestic retail lamb | 0.15[b] | 3.96[b] |
| $\eta_{Li}^{r}$ | Own-price elasticity of demand for imported retail lamb | -0.41[b] | -0.63[b] |
| $\eta_{LiLd}^{r}$ | Cross-price elasticity of demand for imported retail lamb with respect to the price of domestic retail lamb | 0.78[b] | |
| $\eta_{LiB}^{r}$ | Cross-price elasticity of demand for imported retail lamb with respect to the price of retail beef | 0.05[c] | |
| $\eta_{LiK}^{r}$ | Cross-price elasticity of demand for imported retail lamb with respect to the price of retail pork | 0.02[c] | |
| $\eta_{LiY}^{r}$ | Cross-price elasticity of demand for imported retail lamb with respect to the price of retail poultry | 0.02[c] | |
| $\varepsilon_{Li}^{r}$ | Own-price elasticity of supply for imported retail lamb | 10.00[b] | 10.00[b] |
| $\eta_{L}^{w}$ | Own-price elasticity of demand for wholesale lamb | -0.35[b] | -1.03[b] |
| $\varepsilon_{L}^{w}$ | Own-price elasticity of supply for wholesale lamb | 0.16[b] | 3.85[b] |
| $\eta_{L}^{s}$ | Own-price elasticity of demand for slaughter lamb | -0.33[b] | -0.87[b] |
| $\varepsilon_{L}^{s}$ | Own-price elasticity of supply for slaughter lamb | 0.12[b] | 2.95[b] |
| $\eta_{L}^{f}$ | Own-price elasticity of demand for feeder lamb | -0.11[b] | -0.29[b] |

**Table A-1. Elasticity Definitions, Estimates, and Sources for the Log Differential Equilibrium Displacement Model, Cont.**

| Symbol | Definition | Estimate | |
|---|---|---|---|
| | | Short Run | Long Run |
| $\varepsilon_L^f$ | Own-price elasticity of supply for feeder lamb | 0.09[b] | 2.26[b] |
| $\eta_Y^r$ | Own-price elasticity of demand for retail poultry | -0.29[h] | -1.00[c] |
| $\eta_{YB}^r$ | Cross-price elasticity of demand for retail poultry with respect to the price of retail beef | 0.18[h] | |
| $\eta_{YK}^r$ | Cross-price elasticity of demand for retail poultry with respect to the price of retail pork | 0.04[h] | |
| $\eta_{YLd}^r$ | Cross-price elasticity of demand for retail poultry with respect to the price of domestic retail lamb | 0.02[c] | |
| $\eta_{YLi}^r$ | Cross-price elasticity of demand for retail poultry with respect to the price of imported retail lamb | 0.02[c] | |
| $\varepsilon_Y^r$ | Own-price elasticity of supply for retail poultry | 0.18[d] | 13.10[d] |
| $\eta_Y^w$ | Own-price elasticity of demand for wholesale poultry | -0.22[d] | -1.00[d] |
| $\varepsilon_Y^w$ | Own-price elasticity of supply for wholesale poultry | 0.14[d] | 14.00[d] |
| $\eta_{Ye}^w$ | Own-price elasticity of demand for wholesale poultry exports | -0.31[c] | -1.00[c] |
| $\gamma_B^{wr}$ | Percentage change in retail beef supply given a 1% change in wholesale beef supply | 0.771[c] | |
| $\tau_B^{rw}$ | Percentage change in wholesale beef demand given a 1% change in retail beef demand | 0.995[c] | |
| $\gamma_B^{sw}$ | Percentage change in wholesale beef supply given a 1% change in slaughter cattle supply | 0.909[c] | |
| $\tau_B^{ws}$ | Percentage change in slaughter cattle demand given a 1% change in wholesale beef demand | 1.09[c] | |
| $\gamma_B^{fs}$ | Percentage change in slaughter cattle supply given a 1% change in feeder cattle supply | 1.07[c] | |
| $\tau_B^{sf}$ | Percentage change in feeder cattle demand given a 1% change in slaughter cattle demand | 0.957[c] | |
| $\gamma_K^{wr}$ | Percentage change in retail pork supply given a 1% change in wholesale pork supply | 0.962[c] | |
| $\tau_K^{rw}$ | Percentage change in wholesale pork demand given a 1% change in retail pork demand | 0.983[c] | |
| $\gamma_K^{sw}$ | Percentage change in wholesale pork supply given a 1% change in slaughter hog supply | 0.963[c] | |
| $\tau_K^{ws}$ | Percentage change in slaughter hog demand given a 1% change in wholesale pork demand | 0.961[c] | |
| $\gamma_L^{wr}$ | Percentage change in retail domestic lamb supply given a 1% change in wholesale lamb supply | 0.908[c] | |

**Table A-1. Elasticity Definitions, Estimates, and Sources for the Log Differential Equilibrium Displacement Model, Cont.**

| | | |
|---|---|---|
| $\tau_L^{rw}$ | Percentage change in wholesale lamb demand given a 1% change in retail domestic lamb demand | 0.731[c] |
| $\gamma_L^{sw}$ | Percentage change in wholesale lamb supply given a 1% change in slaughter lamb supply | 1.007[c] |
| $\tau_L^{ws}$ | Percentage change in slaughter lamb demand given a 1% change in wholesale lamb demand | 0.993[c] |
| $\gamma_L^{fs}$ | Percentage change in slaughter lamb supply given a 1% change in feeder lamb supply | 0.864[c] |
| $\tau_L^{sf}$ | Percentage change in feeder lamb demand given a 1% change in slaughter lamb demand | 0.962[c] |
| $\gamma_Y^{wr}$ | Percentage change in retail poultry supply given a 1% change in wholesale poultry supply | 0.806[c] |
| $\tau_Y^{rw}$ | Percentage change in wholesale poultry demand given a 1% change in retail poultry demand | 1.035[c] |

[a]Brester and Schroeder (1995); [b]RTI Meat Marketing Study (2007a,b); [c]Pendell et al. (2010); [d]Brester, Marsh, and Atwood (2004); [e]Zhao, Wahl, and Marsh (2006); [f]Marsh (1994); [g]Marsh (2003); [h]Brester (1996); [i]Paarlberg et al. (2008); [j]Wohlgenant (2005); [k]Lemieux and Wohlgenant (1989).

**Table A-2. Variable Definitions and Estimates for the Structural and Equilibrium Displacement Models, 2009**

| Symbol | Definition | Mean[a] |
|---|---|---|
| $Q_B^r$ | Quantity (consumption) of retail beef, billions pounds (retail weight) | 18.79 |
| $P_B^r$ | Price of Choice retail beef, cents per pound | 425.96 |
| $P_K^r$ | Price of retail pork, cents per pound | 291.97 |
| $P_{Ld}^r$ | Price of retail domestic lamb, cents per pound | 506.43 |
| $P_{Li}^r$ | Price of retail imported lamb, cents per pound | 526.00 |
| $P_Y^r$ | Price of retail poultry, cents per pound | 177.97 |
| $Q_B^w$ | Quantity of wholesale beef, billions pounds (carcass weight) | 26.10 |
| $P_B^w$ | Price of wholesale Choice beef, cents per pound | 140.78 |
| $Q_B^s$ | Quantity of beef obtained from slaughter cattle, billions pounds (live weight) | 43.12 |
| $Q_{Bi}^w$ | Quantity of wholesale beef imports, billions pounds (carcass weight) | 1.98 |
| $Q_{Be}^w$ | Quantity of wholesale beef exports, billions pounds (carcass weight) | 1.96 |
| $P_{Bi}^w$ | Price of wholesale beef imports, cents per pound | 143.45 |
| $\boldsymbol{P_{Be}^w}$ | Price of wholesale beef exports, cents per pound | 155.96 |
| $P_B^s$ | Price of slaughter cattle, $/cwt (live weight) | 83.25 |
| $Q_B^f$ | Quantity of beef obtained from feeder cattle, billions pounds (live weight) | 26.86 |
| $P_B^f$ | Price of feeder cattle, $/cwt | 96.14 |
| $Q_K^r$ | Quantity (consumption) of retail pork, billions pounds (retail weight) | 15.27 |
| $Q_K^w$ | Quantity of wholesale pork, billions pounds (carcass weight) | 23.00 |

**Table A-2. Variable Definitions and Estimates for the Structural and Equilibrium Displacement Models, 2009, Cont.**

| Symbol | Definition | Mean |
|---|---|---|
| $P_K^w$ | Price of wholesale pork, cents per pound | 58.19 |
| $Q_K^s$ | Quantity of pork obtained from slaughter hogs, billions pounds (live weight) | 30.74 |
| $Q_{Ki}^w$ | Quantity of wholesale pork imports, billions pounds (carcass weight) | 0.49 |
| $Q_{Ke}^w$ | Quantity of wholesale pork exports, billions pounds (carcass weight) | 4.11 |
| $P_{Ki}^w$ | Price of wholesale pork imports, cents per pound | 129.79 |
| $P_{Ke}^w$ | Price of wholesale pork exports, cents per pound | 105.26 |
| $P_K^s$ | Price of slaughter hogs, $/cwt (live weight) | 41.25 |
| $Q_{Ld}^r$ | Quantity (consumption) of retail domestic lamb, billions pounds (retail weight) | 0.15 |
| $Q_L^w$ | Quantity of wholesale lamb, billions pounds (carcass weight) | 0.17 |
| $Q_{Li}^r$ | Quantity (consumption) of retail imported lamb, billions pounds (retail weight) | 0.15 |
| $P_L^w$ | Price of wholesale lamb, cents per pound | 194.98 |
| $Q_L^s$ | Quantity of lamb obtained from slaughter lamb, billions pounds (live weight) | 0.34 |
| $P_L^s$ | Price of slaughter lamb, $/cwt (live weight) | 90.10 |
| $Q_L^f$ | Quantity of lamb obtained from feeder lamb, billions pounds (live weight) | 0.28 |
| $P_L^f$ | Price of feeder lamb, $/cwt | 109.39 |
| $Q_Y^r$ | Quantity (consumption) of retail poultry, billions pounds (retail weight) | 29.79 |

**Table A-2. Variable Definitions and Estimates for the Structural and Equilibrium Displacement Models, 2009, Cont.**

| Symbol | Definition | Mean |
|---|---|---|
| $Q_{Ye}^{r}$ | Quantity of retail poultry exports, billions pounds (retail weight) | 8.57 |
| $Q_{Y}^{w}$ | Quantity of wholesale poultry, billions pounds (RTC) | 55.67 |
| $P_{Y}^{w}$ | Price of retail poultry export, cents per pound | 49.00 |
| $P_{Y}^{w}$ | Price of wholesale poultry, cents per pound | 77.14 |
| $\boldsymbol{Z}_{kl}^{i}$ | Demand shifters at the *i* th market level for the *k* th commodity and *l* th market (domestic/import) | -[b] |
| $\boldsymbol{W}_{kl}^{i}$ | Supply shifters at the *i* th market level for the *k* th commodity and *l* th market (domestic/import) | -[b] |

[a]Source: Livestock Marketing Information Center.

