RURAL ECONOMY

Traceability – a literature review

Dawn Trautman, Ellen Goddard and Tomas Nilsson

Project Report # 08-02

Project Report

Department of Rural Economy
Faculty of Agricultural, Life and Environmental Sciences
University of Alberta
Edmonton, Canada

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The authors are, respectively, student, Professor and Assistant Professor, Department of Rural Economy, the University of Alberta, Edmonton.

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ABSTRACT

In light of recent food safety crises and international trade concerns associated with food or animal associated diseases, traceability has once again become important in the minds of public policymakers, business decision makers, consumers and special interest groups. This study reviews studies on traceability, government regulation and consumer behaviour, provide case studies of current traceability systems and a rough breakdown of various costs and benefits of traceability. This report aims to identify gaps that may currently exist in the literature on traceability in the domestic beef supply chain, as well as provide possible directions for future research into said issue. Three main conclusions can be drawn from this study. First, there is a lack of a common definition of traceability. Hence identifying similarities and differences across studies becomes difficult if not impossible. To this end, this study adopts CFIA's definition of traceability. This definition has been adopted by numerous other agencies including the EU's official definition of traceability however it may or may not be acceptable from the perspective of major Canadian beef and cattle trade partners. Second, the studies reviewed in this report address one or more of five key objectives; *the impact of changing consumer behaviour on market participants, suppliers incentive to adopt or participate in traceability, impact of regulatory changes, supplier response to crisis and technical description of traceability systems.* Drawing from the insights from the consumer studies, it seems as if consumers do not value traceability per se, traceability is a means for consumers to receive validation of another production or process attribute that they are interested in. Moreover, supply chain improvement, food safety control and accessing foreign market segments are strong incentives for primary producers and processors to participate in programs with traceability features. However the objectives addressed by the studies reviewed in this paper are not necessarily the objectives that are of most immediate relevance to decision makers about appropriate traceability standards to recommend, require, subsidize etc. In many cases the research objectives of previous work have been extremely narrow creating a body of literature that is incomplete in certain key areas. Third, case studies of existing traceability systems in Australia, the UK, Scotland, Brazil and Uruguay indicate that the pattern of development varies widely across sectors and regions.

In summary, a traceability system by itself cannot provide value-added for all participants in the industry; it is merely a protocol for documenting and sharing information. Value is added to participants in the marketing chain through traceability in the form of reduced transactions costs in the case of a food safety incident and through the ability to shift liability. To ensure consumer benefit and have premiums returned to primary producers the type of information that consumers value is an important issue for future research. A successful program that peaks consumer interest and can enhance their eating experience can generate economic benefits to all sectors in the beef industry. International market access will increasingly require traceability in the marketing system in order to satisfy trade restrictions in the case of animal diseases and country of origin labelling, to name only a few examples. Designing appropriate traceability protocols industry wide is therefore becoming very important.

JEL Codes: D020, D100, D200, Q100

Keywords: traceability, institutions, Canada, consumer behaviour, producer behaviour, supply chain

1. INTRODUCTION

For many years, farmers, processors and retailers have maintained different types of traceability programs with varying degree of precision, accuracy and speed. Several EU countries, the U.S. and Canada have developed traceability programs in the livestock sector. However, more than often these programs do not provide information to the consumer about live animal management, processing, storage and distribution practices. Rather, traceability is viewed as a mechanism for improving food safety control by ensuring rapid product recall ability, should a food safety incident occur.

In the wake of several food safety related occurrences such as BSE, *Salmonella* and *E. Coli*, and concerns about production and process attributes such as genetic modification, antibiotics and animal welfare, the interest in tracing individual food items back to its original source of conception in Canada extends past the walls of academia, e.g. see Cooper (2008). According to Golan et al, traceability systems are "recordkeeping systems designed to track the flow of product or product attributes through the production process or supply chain" (2004: 1). Industry studies show that the benefits of traceability go beyond food safety management: traceability can be used as a tool to monitor and manage information and product flow, which may lead to improved efficiency and ultimately enhanced profitability. In addition to food safety control and supply chain management, traceability can also be used in new product development and is increasingly required in securing foreign market access.

The objective of this report is to present a literature review on the current state of knowledge about food traceability systems, in particular traceability systems in beef supply chains. The report aims to identify information gaps that may currently exist in the literature on traceability in the domestic beef supply chain. Traceability has existed in different forms in the livestock sector such as individual animal identification for at least 3,800 years Blancou (2001).

Moreover, considerable research has been devoted to the pros and cons of traceability. This study provides a literature review on studies of traceability; literature which is available through public sources e.g. government websites, university library databases and search engines on the Internet (e.g. Google Scholar, YAHOO). Examples of existing systems, elsewhere in the world are also provided.