[b]Variables without names are inputs to the model and thus do not have data values.

## Appendix B. Median Percentage Changes in Prices and Quantities.

**Table B-1. Median Percentage Changes from No Expansion in Traceability and Losing Beef Exports to South Korea (7.3% Decline in Total Beef Exports)**

| Endogenous Variables | Short Run | Long Run |
|---|---|---|
| Retail Beef Quantity | 0.184% | -0.017% |
| Retail Beef Price | -0.217% | 0.014% |
| Wholesale Beef Quantity | 0.356% | -0.108% |
| Wholesale Beef Price | -0.286% | 0.098% |
| Imported Wholesale Beef Quantity | -0.156% | -0.599% |
| Imported Wholesale Beef Price | -0.085% | -0.060% |
| Exported Wholesale Beef Quantity | -7.154% | -7.567% |
| Slaughter Cattle Quantity | -0.058% | -0.642% |
| Slaughter Cattle Price | -0.262% | -0.041% |
| Feeder Cattle Quantity | -0.022% | -0.482% |
| Feeder Cattle Price | -0.214% | -0.171% |
| Retail Pork Quantity | -0.030% | 0.002% |
| Retail Pork Price | -0.014% | 0.000% |
| Wholesale Pork Quantity | -0.019% | 0.002% |
| Wholesale Pork Price | -0.013% | 0.000% |
| Imported Wholesale Pork Quantity | -0.012% | 0.002% |
| Imported Wholesale Pork Price | -0.009% | 0.000% |
| Exported Wholesale Pork Quantity | 0.012% | 0.000% |
| Slaughter Hog Quantity | -0.008% | 0.001% |
| Slaughter Hog Price | -0.020% | 0.001% |
| Domestic Retail Lamb Quantity | -0.004% | 0.001% |
| Domestic Retail Lamb Price | -0.017% | 0.000% |
| Imported Retail Lamb Quantity | -0.024% | 0.001% |
| Imported Retail Lamb Price | -0.002% | 0.000% |
| Wholesale Lamb Quantity | -0.001% | 0.000% |
| Wholesale Lamb Price | -0.004% | 0.000% |
| Slaughter Lamb Quantity | 0.000% | 0.000% |
| Slaughter Lamb Price | -0.002% | 0.000% |
| Feeder Lamb Quantity | 0.000% | 0.000% |
| Feeder Lamb Price | -0.002% | 0.000% |
| Retail Poultry Quantity | -0.032% | 0.002% |
| Retail Poultry Price | -0.029% | 0.000% |
| Wholesale Poultry Quantity | -0.013% | 0.002% |
| Wholesale Poultry Price | -0.091% | 0.000% |
| Exported Retail Poultry Quantity | 0.009% | 0.000% |

**Table B-2. Median Percentage Changes from No Expansion in Traceability and Losing Pork Exports to South Korea (6.3% Decline in Total Pork Exports)**

| Endogenous Variables | Short Run | Long Run |
|---|---|---|
| Retail Beef Quantity | -0.016% | -0.002% |
| Retail Beef Price | -0.022% | 0.000% |
| Wholesale Beef Quantity | -0.010% | -0.002% |
| Wholesale Beef Price | -0.010% | 0.000% |
| Imported Wholesale Beef Quantity | -0.007% | -0.002% |
| Imported Wholesale Beef Price | -0.004% | 0.000% |
| Exported Wholesale Beef Quantity | 0.004% | -0.001% |
| Slaughter Cattle Quantity | -0.004% | -0.002% |
| Slaughter Cattle Price | -0.016% | 0.000% |
| Feeder Cattle Quantity | -0.001% | -0.002% |
| Feeder Cattle Price | -0.015% | -0.001% |
| Retail Pork Quantity | 0.234% | 0.019% |
| Retail Pork Price | -0.355% | -0.019% |
| Wholesale Pork Quantity | 0.532% | 0.102% |
| Wholesale Pork Price | -0.405% | -0.082% |
| Imported Wholesale Pork Quantity | 0.245% | -0.034% |
| Imported Wholesale Pork Price | 0.179% | -0.003% |
| Exported Wholesale Pork Quantity | -5.952% | -6.227% |
| Slaughter Hog Quantity | -0.275% | -0.665% |
| Slaughter Hog Price | -0.672% | -0.369% |
| Domestic Retail Lamb Quantity | -0.003% | 0.000% |
| Domestic Retail Lamb Price | -0.012% | 0.000% |
| Imported Retail Lamb Quantity | -0.017% | 0.000% |
| Imported Retail Lamb Price | -0.002% | 0.000% |
| Wholesale Lamb Quantity | -0.001% | 0.000% |
| Wholesale Lamb Price | -0.003% | 0.000% |
| Slaughter Lamb Quantity | 0.000% | 0.000% |
| Slaughter Lamb Price | -0.001% | 0.000% |
| Feeder Lamb Quantity | 0.000% | 0.000% |
| Feeder Lamb Price | -0.001% | 0.000% |
| Retail Poultry Quantity | -0.015% | -0.001% |
| Retail Poultry Price | -0.013% | 0.000% |
| Wholesale Poultry Quantity | -0.006% | -0.001% |
| Wholesale Poultry Price | -0.042% | 0.000% |
| Exported Retail Poultry Quantity | 0.004% | 0.000% |

**Table B-3. Median Percentage Changes from No Expansion in Traceability and Losing Beef and Pork Exports to South Korea (7.3% Decline in Total Beef Exports and a 6.3% Decline in Total Pork Exports)**

| Endogenous Variables | Short Run | Long Run |
|---|---|---|
| Retail Beef Quantity | 0.168% | -0.018% |
| Retail Beef Price | -0.242% | 0.014% |
| Wholesale Beef Quantity | 0.348% | -0.110% |
| Wholesale Beef Price | -0.298% | 0.099% |
| Imported Wholesale Beef Quantity | -0.163% | -0.602% |
| Imported Wholesale Beef Price | -0.089% | -0.060% |
| Exported Wholesale Beef Quantity | -7.150% | -7.569% |
| Slaughter Cattle Quantity | -0.062% | -0.644% |
| Slaughter Cattle Price | -0.280% | -0.041% |
| Feeder Cattle Quantity | -0.023% | -0.483% |
| Feeder Cattle Price | -0.230% | -0.171% |
| Retail Pork Quantity | 0.200% | 0.022% |
| Retail Pork Price | -0.373% | -0.019% |
| Wholesale Pork Quantity | 0.509% | 0.104% |
| Wholesale Pork Price | -0.420% | -0.082% |
| Imported Wholesale Pork Quantity | 0.231% | -0.032% |
| Imported Wholesale Pork Price | 0.167% | -0.003% |
| Exported Wholesale Pork Quantity | -5.937% | -6.227% |
| Slaughter Hog Quantity | -0.284% | -0.663% |
| Slaughter Hog Price | -0.695% | -0.368% |
| Domestic Retail Lamb Quantity | -0.006% | 0.000% |
| Domestic Retail Lamb Price | -0.030% | 0.000% |
| Imported Retail Lamb Quantity | -0.043% | 0.000% |
| Imported Retail Lamb Price | -0.004% | 0.000% |
| Wholesale Lamb Quantity | -0.002% | 0.000% |
| Wholesale Lamb Price | -0.008% | 0.000% |
| Slaughter Lamb Quantity | -0.001% | 0.000% |
| Slaughter Lamb Price | -0.003% | 0.000% |
| Feeder Lamb Quantity | 0.000% | 0.000% |
| Feeder Lamb Price | -0.003% | 0.000% |
| Retail Poultry Quantity | -0.048% | 0.002% |
| Retail Poultry Price | -0.043% | 0.000% |
| Wholesale Poultry Quantity | -0.019% | 0.002% |
| Wholesale Poultry Price | -0.136% | 0.000% |
| Exported Retail Poultry Quantity | 0.013% | 0.000% |

**Table B-4. Median Percentage Changes from No Expansion in Traceability and Losing All non-North American Beef Exports (48.7% Decline in Total Beef Exports)**

| Endogenous Variables | Short Run | Long Run |
|---|---|---|
| Retail Beef Quantity | 1.232% | -0.111% |
| Retail Beef Price | -1.455% | 0.095% |
| Wholesale Beef Quantity | 2.388% | -0.722% |
| Wholesale Beef Price | -1.919% | 0.660% |
| Imported Wholesale Beef Quantity | -1.043% | -4.018% |
| Imported Wholesale Beef Price | -0.572% | -0.402% |
| Exported Wholesale Beef Quantity | -47.954% | -50.726% |
| Slaughter Cattle Quantity | -0.391% | -4.304% |
| Slaughter Cattle Price | -1.756% | -0.275% |
| Feeder Cattle Quantity | -0.146% | -3.229% |
| Feeder Cattle Price | -1.437% | -1.145% |
| Retail Pork Quantity | -0.202% | 0.016% |
| Retail Pork Price | -0.096% | 0.000% |
| Wholesale Pork Quantity | -0.130% | 0.014% |
| Wholesale Pork Price | -0.088% | 0.001% |
| Imported Wholesale Pork Quantity | -0.082% | 0.013% |
| Imported Wholesale Pork Price | -0.060% | 0.001% |
| Exported Wholesale Pork Quantity | 0.077% | -0.001% |
| Slaughter Hog Quantity | -0.055% | 0.009% |
| Slaughter Hog Price | -0.133% | 0.005% |
| Domestic Retail Lamb Quantity | -0.024% | 0.004% |
| Domestic Retail Lamb Price | -0.112% | 0.000% |
| Imported Retail Lamb Quantity | -0.160% | 0.005% |
| Imported Retail Lamb Price | -0.016% | 0.000% |
| Wholesale Lamb Quantity | -0.007% | 0.003% |
| Wholesale Lamb Price | -0.028% | 0.000% |
| Slaughter Lamb Quantity | -0.002% | 0.003% |
| Slaughter Lamb Price | -0.013% | 0.000% |
| Feeder Lamb Quantity | -0.001% | 0.002% |
| Feeder Lamb Price | -0.012% | 0.001% |
| Retail Poultry Quantity | -0.212% | 0.017% |
| Retail Poultry Price | -0.192% | 0.000% |
| Wholesale Poultry Quantity | -0.084% | 0.016% |
| Wholesale Poultry Price | -0.609% | 0.002% |
| Exported Retail Poultry Quantity | 0.058% | 0.000% |

**Table B-5. Median Percentage Changes from No Expansion in Traceability and Losing All non-North American Pork Exports (68.3% Decline in Total Pork Exports)**

| Endogenous Variables | Short Run | Long Run |
|---|---|---|
| Retail Beef Quantity | -0.173% | -0.020% |
| Retail Beef Price | -0.244% | 0.000% |
| Wholesale Beef Quantity | -0.105% | -0.024% |
| Wholesale Beef Price | -0.104% | 0.003% |
| Imported Wholesale Beef Quantity | -0.080% | -0.021% |
| Imported Wholesale Beef Price | -0.044% | -0.002% |
| Exported Wholesale Beef Quantity | 0.042% | -0.010% |
| Slaughter Cattle Quantity | -0.041% | -0.024% |
| Slaughter Cattle Price | -0.175% | -0.001% |
| Feeder Cattle Quantity | -0.016% | -0.017% |
| Feeder Cattle Price | -0.160% | -0.006% |
| Retail Pork Quantity | 2.530% | 0.211% |
| Retail Pork Price | -3.841% | -0.211% |
| Wholesale Pork Quantity | 5.756% | 1.104% |
| Wholesale Pork Price | -4.387% | -0.886% |
| Imported Wholesale Pork Quantity | 2.653% | -0.372% |
| Imported Wholesale Pork Price | 1.936% | -0.037% |
| Exported Wholesale Pork Quantity | -64.451% | -67.434% |
| Slaughter Hog Quantity | -2.975% | -7.198% |
| Slaughter Hog Price | -7.279% | -3.999% |
| Domestic Retail Lamb Quantity | -0.027% | -0.004% |
| Domestic Retail Lamb Price | -0.130% | 0.000% |
| Imported Retail Lamb Quantity | -0.187% | -0.004% |
| Imported Retail Lamb Price | -0.019% | 0.000% |
| Wholesale Lamb Quantity | -0.008% | -0.003% |
| Wholesale Lamb Price | -0.032% | 0.000% |
| Slaughter Lamb Quantity | -0.003% | -0.002% |
| Slaughter Lamb Price | -0.015% | 0.000% |
| Feeder Lamb Quantity | -0.001% | -0.002% |
| Feeder Lamb Price | -0.014% | -0.001% |
| Retail Poultry Quantity | -0.158% | -0.008% |
| Retail Poultry Price | -0.141% | 0.000% |
| Wholesale Poultry Quantity | -0.062% | -0.007% |
| Wholesale Poultry Price | -0.454% | -0.001% |
| Exported Retail Poultry Quantity | 0.043% | 0.000% |

**Table B-6. Median Percentage Changes from No Expansion in Traceability and Losing All non-North American Beef and Pork Exports (48.7% Decline in total Beef Exports and a 68.3% Decline in Total Pork Exports)**

| Endogenous Variables | Short Run | Long Run |
|---|---|---|
| Retail Beef Quantity | 1.061% | -0.131% |
| Retail Beef Price | -1.731% | 0.094% |
| Wholesale Beef Quantity | 2.295% | -0.746% |
| Wholesale Beef Price | -2.043% | 0.664% |
| Imported Wholesale Beef Quantity | -1.124% | -4.037% |
| Imported Wholesale Beef Price | -0.619% | -0.404% |
| Exported Wholesale Beef Quantity | -47.906% | -50.738% |
| Slaughter Cattle Quantity | -0.433% | -4.330% |
| Slaughter Cattle Price | -1.947% | -0.276% |
| Feeder Cattle Quantity | -0.158% | -3.240% |
| Feeder Cattle Price | -1.589% | -1.149% |
| Retail Pork Quantity | 2.309% | 0.229% |
| Retail Pork Price | -3.968% | -0.210% |
| Wholesale Pork Quantity | 5.604% | 1.119% |
| Wholesale Pork Price | -4.483% | -0.885% |
| Imported Wholesale Pork Quantity | 2.560% | -0.355% |
| Imported Wholesale Pork Price | 1.870% | -0.035% |
| Exported Wholesale Pork Quantity | -64.363% | -67.435% |
| Slaughter Hog Quantity | -3.043% | -7.188% |
| Slaughter Hog Price | -7.431% | -3.993% |
| Domestic Retail Lamb Quantity | -0.054% | 0.001% |
| Domestic Retail Lamb Price | -0.254% | 0.000% |
| Imported Retail Lamb Quantity | -0.360% | 0.001% |
| Imported Retail Lamb Price | -0.036% | 0.000% |
| Wholesale Lamb Quantity | -0.016% | 0.001% |
| Wholesale Lamb Price | -0.064% | 0.000% |
| Slaughter Lamb Quantity | -0.006% | 0.001% |
| Slaughter Lamb Price | -0.029% | 0.000% |
| Feeder Lamb Quantity | -0.002% | 0.000% |
| Feeder Lamb Price | -0.026% | 0.000% |
| Retail Poultry Quantity | -0.385% | 0.010% |
| Retail Poultry Price | -0.348% | 0.000% |
| Wholesale Poultry Quantity | -0.150% | 0.009% |
| Wholesale Poultry Price | -1.090% | 0.001% |
| Exported Retail Poultry Quantity | 0.105% | 0.000% |

**Table B-7. Median Percentage Changes from achieving 20% Traceability in the U.S. Beef Industry (No Increase in Trade)**

| Endogenous Variables | Short Run | Long Run |
|---|---|---|
| Retail Beef Quantity | -0.071% | 0.002% |
| Retail Beef Price | 0.086% | -0.002% |
| Wholesale Beef Quantity | -0.134% | 0.013% |
| Wholesale Beef Price | 0.108% | -0.012% |
| Imported Wholesale Beef Quantity | -0.042% | 0.081% |
| Imported Wholesale Beef Price | -0.023% | 0.008% |
| Exported Wholesale Beef Quantity | 0.964% | 1.045% |
| Slaughter Cattle Quantity | -0.058% | 0.084% |
| Slaughter Cattle Price | -0.024% | 0.010% |
| Feeder Cattle Quantity | -0.044% | 0.056% |
| Feeder Cattle Price | -0.075% | 0.033% |
| Retail Pork Quantity | 0.012% | 0.000% |
| Retail Pork Price | 0.006% | 0.000% |
| Wholesale Pork Quantity | 0.008% | 0.000% |
| Wholesale Pork Price | 0.005% | 0.000% |
| Imported Wholesale Pork Quantity | 0.005% | 0.000% |
| Imported Wholesale Pork Price | 0.004% | 0.000% |
| Exported Wholesale Pork Quantity | -0.005% | 0.000% |
| Slaughter Hog Quantity | 0.003% | 0.000% |
| Slaughter Hog Price | 0.008% | 0.000% |
| Domestic Retail Lamb Quantity | 0.001% | 0.000% |
| Domestic Retail Lamb Price | 0.007% | 0.000% |
| Imported Retail Lamb Quantity | 0.009% | 0.000% |
| Imported Retail Lamb Price | 0.001% | 0.000% |
| Wholesale Lamb Quantity | 0.000% | 0.000% |
| Wholesale Lamb Price | 0.002% | 0.000% |
| Slaughter Lamb Quantity | 0.000% | 0.000% |
| Slaughter Lamb Price | 0.001% | 0.000% |
| Feeder Lamb Quantity | 0.000% | 0.000% |
| Feeder Lamb Price | 0.001% | 0.000% |
| Retail Poultry Quantity | 0.013% | 0.000% |
| Retail Poultry Price | 0.011% | 0.000% |
| Wholesale Poultry Quantity | 0.005% | 0.000% |
| Wholesale Poultry Price | 0.036% | 0.000% |
| Exported Retail Poultry Quantity | -0.003% | 0.000% |