2. OUTLINE

The project report consists of 7 sections. Section 3 in this report discusses the different definitions of traceability that exist in the literature and among industry stakeholders. Section 4 presents the study methodology, criteria used in retrieving studies deemed relevant for this project, in particular categorizing the study objectives and motivation. Five case studies on countries that have implemented various voluntary and mandatory traceability programs are discussed in Section 5. Section 6 summarizes the costs and benefits of traceability on individual stakeholders in the food supply chain. Section 7 summarizes quantitative estimates of costs and benefits based on studies that did provide empirical estimates of the cost impact of traceability or food safety protocol. Section 8 provides a brief overview of the Canadian cattle industry and highlight current patterns such as international and interprovincial trade, primary producer structure, and current slaughter and processor distribution and capacity. Conclusions and study limitations are discussed in Section 9 of this report.

3. DEFINITIONS OF TRACEABILITY

In documenting the benefits and costs of food traceability systems on stakeholders in the Canadian agri-food systems it is important adopt a structured yet inclusive definition of the term traceability. However, although there is an extensive literature on traceability, each study uses its own definition of the term, which makes it difficult to quantify what the costs and benefits of traceability on primary producers, processors, retailers and food service might be. Table 3.1 presents a summary of 30 commonly found definitions of traceability.

In particular definitions of traceability varies widely because of differences in geographic coverage, time period, business activities, industry structure, consumer perceptions and the legal framework regulating consumer and producer rights. Even within Canada, the definition of traceability varies slightly, e.g. see Agri-Traçabilité Québec, Alberta Agriculture and Food and CFIA in Table 1. The Canadian Food Inspection Agency (CFIA) has adopted the European Commission's (EC) definition for traceability as established by the European General Food Law:

> *"Traceability is the ability to trace and follow food, feed, food-producing animals or substances intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution."*

This definition is broad as it can be applied to both companies involved in the food supply chain and may also have relevance for non-food producers (ECR Europe 2004). This definition makes it clear that traceability is an issue involving all steps in a complete supply chain. According to ECR Europe (2004) companies in the supply chain collaborate to optimize the interfaces determined by its different directions, areas and sub-processes and thus consider traceability a method to meet consumers' expectations of product safety and quality.

Arisland and Kjærnsrød (2005) use the ISO definition of traceability for the TraceTracker Traceability Glossary:

> *"The ability to trace the history, application or location of an item or activity by means of recorded identification. When considering product (3.4.2), traceability can relate to the origin of materials and part, the processing history, and the distribution and location of the product after delivery."*

This definition is rather generic and does not specify characteristics such as precision i.e. tracing individual product packages back to individual animals vs. batches of animals, accuracy i.e. 100 per cent accuracy vs. 10 per cent, and speed i.e. time it takes to recall a product; hours vs. days. Hence comparing the costs and benefits of traceability in supply chains that have adopted the ISO protocol for feed and food traceability, ISO 22005:2007, becomes challenging. Moreover, the literature indicated that some studies refer to traceability as the ability to identify individual animals and their product flow whereas others refer to traceability more broadly as a system to ensure food safety.

Dessureault (2006) considers the ISO definition the most commonly used, as it is also very broad and does not specify a standard measurement, a standard location size, a list of processes that must be identified, where the information is recorded, or the bookkeeping technology (Golan et al. 2004). The Codex Alimentarius Commission (2006) uses a similar definition to ISO, where "*traceability or product tracing is the ability to follow the movement of food through specified stage(s) of production, processing and distribution*."

Another fairly broad definition is developed by Golan *et al.* (2004) where traceability is defined as "*a record keeping system designed to track the flow of product or product attributes through all stages of production, processing and distribution."* This definition only describes one direction of traceability from the channel of distribution to the consumer. Golan et al. (2004) specify that a traceability system is designed to track the flow of a product, but the need of a broad definition is due to the fact that traceability is a tool for achieving different objectives. When the Codex Alimentarius Commission together with the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) presented a definition in 2004 it was increasingly specific to food:

> *"A tool that may be applied within a broader food inspection and certification system as part of a risk management option for meeting specific food safety or fair trading practice objectives."*

Specific to agriculture and agri-food is the OnTrace (2007) definition of traceability:

> *"The ability to locate an animal, commodity, food product or ingredient and follow its history in the supply chain forward (from source to consumer) or backward (from consumer to source."*

General definitions of traceability such as those presented above have made some stakeholders concerned. There are concerns that the lack of detailed definitions prevents the possibility to achieve necessary food safety or assurance goals (Farm Foundation 2004). Farm Foundation defines traceability as

> *"The efficient and rapid tracking of physical product and traits from and to critical points of origin or destination in the food chain necessary to achieve specific food safety and, or, assurance goals."*

Moreover, specific definitions such as this lead to new objectives of traceability, such as consumer assurance (Dessureault 2006). In this vein, Agri-Traçabilité Québec's (2007) definition also entails other uses of traceability as *"a tool that will allow for the rapid identification of sites affected, preventing the spread to other sites and narrow as soon as possible disease or health problems."* The definition given by Smith et al. (2000) even suggests the use of traceability to ascertain ownership, identify parentage, improve palatability, and assure safety.

The concept of traceability may also be referred to by other terms. Traceback, traceability and source verification are referred to with the same definition in Smith *et al.* (2000) as

> *"the ability to identify origin of animals or meat as far back in the production sequence as necessary to ascertain ownership, identify parentage, improve palatability, assure safety and determine compliance in 'branded beef' programs."*

Dickinson, Hobbs, and Bailey (2003) use both traceability and identity preservation in their definition of traceability: *"the ability to track the inputs used to make food products backward and forward to/from their source at different levels of the marketing chain."* Becker (2007) defines animal identification as *"the marking of individual farm animals, or a group or lot of animals, so that they can be tracked from birth to slaughter."* Hobbs (2004) distinguishes between *ex post* traceability as the process of tracing something to the source of origin, and *ex ante* traceability as the provision of information on process attributes that verifies product quality.

There are also several terms used within or implied by the definitions of traceability. While the CFIA and EU definition of traceability imply the areas of traceability, the idea of tracking and tracing are stated by OnTrace (2007). Meuwissen et al. (2003) describe tracking as the ability to track food and food ingredients forward along the supply chain which can be used to find and recall products which may pose risk to consumers' health. This is contrasted to tracing which is described as the ability to trace food and food ingredients back along the supply chain from end user to producer or supplier to producer (Meuwissen et al. 2003). ECR Europe (2004) further explain tracking and tracing in legal terms with tracking being the one-step forward legal principle and tracing being the one-step back legal principle.

ECR Europe (2004) also defines the areas of traceability where upstream covers the first part of the supply chain including producers of raw materials, ingredients, packaging and all intermediate suppliers, while downstream covers the final part of the supply chain starting at the final product manufacturer, logistic service providers, distribution centers and ending at the retail point of sale. The forward-backward or one-up, one-down traceability can also be defined through internal traceability where

> "*Traceability within one single company, including complete records of the origin of all incoming materials received from external sources (suppliers) and of the destination of all outgoing products delivered to external destinations (customers)"* (Arisland and Kjærnsrød 2005).

Global traceability or chain traceability is then defined as *"traceability across companies having internal traceability and/or conglomerate enterprises having enterprise traceability"* (Arisland and Kjærnsrød 2005).

This study adopts CFIA's definition of traceability, "The ability to trace and follow food, feed, food-producing animals or substances intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution. There are three recognized pillars to traceability: Animal or product identification; Animal or product movement; Premises identification." Furthermore, this definition appears conformable to the European Union definition of traceability, "traceability means the ability to track any food, feed, food-producing animal or substance that will be used for consumption, through all stages of production, processing and distribution" (EU Food Law 2008). There are at least three limitations that apply to this definition however. First, CFIA's definition of traceability may not imply automatically that individual animal information (e.g. precision), live animal management practices, slaughter and processing practices are recorded or verified. Second, this definition may or may not be considered acceptable from the perspective of importers of Canadian cattle and beef. Third, issues surrounding cost impact and liability are largely unresolved.

In particular, the definition does not provide information or guidelines to determine how the costs associated with traceability might be distributed across the market participants within the supply chain. For example, with regards to liability, according to Golan et al., "Many in the livestock sector worry that traceability systems linking meat to animals will break this tradition and shift at least some of the liability for food borne illness back to cow-calf operators and feedlots. Some livestock organizations have even publicly called for limits on liability that may arise from animal identification" (page no.; 2004).

4. OVERVIEW OF SELECTED LITERATURE

The objective of this overview of selected literature is to categorize selected literature on traceability, summarize studies of changes in the marketplace and its impact on suppliers, and review studies that show why traceability might provide opportunities for firms in the beef supply chain. The literature will be assessed for consistency in their definition of traceability, how the definition varies across markets, impact on stakeholders and opportunities for traceability in the food system. The literature presented in this section is a summary of published articles in scholarly journals and the grey literature. Grey literature refers to publications by government, academia and industry that are not necessarily peer-reviewed. Selected literature will be retrieved in a three step process further described below.