**Table B-8. Median Percentage Changes from achieving 20% Traceability in the U.S. Pork Industry (No Increase in Trade)**

| Endogenous Variables | Short Run | Long Run |
|---|---|---|
| Retail Beef Quantity | 0.002% | 0.000% |
| Retail Beef Price | 0.003% | 0.000% |
| Wholesale Beef Quantity | 0.001% | 0.000% |
| Wholesale Beef Price | 0.001% | 0.000% |
| Imported Wholesale Beef Quantity | 0.001% | 0.000% |
| Imported Wholesale Beef Price | 0.001% | 0.000% |
| Exported Wholesale Beef Quantity | -0.001% | 0.000% |
| Slaughter Cattle Quantity | 0.000% | 0.000% |
| Slaughter Cattle Price | 0.002% | 0.000% |
| Feeder Cattle Quantity | 0.000% | 0.000% |
| Feeder Cattle Price | 0.002% | 0.000% |
| Retail Pork Quantity | -0.030% | -0.003% |
| Retail Pork Price | 0.044% | 0.003% |
| Wholesale Pork Quantity | -0.066% | -0.015% |
| Wholesale Pork Price | 0.050% | 0.012% |
| Imported Wholesale Pork Quantity | -0.035% | -0.003% |
| Imported Wholesale Pork Price | -0.025% | 0.000% |
| Exported Wholesale Pork Quantity | 0.485% | 0.518% |
| Slaughter Hog Quantity | -0.001% | 0.042% |
| Slaughter Hog Price | 0.063% | 0.038% |
| Domestic Retail Lamb Quantity | 0.000% | 0.000% |
| Domestic Retail Lamb Price | 0.002% | 0.000% |
| Imported Retail Lamb Quantity | 0.002% | 0.000% |
| Imported Retail Lamb Price | 0.000% | 0.000% |
| Wholesale Lamb Quantity | 0.000% | 0.000% |
| Wholesale Lamb Price | 0.000% | 0.000% |
| Slaughter Lamb Quantity | 0.000% | 0.000% |
| Slaughter Lamb Price | 0.000% | 0.000% |
| Feeder Lamb Quantity | 0.000% | 0.000% |
| Feeder Lamb Price | 0.000% | 0.000% |
| Retail Poultry Quantity | 0.002% | 0.000% |
| Retail Poultry Price | 0.002% | 0.000% |
| Wholesale Poultry Quantity | 0.001% | 0.000% |
| Wholesale Poultry Price | 0.005% | 0.000% |
| Exported Retail Poultry Quantity | 0.000% | 0.000% |

**Table B-9. Median Percentage Changes from achieving Full Traceability in the U.S. Beef Industry (No Increase in Trade)**

| Endogenous Variables | Short Run | Long Run |
|---|---|---|
| Retail Beef Quantity | -1.991% | 0.059% |
| Retail Beef Price | 2.409% | -0.050% |
| Wholesale Beef Quantity | -3.730% | 0.382% |
| Wholesale Beef Price | 3.016% | -0.351% |
| Imported Wholesale Beef Quantity | -1.096% | 2.383% |
| Imported Wholesale Beef Price | -0.609% | 0.238% |
| Exported Wholesale Beef Quantity | 28.223% | 30.552% |
| Slaughter Cattle Quantity | -1.567% | 2.460% |
| Slaughter Cattle Price | -0.561% | 0.328% |
| Feeder Cattle Quantity | -1.064% | 1.684% |
| Feeder Cattle Price | -3.012% | 0.870% |
| Retail Pork Quantity | 0.327% | -0.009% |
| Retail Pork Price | 0.157% | 0.000% |
| Wholesale Pork Quantity | 0.212% | -0.007% |
| Wholesale Pork Price | 0.145% | -0.001% |
| Imported Wholesale Pork Quantity | 0.142% | -0.007% |
| Imported Wholesale Pork Price | 0.102% | -0.001% |
| Exported Wholesale Pork Quantity | -0.129% | 0.001% |
| Slaughter Hog Quantity | 0.090% | -0.005% |
| Slaughter Hog Price | 0.223% | -0.003% |
| Domestic Retail Lamb Quantity | 0.039% | -0.002% |
| Domestic Retail Lamb Price | 0.187% | 0.000% |
| Imported Retail Lamb Quantity | 0.260% | -0.002% |
| Imported Retail Lamb Price | 0.027% | 0.000% |
| Wholesale Lamb Quantity | 0.012% | -0.002% |
| Wholesale Lamb Price | 0.049% | 0.000% |
| Slaughter Lamb Quantity | 0.004% | -0.002% |
| Slaughter Lamb Price | 0.022% | 0.000% |
| Feeder Lamb Quantity | 0.002% | -0.001% |
| Feeder Lamb Price | 0.020% | -0.001% |
| Retail Poultry Quantity | 0.355% | -0.009% |
| Retail Poultry Price | 0.320% | 0.000% |
| Wholesale Poultry Quantity | 0.141% | -0.008% |
| Wholesale Poultry Price | 1.008% | -0.001% |
| Exported Retail Poultry Quantity | -0.096% | 0.000% |

**Table B-10. Median Percentage Changes from achieving Full Traceability in the U.S. Pork Industry (No Increase in Trade)**

| Endogenous Variables | Short Run | Long Run |
|---|---|---|
| Retail Beef Quantity | 0.013% | 0.002% |
| Retail Beef Price | 0.018% | 0.000% |
| Wholesale Beef Quantity | 0.008% | 0.002% |
| Wholesale Beef Price | 0.008% | 0.000% |
| Imported Wholesale Beef Quantity | 0.006% | 0.002% |
| Imported Wholesale Beef Price | 0.003% | 0.000% |
| Exported Wholesale Beef Quantity | -0.003% | 0.001% |
| Slaughter Cattle Quantity | 0.003% | 0.002% |
| Slaughter Cattle Price | 0.013% | 0.000% |
| Feeder Cattle Quantity | 0.001% | 0.002% |
| Feeder Cattle Price | 0.012% | 0.001% |
| Retail Pork Quantity | -0.190% | -0.018% |
| Retail Pork Price | 0.281% | 0.018% |
| Wholesale Pork Quantity | -0.417% | -0.097% |
| Wholesale Pork Price | 0.319% | 0.078% |
| Imported Wholesale Pork Quantity | -0.221% | -0.018% |
| Imported Wholesale Pork Price | -0.156% | -0.002% |
| Exported Wholesale Pork Quantity | 3.077% | 3.282% |
| Slaughter Hog Quantity | -0.007% | 0.268% |
| Slaughter Hog Price | 0.397% | 0.243% |
| Domestic Retail Lamb Quantity | 0.002% | 0.000% |
| Domestic Retail Lamb Price | 0.010% | 0.000% |
| Imported Retail Lamb Quantity | 0.014% | 0.000% |
| Imported Retail Lamb Price | 0.001% | 0.000% |
| Wholesale Lamb Quantity | 0.001% | 0.000% |
| Wholesale Lamb Price | 0.002% | 0.000% |
| Slaughter Lamb Quantity | 0.000% | 0.000% |
| Slaughter Lamb Price | 0.001% | 0.000% |
| Feeder Lamb Quantity | 0.000% | 0.000% |
| Feeder Lamb Price | 0.001% | 0.000% |
| Retail Poultry Quantity | 0.012% | 0.001% |
| Retail Poultry Price | 0.011% | 0.000% |
| Wholesale Poultry Quantity | 0.005% | 0.001% |
| Wholesale Poultry Price | 0.034% | 0.000% |
| Exported Retail Poultry Quantity | -0.003% | 0.000% |

**Table B-11. Median Percentage Changes from achieving 20% Traceability in both the U.S. Beef and Pork Industries (No Increase in Trade)**

| Endogenous Variables | Short Run | Long Run |
|---|---|---|
| Retail Beef Quantity | -0.044% | 0.000% |
| Retail Beef Price | 0.056% | 0.000% |
| Wholesale Beef Quantity | -0.085% | -0.002% |
| Wholesale Beef Price | 0.069% | 0.002% |
| Imported Wholesale Beef Quantity | -0.063% | -0.002% |
| Imported Wholesale Beef Price | -0.034% | 0.000% |
| Exported Wholesale Beef Quantity | -0.028% | -0.006% |
| Slaughter Cattle Quantity | -0.067% | -0.005% |
| Slaughter Cattle Price | -0.057% | 0.005% |
| Feeder Cattle Quantity | -0.048% | -0.011% |
| Feeder Cattle Price | -0.113% | 0.009% |
| Retail Pork Quantity | -0.002% | -0.001% |
| Retail Pork Price | 0.019% | 0.001% |
| Wholesale Pork Quantity | -0.016% | -0.007% |
| Wholesale Pork Price | 0.021% | 0.005% |
| Imported Wholesale Pork Quantity | -0.010% | -0.006% |
| Imported Wholesale Pork Price | -0.007% | -0.001% |
| Exported Wholesale Pork Quantity | -0.018% | -0.005% |
| Slaughter Hog Quantity | -0.022% | -0.014% |
| Slaughter Hog Price | 0.014% | 0.007% |
| Domestic Retail Lamb Quantity | 0.001% | 0.000% |
| Domestic Retail Lamb Price | 0.005% | 0.000% |
| Imported Retail Lamb Quantity | 0.007% | 0.000% |
| Imported Retail Lamb Price | 0.001% | 0.000% |
| Wholesale Lamb Quantity | 0.000% | 0.000% |
| Wholesale Lamb Price | 0.001% | 0.000% |
| Slaughter Lamb Quantity | 0.000% | 0.000% |
| Slaughter Lamb Price | 0.001% | 0.000% |
| Feeder Lamb Quantity | 0.000% | 0.000% |
| Feeder Lamb Price | 0.001% | 0.000% |
| Retail Poultry Quantity | 0.009% | 0.000% |
| Retail Poultry Price | 0.008% | 0.000% |
| Wholesale Poultry Quantity | 0.003% | 0.000% |
| Wholesale Poultry Price | 0.024% | 0.000% |
| Exported Retail Poultry Quantity | -0.002% | 0.000% |