The first stage of this overview is to identify appropriate databases to search. Utilizing the information from University of Alberta libraries, 13 databases were identified. These databases are (descriptor of each database as given by the provider in parenthesis): ABI Inform Global (business and management, engineering, health, and education), Academic Search Complete (interdisciplinary), AgEcon Search (agricultural and applied economics), Blackwell Journals (interdisciplinary), Business and Industry Database (business and trade articles on companies, industries and markets), Business Source Complete (business journal and magazine articles), EconLit (Economics journal articles), Emerald Insight (interdisciplinary) Google Scholar (interdisciplinary), Proquest (Dissertations and theses in Canada, the U.S. and the EU), ScienceDirect (scientific, technical, medical, business and economics literature), Scopus (science, technology, medicine, social sciences), Web of Science (natural and social sciences) and Statistics Canada (government publication).

The databases provide a comprehensive coverage of journals and grey literature in agricultural economics, applied economics, consumer behaviour, supply chain management, marketing and business. The period of the literature review extends from January 1991 to March 2008.

The second stage includes listing appropriate keywords for the literature search. The keywords used for this review include: animal identification, country of origin labelling, identity preservation, meat supply chain, quality assurance, quality control, traceability, trace back, tracing, and tracking. In total 320 articles were retrieved from the databases using the aforementioned keywords and search delimiters. The complete list of references is available in Section 10 of this report.

In the final and third stage, articles were selected based the study's perceived relevance to the research topic. This selection process resulted in published Master Theses or Dissertations and working papers in departments of agricultural economics across North America, articles published in journals with focus on agriculture, agribusiness or food economics, papers presented at agricultural economics conferences, industry white papers or government publications. Of the total 320 articles, 135 articles were ultimately selected. Three databases provided a fairly large proportion of articles that were reviewed: 12 articles were published by the OIE, 17 by Emerald insight and 15 by ScienceDirect. Each study is categorized according to six criterion: (1) study author, geographic focus and year; (2) definition of traceability; (3) context and scope; (4) objective; (5) methods; and (6) aggregate summary. On basis of these criterions it is feasible to identify commonalities and differences across papers.

4.1 STUDY AUTHOR, GEOGRAPHIC FOCUS AND YEAR

Of the 135 articles, 30 were published during the period 1995 to 2002, 16 in 2003, 19 in 2004, 13 in 2005, 22 in 2006 and 22 between 2007 and 2008. Moreover, 57 studies focused on EU markets (e.g. 2, 3, 5, 8, 13, 19, 22, 28, 29, 30, 33, 34, 37, 38, 40, 41, 42, 43, 44, 45, 46, 47, 48, 55, 56, 57, 60, 64, 66, 71, 74, 75, 77, 79, 80, 81, 88, 89, 93, 98, 99, 102, 104, 108, 109, 110, 111, 113, 115, 116, 118, 121, 126, 127, 129, 130 and 134), whereas 59 focused on the North American market (e.g. 1, 6, 7, 9, 11, 12, 17, 18, 20, 21, 23, 24, 25, 27, 31, 32, 33, 34, 35, 36, 37, 39, 45, 49, 50, 51, 52, 53, 54, 58, 59, 61, 62, 63, 64, 66, 67, 68, 69, 79, 82, 83, 86, 87, 90, 93, 98, 103, 106, 107, 112, 113, 114, 120, 121, 122, 125, 132 and 133), and 12 on the Asian or Oceania markets (e.g. 4, 26, 33, 34, 45, 66, 70, 76, 79, 93, 113 and 118). Several studies focused on several markets. For example at least 12 studies focused on both North America and the EU (e.g. 33, 34, 37, 45, 64, 66, 79, 93, 98, 113 and 121).

4.2 DEFINITION OF TRACEABILITY

As indicated in Section 3, the definition of traceability varies across markets and time. Hence, comparing two studies that documents the costs and benefits of traceability that use different definitions of the term becomes a difficult task, if not impossible. Of the 135 articles, there are a total of 83 different definitions of traceability (e.g. the second column of Table 4.1). Of the total 33 articles apply one of the definitions of traceability by the EU, ISO or Codex Alimentarius Commission, or choose a definition that is similar (7, 10, 13, 16, 21, 23, 24, 26, 29, 30, 32, 35, 42, 43, 44, 52, 56, 65, 68, 69, 70, 72, 74, 75, 82, 93, 98, 99, 107, 109, 114, 118, 128). There are 37 studies which do not use one of the EU, ISO or Codex Alimentarius Commission definitions but apply their own definition of traceability, which may include all stages/participants in the food chain (8, 9, 11, 19, 22, 34, 36, 39, 45, 46, 48, 57, 61, 63, 64, 67, 76, 77, 79, 84, 89, 90, 91, 94, 100, 101, 102, 103, 104, 112, 113, 115, 120, 125, 130, 132, 134).

Example of such definitions of traceability are "[Traceability] can be used to establish or affirm the reputations of producers and suppliers by communicating either positive or negative information to consumers" (7), "The ability to trace the history of a product's origin including the identity of the farms and the marketing firms along a supply chain" (102), and "Traceability systems are record-keeping systems designed to track the flow of product or product attributes through the production process or supply chain" (120). Approximately ten studies apply a less precise definition of farm-to-fork traceability e.g. "To be able to follow the animal back to the farm of origin" (60), "Tracing a product or animal forward or tracking a product or animal back" (88). That is, it is not clear to discern from the definition how or if information is transmitted between the stakeholders in the food supply chain.

4.3 CONTEXT AND SCOPE

The reviewed studies focused on traceability, or opportunities for traceability in the food/meat sector in general (11, 13, 17, 18, 19, 20, 21, 23, 26, 30, 31, 33, 34, 35, 36, 39, 42, 43, 44, 46, 47, 49, 50, 51, 52, 53, 54, 57, 58, 61, 62, 63, 64, 65, 66, 68, 72, 73, 74, 74, 75, 77, 78, 80, 85, 89, 91, 92, 93, 95, 96, 98, 100, 101, 102, 104, 108, 109, 112, 114, 116, 117, 119, 123, 124, 129, 130, 134 and 135) or the cattle/beef/livestock sector (1, 2, 3, 4, 5, 7, 8, 8, 9, 12, 16, 17, 18, 18, 21, 22, 23, 25, 27, 28, 29, 37, 40, 45, 48, 48, 55, 56, 57, 59, 60, 61, 62, 64, 67, 68, 69, 69, 70, 71, 71, 76, 81, 82, 83, 86, 87, 90, 94, 97, 97, 99, 103, 103, 104, 106, 107, 111, 112, 113, 114, 118, 121, 122, 127 and 132). In particular, 44 of the reviewed studies focused on the cattle/beef sector (2, 5, 8, 9, 12, 16, 17, 18, 21, 22, 23, 25, 27, 28, 37, 40, 48, 55, 56, 57, 59, 60, 64, 67, 70, 71, 76, 81, 82, 83, 86, 87, 90, 94, 97, 103, 106, 107, 111, 113, 118, 121, 127 and 132).

Moreover, the traceability studies can be classified into four different categories of scope. The categories are farm-to-fork, farmer to processor stage, retail and consumer. In particular, 56 studies focus on traceability with a farm-to-fork perspective (1, 3, 7, 10, 11, 13, 19, 23, 24, 26, 28, 29, 30, 33, 37, 38, 39, 40, 43, 48, 56, 57, 58, 59, 60, 70, 75, 76, 77, 78, 80, 81, 83, 84, 85, 86, 87, 88, 89, 91, 94, 95, 97, 98, 100, 101, 104, 107, 109, 111, 112, 115, 118, 119, 124, 126, 130, 132, 134, 135, 2, 4, 5, 6, 8, 9, 12, 14, 15, 18, 20, 21, 22, 25, 27, 31, 32, 34, 35, 36, 41, 42, 44, 45, 46, 47, 49, 50, 51, 52, 53, 54, 55, 61, 62, 63, 64, 65, 66, 67, 68, 69, 71, 72, 73, 74, 79, 82, 90, 92, 93, 96, 99, 102, 103, 105, 106, 108, 110, 113, 114, 116, 117, 120, 121, 122, 123, 125, 127, 128, 129, 131 and 133), 17 studies on the farm to processor stage (4, 12, 14, 15, 22, 45, 71, 102, 103,

105, 106, 110, 120, 122, 125, 127 and 133) and 11 studies (2, 5, 42, 47, 55, 74, 82, 90, 108, 123 and 129) with a focus primarily on consumer reaction to traceability.

4.4 STUDY OBJECTIVES

The objective gives the main thrust of a paper as it motivates the importance of the study and the type of information sought. The objective also provides information on relevant theoretical approach, appropriate research methodology used and the type of empirical data that is collected, if any. In this vein, although two authors may study the same economic phenomena, the results and recommendations may differ because their objectives differ.