**Table B-12. Median Percentage Changes from achieving Full Traceability in both the U.S. Beef and Pork Industries (No Increase in Trade)**

| Endogenous Variables | Short Run | Long Run |
|---|---|---|
| Retail Beef Quantity | -1.218% | -0.008% |
| Retail Beef Price | 1.479% | 0.007% |
| Wholesale Beef Quantity | -2.329% | -0.054% |
| Wholesale Beef Price | 1.856% | 0.050% |
| Imported Wholesale Beef Quantity | -1.710% | -0.049% |
| Imported Wholesale Beef Price | -0.941% | -0.005% |
| Exported Wholesale Beef Quantity | -0.773% | -0.150% |
| Slaughter Cattle Quantity | -1.843% | -0.143% |
| Slaughter Cattle Price | -1.532% | 0.160% |
| Feeder Cattle Quantity | -1.173% | -0.270% |
| Feeder Cattle Price | -4.098% | 0.177% |
| Retail Pork Quantity | 0.135% | -0.007% |
| Retail Pork Price | 0.200% | 0.008% |
| Wholesale Pork Quantity | -0.002% | -0.041% |
| Wholesale Pork Price | 0.204% | 0.034% |
| Imported Wholesale Pork Quantity | -0.002% | -0.036% |
| Imported Wholesale Pork Price | -0.001% | -0.004% |
| Exported Wholesale Pork Quantity | -0.182% | -0.034% |
| Slaughter Hog Quantity | -0.095% | -0.085% |
| Slaughter Hog Price | 0.184% | 0.047% |
| Domestic Retail Lamb Quantity | 0.024% | 0.001% |
| Domestic Retail Lamb Price | 0.119% | 0.000% |
| Imported Retail Lamb Quantity | 0.168% | 0.001% |
| Imported Retail Lamb Price | 0.017% | 0.000% |
| Wholesale Lamb Quantity | 0.007% | 0.000% |
| Wholesale Lamb Price | 0.030% | 0.000% |
| Slaughter Lamb Quantity | 0.003% | 0.000% |
| Slaughter Lamb Price | 0.014% | 0.000% |
| Feeder Lamb Quantity | 0.001% | 0.000% |
| Feeder Lamb Price | 0.013% | 0.000% |
| Retail Poultry Quantity | 0.222% | 0.002% |
| Retail Poultry Price | 0.203% | 0.000% |
| Wholesale Poultry Quantity | 0.088% | 0.002% |
| Wholesale Poultry Price | 0.624% | 0.000% |
| Exported Retail Poultry Quantity | -0.060% | 0.000% |

## Appendix C. Median Changes in Producer and Consumer Surplus

**Table C-1. Median Producer and Consumer Surplus Changes from No Expansion in Traceability and Losing Beef Exports to South Korea (7.3% Decline in Total Beef Exports)**

| Surplus Measure | Short Run[a] | Long Run[a] | Cumulative | Cumulative Present Value | Cumulative As A Percent Of Total |
|---|---|---|---|---|---|
| | million dollars | | | | |
| Producer Surplus | | | | | |
| Retail Beef | 118.10 | 4.23 | 204.44 | 183.05 | 0.063% |
| Wholesale Beef | 177.82 | 12.27 | 300.85 | 270.77 | 0.177% |
| Slaughter Cattle | -132.10 | -42.64 | -1,578.69 | -1,276.95 | -0.725% |
| Feeder Cattle | -55.36 | -44.00 | -1,058.59 | -826.45 | -0.614% |
| Total Beef Producer Surplus | 113.36 | -70.38 | -2,138.11 | -1,638.51 | -0.377% |
| Retail Pork | -12.26 | 0.15 | -16.64 | -16.28 | -0.013% |
| Wholesale Pork | -3.89 | 0.09 | -4.55 | -4.62 | -0.008% |
| Slaughter Hog | -2.52 | 0.09 | -2.42 | -2.59 | -0.004% |
| Total Pork Producer Surplus | -19.29 | 0.34 | -24.73 | -24.44 | -0.010% |
| Retail Domestic Lamb | -0.15 | 0.00 | -0.21 | -0.20 | -0.006% |
| Wholesale Lamb | -0.02 | 0.00 | -0.02 | -0.02 | -0.002% |
| Slaughter Lamb | -0.01 | 0.00 | -0.01 | -0.01 | -0.001% |
| Feeder Lamb | -0.01 | 0.00 | 0.00 | 0.00 | 0.000% |
| Total Lamb Producer Surplus | -0.19 | 0.00 | -0.24 | -0.24 | -0.003% |
| Retail Poultry | -54.63 | 0.06 | -74.08 | -70.68 | -0.037% |
| Wholesale Poultry | -3.82 | 0.01 | -5.06 | -4.84 | -0.029% |
| Total Poultry Producer Surplus | -58.78 | 0.07 | -79.35 | -75.34 | -0.037% |
| Total Meat Producer Surplus | 35.33 | -69.94 | -2,248.13 | -1,750.52 | -0.233% |
| Consumer Surplus | | | | | |
| Retail Beef | 172.22 | -11.35 | 164.39 | 184.69 | 0.060% |
| Retail Pork | -6.11 | 0.52 | -4.44 | -5.38 | -0.003% |
| Retail Domestic Lamb | 0.04 | 0.00 | 0.08 | 0.07 | 0.002% |
| Retail Imported Lamb | -0.22 | 0.00 | -0.28 | -0.28 | -0.005% |
| Retail Poultry | -21.44 | 0.65 | -24.07 | -25.45 | -0.006% |
| Total Meat Consumer Surplus | 142.01 | -10.11 | 132.63 | 154.16 | 0.013% |

Note: Totals are not identical to sums of individual surpluses because they are medians of simulations.
[a]Short-run is year 1 and long-run is year 10.

**Table C-2. Median Producer and Consumer Surplus Changes from No Expansion in Traceability and Losing Pork Exports to South Korea (6.3% Decline in Total Pork Exports)**

| Surplus Measure | Short Run[a] | Long Run[a] | Cumulative | Cumulative Present Value | Cumulative As A Percent Of Total |
|---|---|---|---|---|---|
| | million dollars | | | | |
| Producer Surplus | | | | | |
| Retail Beef | -27.91 | -0.16 | -76.78 | -67.79 | -0.023% |
| Wholesale Beef | -8.53 | -0.03 | -28.96 | -25.44 | -0.017% |
| Slaughter Cattle | -8.11 | -0.15 | -40.80 | -35.15 | -0.020% |
| Feeder Cattle | -3.81 | -0.14 | -24.04 | -20.22 | -0.015% |
| Total Beef Producer Surplus | -49.49 | -0.54 | -176.67 | -153.16 | -0.035% |
| Retail Pork | -5.53 | -3.21 | -83.20 | -66.20 | -0.054% |
| Wholesale Pork | 52.71 | -1.94 | 128.40 | 116.88 | 0.204% |
| Slaughter Hog | -85.14 | -46.67 | -683.04 | -541.05 | -0.970% |
| Total Pork Producer Surplus | -38.87 | -51.48 | -649.39 | -499.86 | -0.211% |
| Retail Domestic Lamb | -0.11 | 0.00 | -0.28 | -0.25 | -0.007% |
| Wholesale Lamb | -0.01 | 0.00 | -0.04 | -0.04 | -0.002% |
| Slaughter Lamb | -0.01 | 0.00 | -0.03 | -0.02 | -0.001% |
| Feeder Lamb | 0.00 | 0.00 | -0.03 | -0.02 | -0.001% |
| Total Lamb Producer Surplus | -0.13 | 0.00 | -0.38 | -0.33 | -0.004% |
| Retail Poultry | -25.30 | -0.02 | -48.10 | -43.87 | -0.023% |
| Wholesale Poultry | -1.76 | 0.00 | -3.83 | -3.47 | -0.021% |
| Total Poultry Producer Surplus | -27.18 | -0.02 | -52.17 | -47.56 | -0.023% |
| Total Meat Producer Surplus | -120.36 | -52.02 | -887.34 | -709.87 | -0.093% |
| Consumer Surplus | | | | | |
| Retail Beef | 1.79 | -0.63 | -18.50 | -14.26 | -0.004% |
| Retail Pork | 156.31 | 8.68 | 605.82 | 516.05 | 0.240% |
| Retail Domestic Lamb | 0.03 | 0.00 | 0.02 | 0.02 | 0.001% |
| Retail Imported Lamb | -0.16 | 0.00 | -0.43 | -0.38 | -0.006% |
| Retail Poultry | -9.97 | -0.19 | -30.73 | -27.01 | -0.006% |
| Total Meat Consumer Surplus | 145.36 | 7.75 | 544.28 | 466.84 | 0.038% |

Note: Totals are not identical to sums of individual surpluses because they are medians of simulations.
[a]Short-run is year 1 and long-run is year 10.

**Table C-3. Median Producer and Consumer Surplus Changes from No Expansion in Traceability and Losing Beef and Pork Exports to South Korea (7.3% Decline in Total Beef Exports and a 6.3% Decline in Total Pork Exports)**

| Surplus Measure | Short Run[a] | Long Run[a] | Cumulative | Cumulative Present Value | Cumulative As A Percent Of Total |
|---|---|---|---|---|---|
| | million dollars | | | | |
| Producer Surplus | | | | | |
| Retail Beef | 88.12 | 4.02 | 127.47 | 111.77 | 0.039% |
| Wholesale Beef | 167.77 | 12.21 | 269.84 | 241.39 | 0.161% |
| Slaughter Cattle | -138.94 | -42.76 | -1,618.84 | -1,310.87 | -0.746% |
| Feeder Cattle | -59.34 | -44.10 | -1,089.14 | -856.03 | -0.636% |
| Total Beef Producer Surplus | 69.35 | -70.94 | -2,289.89 | -1,792.37 | -0.409% |
| Retail Pork | -18.23 | -3.01 | -98.50 | -81.94 | -0.067% |
| Wholesale Pork | 48.41 | -1.83 | 124.55 | 112.28 | 0.197% |
| Slaughter Hog | -88.03 | -46.56 | -685.20 | -544.64 | -0.978% |
| Total Pork Producer Surplus | -59.23 | -51.13 | -664.37 | -518.39 | -0.218% |
| Retail Domestic Lamb | -0.27 | 0.00 | -0.50 | -0.45 | -0.013% |
| Wholesale Lamb | -0.03 | 0.00 | -0.07 | -0.06 | -0.004% |
| Slaughter Lamb | -0.01 | 0.00 | -0.03 | -0.03 | -0.002% |
| Feeder Lamb | -0.01 | 0.00 | -0.02 | -0.02 | -0.001% |
| Total Lamb Producer Surplus | -0.33 | 0.00 | -0.63 | -0.58 | -0.007% |
| Retail Poultry | -82.37 | 0.04 | -124.87 | -117.09 | -0.062% |
| Wholesale Poultry | -5.71 | 0.01 | -9.00 | -8.36 | -0.050% |
| Total Poultry Producer Surplus | -88.01 | 0.05 | -134.88 | -126.44 | -0.061% |
| Total Meat Producer Surplus | -70.06 | -122.18 | -3,115.72 | -2,448.33 | -0.324% |
| Consumer Surplus | | | | | |
| Retail Beef | 173.37 | -11.87 | 147.94 | 174.66 | 0.056% |
| Retail Pork | 147.82 | 9.29 | 605.35 | 513.20 | 0.238% |
| Retail Domestic Lamb | 0.07 | 0.00 | 0.11 | 0.10 | 0.002% |
| Retail Imported Lamb | -0.40 | 0.00 | -0.70 | -0.65 | -0.011% |
| Retail Poultry | -32.36 | 0.47 | -54.31 | -51.71 | -0.012% |
| Total Meat Consumer Surplus | 302.74 | -3.33 | 675.18 | 610.42 | 0.050% |

Note: Totals are not identical to sums of individual surpluses because they are medians of simulations.
[a]Short-run is year 1 and long-run is year 10.