Five main study objectives can be discerned from the reviewed literature. The objectives range from analyzing the impact of changing consumer behaviour on market participants (2, 9, 25, 26, 31, 33, 34, 35, 36, 46, 47, 54, 55, 61, 62, 66, 74, 80, 82, 86, 89, 90, 94, 130 and 132), how incentives might impact supplier participation in traceability (4, 11, 19, 20, 21, 24, 27, 28, 32, 37, 40, 41, 44, 45, 46, 48, 49, 50, 51, 52, 53, 55, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 73, 77, 78, 79, 86, 91, 97, 101, 103, 104, 111, 112, 113, 115, 116, 118, 119, 120, 121, 122, 123, 126, 127 and 135), impact of regulatory changes on suppliers (11, 17, 18, 19, 23, 30, 32, 39, 40, 43, 44, 48, 49, 51, 53, 59, 67, 78, 80, 83, 88, 98, 100, 102, 103, 114, 115, 118, 122 and 135), response to crises such as BSE in the UK or Canada (7, 8, 30, 32, 37, 39, 40, 43, 46, 60, 78, 80, 81, 99, 104, 106, 117, 125, 129, 132 and133), technical description of a traceability system such as DNA markers or comparisons of traceability systems (1, 3, 4, 5, 6, 7, 8, 10, 12, 13, 14, 15, 16, 19, 20, 22, 23, 24, 29, 38, 41, 42, 43, 45, 46, 52, 54, 56, 57, 65, 69, 71, 72, 73, 75, 76, 77, 79, 84, 85, 87, 88, 92, 93, 95, 96, 98, 102, 105, 107, 108, 109, 110, 111, 112, 114, 120, 124, 128, 131, 134 and135). One study may address more than one objective. Studies that used one of EU, ISO or farm-to-fork definition of traceability and who's study objective concerned consumer behaviour include (9, 34, 35, 36, 46, 61, 74, 82, 89, 90, 94, 130, and 132). For example, study (9) uses the term traceability as "tracking methods for animals and meat" and seeks "to discuss the difficulties associated with a farm-to-fork beef traceability system in the U.S. and to determine if consumers are WTP for BSE testing and traceability". Studies (34) and (35) defined traceability as "the ability to track the inputs used to make food products backward to their source at different levels of the marketing chain".

4.5 METHODS

The study methods in the reviewed literature range from qualitative methods such as literature reviews (3, 4, 7, 8, 9, 14, 19, 20, 21, 24, 25, 26, 27, 29, 37, 38, 39, 42, 43, 44, 45, 46, 48, 49, 50, 52, 53, 56, 57, 65, 68, 72, 74, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 91, 92, 93, 96, 97, 98, 99, 100, 102, 107, 108, 109, 111, 112, 113, 114, 115, 116, 117, 118, 119, 121, 122, 123, 124, 127, 128, 134 and 135), surveys of primary producer, processor and/or retailers (15, 16, 19, 20, 21, 22, 27, 28, 30, 32, 40, 41, 48, 54, 59, 60, 67, 69, 70, 104, 105, 110 and 120), to consumer segmentation analysis and/or estimation of consumer willingness to pay (2, 9, 31, 33, 34, 35, 47, 55, 61, 62, 63, 90, 94, 126 and 130), or fitting a statistical or economic model to model firm behaviour in response to crises or food outbreaks, new regulations, and/or consumer behaviour (17, 18, 32, 51, 58, 64, 66, 75, 95, 101, 103 and 106). Nine consumer studies applied ISO, EU's, Codex Alimenaritus or a similar definition of traceability (9, 34, 35, 36, 61, 63, 90, 94 and130). For example study (9) sought to "determine if consumers are WTP for BSE testing and traceability". About half of the producer studies and review studies applied similar definitions of traceability as described above (16, 21, 30, 32, 69, 70, 19, 22, 48, 67, 104 and 120) and (7, 21, 24, 26, 29, 42, 43, 44, 52, 56, 65, 68, 72, 74, 82, 93, 98, 99, 107, 109, 114, 118, 128, 8, 19, 39, 45, 46, 48, 57, 76, 77, 79, 84, 89, 91, 100, 102, 112, 113, 115 and 134). Several studies that focus on the impact of traceability and changing behaviour on firms tend to take a farm-to-fork perspective on traceability (9, 25, 26, 33, 34, 36, 46, 47, 55, 61, 62, 74, 82 ad 132). Eight studies that adopt the farm to processor scope are qualitative in nature i.e. involve minimal or no statistical analysis (4, 14, 22, 71, 105, 110, 125 and 127). Moreover, 37 of the 56 articles that takes a farm-to-fork perspective on traceability are descriptive or conceptual i.e. qualitative in nature (1, 3, 10, 13, 16, 23, 24, 28, 29, 30, 38, 40, 43, 56, 57, 75, 77, 78, 80, 81, 84, 85, 88, 89, 91, 94, 95, 98, 100, 107, 109, 111, 118, 124, 130, 134 and 135). Twelve studies are written with a focus on North American markets, use a farm-to-fork perspective on traceability and apply a quantitative method in studying the impact of traceability (7, 11, 17, 33, 37, 39, 59, 83, 86, 87, 112 and 132). However, the challenge is that these studies provide only a partial estimate of the costs and benefits associated with traceability such as willingness to pay for traceability (33 and 132), the direct costs associated with implementing traceability (37 and 39, 86), or costs of a specific piece of legislation, country of origin labelling (59 and 83).