**Table C-4. Median Producer and Consumer Surplus Changes from No Expansion in Traceability and Losing All non-North American Beef Exports (48.7% Decline in Total Beef Exports)**

| Surplus Measure | Short Run[a] | Long Run[a] | Cumulative | Cumulative Present Value | Cumulative As A Percent Of Total |
|---|---|---|---|---|---|
| | million dollars | | | | |
| Producer Surplus | | | | | |
| Retail Beef | 784.42 | 28.34 | 1,274.99 | 1,125.66 | 0.396% |
| Wholesale Beef | 1,181.89 | 81.47 | 1,889.67 | 1,698.80 | 1.133% |
| Slaughter Cattle | -884.66 | -284.01 | -10,493.91 | -8,465.98 | -5.018% |
| Feeder Cattle | -370.84 | -290.91 | -6,913.86 | -5,409.01 | -4.161% |
| Total Beef Producer Surplus | 746.39 | -466.91 | -14,249.24 | -10,989.68 | -2.549% |
| Retail Pork | -82.26 | 1.03 | -111.48 | -109.11 | -0.088% |
| Wholesale Pork | -26.07 | 0.58 | -30.48 | -30.95 | -0.054% |
| Slaughter Hog | -16.90 | 0.61 | -16.15 | -17.36 | -0.030% |
| Total Pork Producer Surplus | -129.23 | 2.31 | -165.74 | -163.75 | -0.069% |
| Retail Domestic Lamb | -1.02 | 0.01 | -1.40 | -1.35 | -0.038% |
| Wholesale Lamb | -0.12 | 0.00 | -0.16 | -0.15 | -0.010% |
| Slaughter Lamb | -0.05 | 0.00 | -0.05 | -0.06 | -0.004% |
| Feeder Lamb | -0.04 | 0.00 | -0.01 | -0.02 | -0.001% |
| Total Lamb Producer Surplus | -1.27 | 0.01 | -1.63 | -1.59 | -0.019% |
| Retail Poultry | -366.09 | 0.40 | -496.49 | -473.67 | -0.249% |
| Wholesale Poultry | -25.57 | 0.07 | -33.87 | -32.29 | -0.194% |
| Total Poultry Producer Surplus | -393.90 | 0.46 | -531.76 | -504.73 | -0.248% |
| Total Meat Producer Surplus | 226.56 | -464.23 | -15,001.99 | -11,777.62 | -1.576% |
| Consumer Surplus | | | | | |
| Retail Beef | 1,158.97 | -76.02 | 1,143.74 | 1,290.07 | 0.415% |
| Retail Pork | -40.98 | 3.51 | -29.86 | -36.06 | -0.018% |
| Retail Domestic Lamb | 0.24 | 0.01 | 0.54 | 0.47 | 0.012% |
| Retail Imported Lamb | -1.49 | 0.03 | -1.88 | -1.85 | -0.030% |
| Retail Poultry | -143.85 | 4.34 | -161.56 | -170.72 | -0.039% |
| Total Meat Consumer Surplus | 957.98 | -67.76 | 953.12 | 1,073.72 | 0.089% |

Note: Totals are not identical to sums of individual surpluses because they are medians of simulations.
[b]Short-run is year 1 and long-run is year 10.

**Table C-5. Median Producer and Consumer Surplus Changes from Changes from No Expansion in Traceability and Losing All non-North American Pork Exports (68.3% Decline in Total Pork Exports)**

| Surplus Measure | Short Run[a] | Long Run[a] | Cumulative | Cumulative Present Value | Cumulative As A Percent Of Total |
|---|---|---|---|---|---|
| | million dollars | | | | |
| Producer Surplus | | | | | |
| Retail Beef | -302.07 | -1.77 | -831.19 | -734.72 | -0.254% |
| Wholesale Beef | -92.58 | -0.32 | -319.11 | -279.93 | -0.183% |
| Slaughter Cattle | -87.81 | -1.58 | -441.67 | -380.50 | -0.216% |
| Feeder Cattle | -41.26 | -1.56 | -260.09 | -218.91 | -0.164% |
| Total Beef Producer Surplus | -535.77 | -5.85 | -1,912.87 | -1,658.17 | -0.376% |
| Retail Pork | -74.64 | -34.90 | -956.09 | -762.91 | -0.625% |
| Wholesale Pork | 553.19 | -21.77 | 1,332.07 | 1,216.40 | 2.082% |
| Slaughter Hog | -910.25 | -488.87 | -7,232.30 | -5,731.02 | -11.330% |
| Total Pork Producer Surplus | -444.11 | -541.62 | -6,976.74 | -5,398.15 | -2.316% |
| Retail Domestic Lamb | -1.19 | 0.00 | -2.99 | -2.70 | -0.077% |
| Wholesale Lamb | -0.14 | 0.00 | -0.46 | -0.40 | -0.026% |
| Slaughter Lamb | -0.06 | 0.00 | -0.29 | -0.25 | -0.016% |
| Feeder Lamb | -0.04 | 0.00 | -0.28 | -0.24 | -0.014% |
| Total Lamb Producer Surplus | -1.44 | -0.01 | -4.10 | -3.62 | -0.044% |
| Retail Poultry | -273.97 | -0.20 | -520.75 | -474.94 | -0.250% |
| Wholesale Poultry | -19.04 | -0.03 | -41.47 | -37.55 | -0.226% |
| Total Poultry Producer Surplus | -294.31 | -0.23 | -564.83 | -514.89 | -0.250% |
| Total Meat Producer Surplus | -1,322.46 | -548.33 | -9,553.25 | -7,657.59 | -0.998% |
| Consumer Surplus | | | | | |
| Retail Beef | 19.24 | -6.81 | -201.14 | -154.27 | -0.048% |
| Retail Pork | 1,714.35 | 94.06 | 6,613.72 | 5,632.48 | 2.560% |
| Retail Domestic Lamb | 0.29 | -0.01 | 0.23 | 0.25 | 0.006% |
| Retail Imported Lamb | -1.74 | -0.02 | -4.60 | -4.08 | -0.066% |
| Retail Poultry | -108.12 | -2.11 | -332.90 | -292.61 | -0.067% |
| Total Meat Consumer Surplus | 1,592.53 | 83.99 | 5,967.48 | 5,108.73 | 0.417% |

Note: Totals are not identical to sums of individual surpluses because they are medians of simulations.
[a]Short-run is year 1 and long-run is year 10.

**Table C-6. Median Producer and Consumer Surplus Changes from No Expansion in Traceability and Losing All non-North American Beef and Pork Exports (48.7% Decline in Total Beef Exports and a 68.3% Decline in Total Pork Exports)**

| Surplus Measure | Short Run[a] | Long Run[a] | Cumulative | Cumulative Present Value | Cumulative As A Percent Of Total |
|---|---|---|---|---|---|
| | million dollars | | | | |
| Producer Surplus | | | | | |
| Retail Beef | 463.96 | 26.04 | 426.03 | 396.14 | 0.141% |
| Wholesale Beef | 1,080.23 | 80.74 | 1,582.26 | 1,418.63 | 0.958% |
| Slaughter Cattle | -959.96 | -285.75 | -10,946.24 | -8,841.90 | -5.250% |
| Feeder Cattle | -410.14 | -291.90 | -7,267.34 | -5,705.67 | -4.395% |
| Total Beef Producer Surplus | 249.64 | -472.99 | -15,968.78 | -12,582.30 | -2.953% |
| Retail Pork | -162.82 | -33.57 | -1,060.85 | -871.09 | -0.720% |
| Wholesale Pork | 525.16 | -21.01 | 1,300.38 | 1,182.26 | 2.047% |
| Slaughter Hog | -926.29 | -488.18 | -7,262.41 | -5,766.71 | -11.390% |
| Total Pork Producer Surplus | -581.37 | -539.29 | -7,077.34 | -5,505.21 | -2.378% |
| Retail Domestic Lamb | -2.33 | 0.00 | -4.45 | -4.10 | -0.117% |
| Wholesale Lamb | -0.28 | 0.00 | -0.61 | -0.56 | -0.036% |
| Slaughter Lamb | -0.12 | 0.00 | -0.32 | -0.29 | -0.019% |
| Feeder Lamb | -0.08 | 0.00 | -0.25 | -0.22 | -0.013% |
| Total Lamb Producer Surplus | -2.84 | 0.00 | -5.80 | -5.26 | -0.064% |
| Retail Poultry | -668.03 | 0.23 | -1,039.71 | -968.88 | -0.515% |
| Wholesale Poultry | -45.74 | 0.04 | -76.10 | -69.89 | -0.420% |
| Total Poultry Producer Surplus | -714.82 | 0.27 | -1,124.70 | -1,045.61 | -0.513% |
| Total Meat Producer Surplus | -934.89 | -1,014.60 | -24,424.93 | -19,303.50 | -2.570% |
| Consumer Surplus | | | | | |
| Retail Beef | 1,185.94 | -82.07 | 948.15 | 1,125.55 | 0.363% |
| Retail Pork | 1,661.10 | 99.41 | 6,610.24 | 5,615.52 | 2.553% |
| Retail Domestic Lamb | 0.56 | 0.00 | 0.87 | 0.80 | 0.020% |
| Retail Imported Lamb | -3.33 | 0.01 | -6.44 | -5.93 | -0.096% |
| Retail Poultry | -260.81 | 2.50 | -482.30 | -446.87 | -0.106% |
| Total Meat Consumer Surplus | 2,703.76 | 9.15 | 6,827.00 | 6,094.04 | 0.490% |

Note: Totals are not identical to sums of individual surpluses because they are medians of simulations.
[a]Short-run is year 1 and long-run is year 10.

**Table C-7. Median Producer and Consumer Surplus Changes from achieving 20% Traceability in the U.S. Beef Industry (No Increase in Trade)**

| Surplus Measure | Short Run[b] | Long Run[b] | Cumulative | Cumulative Present Value | Cumulative As A Percent Of Total |
|---|---|---|---|---|---|
| | million dollars | | | | |
| Producer Surplus | | | | | |
| Retail Beef | -13.18 | 0.34 | -58.72 | -52.60 | -0.018% |
| Wholesale Beef | -19.94 | 1.38 | -59.46 | -55.13 | -0.036% |
| Slaughter Cattle | -28.02 | 9.35 | 84.94 | 52.87 | 0.030% |
| Feeder Cattle | -28.94 | 5.10 | 15.10 | 2.63 | 0.002% |
| Total Beef Producer Surplus | -90.62 | 16.17 | -18.52 | -51.43 | -0.012% |
| | | | | 0.36 | |
| Retail Pork | 4.86 | -0.02 | 10.09 | 9.25 | 0.008% |
| Wholesale Pork | 1.57 | -0.01 | 3.40 | 3.13 | 0.006% |
| Slaughter Hog | 1.01 | -0.01 | 2.29 | 2.09 | 0.004% |
| Total Pork Producer Surplus | 7.54 | -0.04 | 16.00 | 14.70 | 0.006% |
| Retail Domestic Lamb | 0.06 | 0.00 | 0.12 | 0.11 | 0.003% |
| Wholesale Lamb | 0.01 | 0.00 | 0.02 | 0.02 | 0.001% |
| Slaughter Lamb | 0.00 | 0.00 | 0.01 | 0.01 | 0.001% |
| Feeder Lamb | 0.00 | 0.00 | 0.01 | 0.01 | 0.000% |
| Total Lamb Producer Surplus | 0.07 | 0.00 | 0.16 | 0.15 | 0.002% |
| Retail Poultry | 22.07 | -0.01 | 37.76 | 35.06 | 0.018% |
| Wholesale Poultry | 1.51 | 0.00 | 2.92 | 2.70 | 0.016% |
| Total Poultry Producer Surplus | 23.69 | -0.01 | 40.66 | 37.64 | 0.018% |
| Total Meat Producer Surplus | -58.95 | 16.13 | 35.75 | -0.05 | 0.000% |
| Consumer Surplus | | | | | |
| Retail Beef | -68.27 | 1.36 | -156.36 | -143.65 | -0.045% |
| Retail Pork | 2.50 | -0.06 | 6.50 | 5.93 | 0.003% |
| Retail Domestic Lamb | -0.01 | 0.00 | -0.02 | -0.02 | 0.000% |
| Retail Imported Lamb | 0.09 | 0.00 | 0.18 | 0.17 | 0.003% |
| Retail Poultry | 8.60 | -0.08 | 19.07 | 17.52 | 0.004% |
| Total Meat Consumer Surplus | -56.27 | 1.21 | -129.23 | -118.92 | -0.010% |

Note: Totals are not identical to sums of individual surpluses because they are medians of simulations.
[a]Short-run is year 1 and long-run is year 10.

**Table C-8. Median Producer and Consumer Surplus Changes from achieving 20% Traceability in the U.S. Pork Industry (No Increase in Trade)**

| Surplus Measure | Short Run[a] | Long Run[a] | Cumulative | Cumulative Present Value | Cumulative As A Percent Of Total |
|---|---|---|---|---|---|
| | million dollars | | | | |
| Producer Surplus | | | | | |
| Retail Beef | 3.50 | 0.03 | 9.80 | 8.71 | 0.003% |
| Wholesale Beef | 1.07 | 0.01 | 3.72 | 3.27 | 0.002% |
| Slaughter Cattle | 1.02 | 0.02 | 5.40 | 4.58 | 0.003% |
| Feeder Cattle | 0.49 | 0.02 | 3.28 | 2.74 | 0.002% |
| Total Beef Producer Surplus | 6.28 | 0.08 | 23.00 | 20.04 | 0.005% |
| | | | | | |
| Retail Pork | -7.78 | -0.33 | -39.97 | -34.23 | -0.028% |
| Wholesale Pork | -4.96 | -1.05 | -35.77 | -29.18 | -0.052% |
| Slaughter Hog | 4.53 | 2.97 | 37.07 | 29.24 | 0.052% |
| Total Pork Producer Surplus | -8.27 | 1.56 | -38.47 | -34.07 | -0.014% |
| | | | | 0.06 | |
| Retail Domestic Lamb | 0.01 | 0.00 | 0.04 | 0.03 | 0.001% |
| Wholesale Lamb | 0.00 | 0.00 | 0.01 | 0.00 | 0.000% |
| Slaughter Lamb | 0.00 | 0.00 | 0.00 | 0.00 | 0.000% |
| Feeder Lamb | 0.00 | 0.00 | 0.00 | 0.00 | 0.000% |
| Total Lamb Producer Surplus | 0.02 | 0.00 | 0.05 | 0.04 | 0.001% |
| | | | | | |
| Retail Poultry | 3.19 | 0.00 | 6.19 | 5.65 | 0.003% |
| Wholesale Poultry | 0.22 | 0.00 | 0.50 | 0.45 | 0.003% |
| Total Poultry Producer Surplus | 3.42 | 0.00 | 6.71 | 6.11 | 0.003% |
| | | | | | |
| Total Meat Producer Surplus | 2.28 | 1.65 | -6.61 | -5.73 | -0.001% |
| | | | | | |
| Consumer Surplus | | | | | |
| Retail Beef | -0.23 | 0.09 | 2.65 | 1.98 | 0.001% |
| Retail Pork | -19.53 | -1.29 | -78.76 | -67.08 | -0.031% |
| Retail Domestic Lamb | 0.00 | 0.00 | 0.00 | 0.00 | 0.000% |
| Retail Imported Lamb | 0.02 | 0.00 | 0.05 | 0.05 | 0.001% |
| Retail Poultry | 1.24 | 0.03 | 3.97 | 3.47 | 0.001% |
| Total Meat Consumer Surplus | -18.44 | -1.17 | -71.59 | -61.10 | -0.005% |

Note: Totals are not identical to sums of individual surpluses because they are medians of simulations.
[a]Short-run is year 1 and long-run is year 10.

**Table C-9. Median Producer and Consumer Surplus Changes from achieving Full Traceability in the U.S. Beef Industry (No Increase in Trade)**

| Surplus Measure | Short Run[a] | Long Run[a] | Cumulative | Cumulative Present Value | Cumulative As A Percent Of Total |
|---|---|---|---|---|---|
| | million dollars | | | | |
| Producer Surplus | | | | | |
| Retail Beef | -419.61 | 10.22 | -1,841.76 | -1,650.00 | -0.566% |
| Wholesale Beef | -610.02 | 41.00 | -1,824.21 | -1,670.17 | -1.104% |
| Slaughter Cattle | -705.16 | 275.96 | 2,808.19 | 1,879.11 | 1.057% |
| Feeder Cattle | -966.89 | 155.49 | 205.77 | -208.43 | -0.152% |
| Total Beef Producer Surplus | -2,694.85 | 482.71 | -726.25 | -1,647.62 | -0.350% |
| | | | | 0.50 | |
| Retail Pork | 135.24 | -0.54 | 277.50 | 256.68 | 0.211% |
| Wholesale Pork | 44.25 | -0.31 | 95.54 | 88.24 | 0.154% |
| Slaughter Hog | 28.24 | -0.32 | 63.89 | 58.95 | 0.106% |
| Total Pork Producer Surplus | 210.56 | -1.21 | 449.98 | 414.37 | 0.174% |
| Retail Domestic Lamb | 1.67 | 0.00 | 3.46 | 3.20 | 0.092% |
| Wholesale Lamb | 0.21 | 0.00 | 0.49 | 0.45 | 0.029% |
| Slaughter Lamb | 0.09 | 0.00 | 0.26 | 0.23 | 0.015% |
| Feeder Lamb | 0.06 | 0.00 | 0.21 | 0.19 | 0.011% |
| Total Lamb Producer Surplus | 2.05 | -0.01 | 4.44 | 4.12 | 0.050% |
| Retail Poultry | 619.76 | -0.21 | 1,053.50 | 979.15 | 0.513% |
| Wholesale Poultry | 42.38 | -0.03 | 81.34 | 75.00 | 0.449% |
| Total Poultry Producer Surplus | 662.93 | -0.24 | 1,140.65 | 1,061.33 | 0.511% |
| Total Meat Producer Surplus | -1,855.28 | 481.18 | 913.15 | -293.39 | -0.031% |
| Consumer Surplus | | | | | |
| Retail Beef | -1,879.63 | 40.30 | -4,250.21 | -3,924.26 | -1.257% |
| Retail Pork | 69.54 | -1.86 | 180.18 | 166.17 | 0.076% |
| Retail Domestic Lamb | -0.41 | -0.01 | -0.63 | -0.58 | -0.014% |
| Retail Imported Lamb | 2.48 | -0.01 | 4.96 | 4.62 | 0.074% |
| Retail Poultry | 242.55 | -2.27 | 531.73 | 490.39 | 0.111% |
| Total Meat Consumer Surplus | -1,542.38 | 35.93 | -3,523.61 | -3,233.71 | -0.267% |

Note: Totals are not identical to sums of individual surpluses because they are medians of simulations.
[a]Short-run is year 1 and long-run is year 10.