4.6 AGGREGATE SUMMARY

The aggregate summary provides a quick overview of the issues covered, study results and implications for policy formation, where appropriate. It is challenging to reach any general conclusions from the literature review. Grouping authors or studies that draw similar conclusions and identifying areas in which authors are in disagreement becomes a difficult task, because of differences in the definitions of traceability and study methods. In particular, comparing studies that estimate or present direct/indirect cost impact of traceability across market participants (e.g. 7, 12 and 45) become problematic as some consider traceability up until the point of processing and not necessarily retail. Six key findings can be drawn from the literature however. First, the results of the studies that looked at consumer perception of food safety and process attributes suggest that consumers do not value traceability per se but rather see traceability as a means to deliver desired product or process attributes (2, 9, 17, 18, 20, 21, 25, 26, 31, 32, 33, 34, 35, 36, 43, 46, 47, 49, 50, 55, 61, 62, 63, 66, 68, 69, 70, 74, 75, 79, 80, 81, 82, 87, 89, 90, 94, 97, 101, 107, 108, 113, 114, 121, 129, 130 and 132). However, it is worth noting that previous estimates of willingness to pay for traceability attributes (e.g. 25, 33, 34, 63 and 82) may or may not be relevant in a current and future Canadian context. In particular, there is still an open question as to what type of attributes that Canadian consumers value that can be provided a farm to fork traceability system (e.g. hormone free, natural, omega-3). Second, retailers may regard traceability programs as an opportunity to intensify the level of product differentiation and brand competition in the meat shelves (16, 17, 18, 19, 20, 21, 26, 40, 41, 46, 48, 49, 50, 52, 53, 54, 55, 58, 59, 60, 65, 67, 72, 75, 77, 80, 81, 83, 89, 97, 98, 99, 101, 102, 103, 107, 111, 114, 115, 116 and 121). In this vein traceability can be seen as a tool to make information on product attributes and process history credible. Third, primary producers' incentives to adopt in traceability systems are driven by factors such as efficiencies through improved supply chain management, food safety/quality control, meeting requirements for accessing foreign markets and creating new niche markets (3, 10, 12, 17, 18, 19, 22, 23, 24, 27, 28, 29, 30, 32, 34, 38, 40, 45, 48, 49, 50, 52, 53, 54, 59, 65, 67, 71, 73, 76, 77, 81, 83, 84, 91, 97, 104, 115 and 116). One key finding that tend to stick out from these studies is that since the cost of adoption of a new regulation entails fixed investments in labour (e.g. hiring qualified staff, education) and capital (renovation of facilities, upgrading equipment to comply with new standards etc), smaller firms with smaller throughput volumes find it relatively more challenging to absorb these costs (7, 45, 48, 122).

Hence, government may have a role to play in providing financial incentives to smaller farm and food firm operators. Fourth, regulatory changes may drive adoption of traceability among retailers and suppliers (3, 4, 5, 6, 7, 9, 17, 18, 23, 26, 30, 39, 43, 44, 48, 60, 61, 64, 69, 70, 98, 99, 100, 103, 107, 113, 118, 122, 125, 133). For example, if there are no private benefits of traceability but there is a net social benefit (i.e. suppliers are not able to realize the social gains), the government may have a role in developing traceability programs and ensuring compliance. Fifth, food safety outbreaks and crises such as BSE, *Salmonella* and *E. coli* may stimulate improved coordination among industry stakeholders (8, 10, 11, 14, 26, 31, 37, 50, 51, 52, 56, 62, 64, 81, 88, 100, 101, 112, 123, 127, 128 and 133). This may in turn lead to development of new programs such as traceability. Lastly, numerous studies have identified opportunities and challenges associated with traceability, such as costs of maintaining animal identification systems, cost of segregating products as it goes through the supply channel and market opportunities associated with new niche markets and improved supply chain control (4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 17, 18, 19, 20, 21, 22, 24, 27, 28, 29, 32, 33, 35, 36, 39, 40, 41, 42, 43, 45, 46, 48, 49, 54, 57, 59, 60, 61, 62, 65, 66, 67, 68, 73, 77, 79, 87, 88, 89, 90, 91, 101, 104, 112, 114, 115, 116, 119, 128, 133, 134 and 135). However, it is difficult to come up with economic estimates of the cost of adoption and maintaining a viable traceability system at the farm, processor and retail stages, respectively. To the knowledge of the authors, no North American study has to date provided a comprehensive quantitative assessment of the costs associated with developing, implementing and maintaining a program at the farm, feedlot, processing and retail stages, with a definition of traceability akin to the one used in the present study. Hence, even establishing cost ranges becomes difficult as the notion of traceability is not used, or applied, in a consistent and precise manner. While as individual studies do provide estimates of consumer willingness to pay and impact assessments on individual stakeholders, this information provide only partial guidance to actors on how the program may impact market participants in terms of cost sharing and government involvement. Indeed, a key limitation that arises from the reviewed literature is that there is very little data collected in quantifying the economic impact on stakeholders of traceability, at the farm to processor stages as well as processor to retail stages of traceability.