**Table C-10. Median Producer and Consumer Surplus Changes from achieving Full Traceability in the U.S. Pork Industry (No Increase in Trade)**

| Surplus Measure | Short Run[a] | Long Run[a] | Cumulative | Cumulative Present Value | Cumulative As A Percent Of Total |
|---|---|---|---|---|---|
| | million dollars | | | | |
| Producer Surplus | | | | | |
| Retail Beef | 22.13 | 0.16 | 62.02 | 55.10 | 0.019% |
| Wholesale Beef | 6.77 | 0.04 | 23.54 | 20.60 | 0.013% |
| Slaughter Cattle | 6.44 | 0.14 | 34.20 | 29.02 | 0.016% |
| Feeder Cattle | 3.08 | 0.14 | 20.76 | 17.35 | 0.013% |
| Total Beef Producer Surplus | 39.77 | 0.51 | 145.56 | 126.89 | 0.029% |
| Retail Pork | -49.50 | -2.11 | -253.54 | -217.10 | -0.175% |
| Wholesale Pork | -31.57 | -6.67 | -227.24 | -185.37 | -0.328% |
| Slaughter Hog | 28.73 | 18.89 | 235.39 | 185.70 | 0.331% |
| Total Pork Producer Surplus | -52.64 | 9.98 | -244.12 | -216.13 | -0.092% |
| | | | | 0.32 | |
| Retail Domestic Lamb | 0.09 | 0.00 | 0.23 | 0.20 | 0.006% |
| Wholesale Lamb | 0.01 | 0.00 | 0.03 | 0.03 | 0.002% |
| Slaughter Lamb | 0.00 | 0.00 | 0.02 | 0.02 | 0.001% |
| Feeder Lamb | 0.00 | 0.00 | 0.02 | 0.02 | 0.001% |
| Total Lamb Producer Surplus | 0.11 | 0.00 | 0.31 | 0.28 | 0.003% |
| Retail Poultry | 20.21 | 0.02 | 39.22 | 35.80 | 0.019% |
| Wholesale Poultry | 1.41 | 0.00 | 3.16 | 2.86 | 0.017% |
| Total Poultry Producer Surplus | 21.68 | 0.02 | 42.45 | 38.65 | 0.019% |
| Total Meat Producer Surplus | 13.90 | 10.50 | -41.97 | -36.87 | -0.005% |
| Consumer Surplus | | | | | |
| Retail Beef | -1.48 | 0.59 | 16.76 | 12.53 | 0.004% |
| Retail Pork | -123.50 | -8.18 | -498.14 | -424.40 | -0.199% |
| Retail Domestic Lamb | -0.02 | 0.00 | -0.02 | -0.02 | 0.000% |
| Retail Imported Lamb | 0.13 | 0.00 | 0.35 | 0.31 | 0.005% |
| Retail Poultry | 7.87 | 0.19 | 25.14 | 21.99 | 0.005% |
| Total Meat Consumer Surplus | -116.63 | -7.40 | -452.89 | -386.40 | -0.031% |

Note: Totals are not identical to sums of individual surpluses because they are medians of simulations.
[a]Short-run is year 1 and long-run is year 10.

**Table C-11. Median Producer and Consumer Surplus Changes from a 20% Expansion in Traceability in both the U.S. Beef and Pork Industries (No Increase in Trade)**

| Surplus Measure | Short Run[a] | Long Run[a] | Cumulative | Cumulative Present Value | Cumulative As A Percent Of Total |
|---|---|---|---|---|---|
| | million dollars | | | | |
| Producer Surplus | | | | | |
| Retail Beef | -6.79 | -0.03 | -54.75 | -46.76 | -0.016% |
| Wholesale Beef | -11.99 | -0.21 | -69.83 | -59.03 | -0.040% |
| Slaughter Cattle | -41.89 | -0.51 | -148.52 | -128.98 | -0.073% |
| Feeder Cattle | -38.59 | -1.02 | -132.70 | -114.83 | -0.085% |
| Total Beef Producer Surplus | -99.17 | -1.77 | -406.29 | -349.40 | -0.079% |
| Retail Pork | 1.21 | -0.14 | -2.81 | -1.89 | -0.002% |
| Wholesale Pork | -0.61 | -0.45 | -9.47 | -7.35 | -0.013% |
| Slaughter Hog | -1.69 | -0.95 | -17.22 | -13.45 | -0.024% |
| Total Pork Producer Surplus | -1.24 | -1.55 | -29.35 | -22.69 | -0.010% |
| Retail Domestic Lamb | 0.04 | 0.00 | 0.11 | 0.09 | 0.003% |
| Wholesale Lamb | 0.01 | 0.00 | 0.02 | 0.01 | 0.001% |
| Slaughter Lamb | 0.00 | 0.00 | 0.01 | 0.01 | 0.001% |
| Feeder Lamb | 0.00 | 0.00 | 0.01 | 0.01 | 0.000% |
| Total Lamb Producer Surplus | 0.05 | 0.00 | 0.14 | 0.13 | 0.002% |
| Retail Poultry | 15.07 | 0.00 | 28.70 | 26.41 | 0.014% |
| Wholesale Poultry | 1.02 | 0.00 | 2.26 | 2.04 | 0.012% |
| Total Poultry Producer Surplus | 16.20 | 0.00 | 30.79 | 28.29 | 0.014% |
| Total Meat Producer Surplus | -87.23 | -3.39 | -405.04 | -346.44 | -0.045% |
| Consumer Surplus | | | | | |
| Retail Beef | -43.05 | -0.18 | -133.31 | -117.96 | -0.037% |
| Retail Pork | -4.52 | -0.57 | -20.64 | -17.34 | -0.008% |
| Retail Domestic Lamb | -0.01 | 0.00 | -0.01 | -0.01 | 0.000% |
| Retail Imported Lamb | 0.06 | 0.00 | 0.16 | 0.14 | 0.002% |
| Retail Poultry | 5.86 | 0.03 | 17.36 | 15.36 | 0.003% |
| Total Meat Consumer Surplus | -43.02 | -0.74 | -141.11 | -123.56 | -0.010% |

Note: Totals are not identical to sums of individual surpluses because they are medians of simulations.
[a]Short-run is year 1 and long-run is year 10.

**Table C-12. Median Producer and Consumer Surplus Changes from Full Traceability in both the U.S. Beef and Pork Industries (No Increase in Trade)**

| Surplus Measure | Short Run[a] | Long Run[a] | Cumulative | Cumulative Present Value | Cumulative As A Percent Of Total |
|---|---|---|---|---|---|
| | million dollars | | | | |
| Producer Surplus | | | | | |
| Retail Beef | -239.09 | -1.34 | -1,804.03 | -1,531.79 | -0.520% |
| Wholesale Beef | -348.38 | -5.83 | -2,208.66 | -1,881.14 | -1.202% |
| Slaughter Cattle | -1,124.35 | -15.88 | -3,993.28 | -3,443.75 | -1.984% |
| Feeder Cattle | -1,240.08 | -24.65 | -4,156.78 | -3,615.05 | -2.741% |
| Total Beef Producer Surplus | -2,954.30 | -47.65 | -11,996.40 | -10,360.02 | -2.371% |
| Retail Pork | 87.19 | -0.78 | 202.43 | 183.95 | 0.147% |
| Wholesale Pork | 13.76 | -2.80 | -2.54 | 3.59 | 0.006% |
| Slaughter Hog | 1.76 | -5.99 | -68.75 | -50.37 | -0.090% |
| Total Pork Producer Surplus | 103.32 | -9.56 | 129.18 | 139.25 | 0.058% |
| Retail Domestic Lamb | 1.08 | 0.00 | 2.61 | 2.35 | 0.066% |
| Wholesale Lamb | 0.13 | 0.00 | 0.39 | 0.35 | 0.023% |
| Slaughter Lamb | 0.06 | 0.00 | 0.24 | 0.21 | 0.013% |
| Feeder Lamb | 0.04 | 0.00 | 0.23 | 0.20 | 0.012% |
| Total Lamb Producer Surplus | 1.33 | 0.00 | 3.56 | 3.19 | 0.038% |
| Retail Poultry | 388.31 | 0.04 | 739.26 | 678.64 | 0.359% |
| Wholesale Poultry | 26.20 | 0.01 | 58.34 | 52.71 | 0.315% |
| Total Poultry Producer Surplus | 415.28 | 0.05 | 794.84 | 732.85 | 0.356% |
| Total Meat Producer Surplus | -2,449.98 | -57.75 | -10,957.43 | -9,383.63 | -1.248% |
| Consumer Surplus | | | | | |
| Retail Beef | -1,152.87 | -5.59 | -3,629.92 | -3,179.43 | -1.019% |
| Retail Pork | 1.78 | -3.32 | -15.48 | -10.73 | -0.005% |
| Retail Domestic Lamb | -0.26 | 0.00 | -0.26 | -0.26 | -0.006% |
| Retail Imported Lamb | 1.56 | 0.00 | 3.89 | 3.48 | 0.055% |
| Retail Poultry | 150.45 | 0.43 | 445.74 | 399.22 | 0.089% |
| Total Meat Consumer Surplus | -994.70 | -8.75 | -3,168.77 | -2,784.66 | -0.224% |

Note: Totals are not identical to sums of individual surpluses because they are medians of simulations.
[a]Short-run is year 1 and long-run is year 10.