5. EXISTING TRACEABILITY SYSTEMS: CASE STUDIES

A number of specific traceability systems, applied to cattle/livestock industries world wide are described in Appendix 3, Table 3. The point of providing brief descriptions of these other traceable systems is to provide context to the discussion of the benefits and costs of traceable systems. Clearly benefits and costs will relate to the coverage in the system, whether the system is mandatory or voluntary, whether developed by specific agents (e.g. grocery store chains) or by all agents within a supply chain (all processors or all retailers, for example).

Traceability systems have evolved differently across sectors and countries depending upon direct market pressures. For example, within Australia a previously voluntary system for national livestock identification became mandatory in 2005 in an attempt 'to maintain competitive advantage' in export markets. Australia has both a livestock identification system and a property identification system, ensuring that since 2005, the animal (through radio-frequency chip) and property of birth are traceable. For export, tracing the history of animals through saleyards and slaughter facilities is mandatory, movements on and off feedlots are also tracked if applicable. Further traceable standards such as DNA samples (through an EAN numbering system) are voluntary and can allow tracing animals back from meat samples. It is also worth noting that these traceable standards are included in a much larger system of quality assurance (Gong et. al, 2007) within the Australian livestock industry. Within Australia there are government administered quality assurance schemes relating to such things as chemical residue status, and hormones as well as traceability and industry administered 'consumer quality standards' such as Cattlecare, administered by third party independent audit of company specific requirements, relating to consistency, environmental management and animal welfare.

In the U.K. post BSE and foot and mouth national quality assurance schemes became more prevalent. Grocery stores such as TESCO have established company Codes of Practice for livestock as "all Tesco fresh meat, farmed fish and animal products have the highest standards of food safety. They also address animal health and welfare, animal feed, animal medicine usage and environmental management and biodiversity. The Codes of Practice cover all aspects of an animal's life from birth, through their life on the farm, transportation and eventually slaughter. They cover not only animals bred for meat but also the breeding stock"

(http://www.tescofarming.com/livestock.asp). The TESCO system builds on and where necessary is more rigorous than the government mandated independently set up national assurance schemes. Grocery store chains have the option to develop additional standards and contributed to the base line national assurance schemes. TESCO prides itself on delivering, where possible, whole life traceability including the husbandry of animals that not be used to supply the stores, such as breeding stock.

Within Japan the system is much more proscribed, government regulations introduced in 2002 and 2003 require the traceback ability of cattle from packing plant to feedlot and from consumption through distribution to production, using an internet based system. In addition retail chains have adopted voluntary systems to provide consumers with certification of assurances from export organizations such as the Australian Feedlot Association, BSE testing certificates and in some cases photographs of producers and information on animal type.

In Scotland, again a combination of government driven mandatory assurance schemes and industry driven voluntary assurance schemes are operating. Mandatory schemes such as the British Cattle Movement Service – provide traceability from birth to death. However producers and industry have collaborated to provide assurances of production methods, producers, animal welfare, animal health management and feed management (since 1992) and to allow full traceability from live animal to batches of meat (1995). In certain cases restaurants are able to trace Scotch lamb and beef to their suppliers.

A major exporting country, Uruguay, has implemented government managed mandatory traceback of animals from slaughter to farm of origin, through region codes, movement records and police authentication. The Uruguayan system also allows for traceability of meat cuts from carcass disassembly to animal lot numbers. In addition the Certified Natural Meat Program of Uruguay, established in 2001, provides assurances of source, of no hormone use, of no antibiotic use, of grass feeding on open ranges. This voluntary system is accredited through independent certification bodies.

In Brazil, a traceable system was imposed by government in 2002. At that time the "Ministry of Agriculture, Husbandry and Supply (MAPA) published Normative Instruction 1, instituting the Brazilian Bovine and Bubaline Identification and Certification System, the Sisbov, to identify register and individually monitor all of the cattle and buffalo born in Brazil or imported since that date. Sisbov is a set of actions, measures and procedures adopted to characterize the origin, sanitary state, production and productivity of Brazilian cattle and buffalo raising, and the safety of foods from this economic activity" (Lima et. al. 2006). However it is worth noting that the existence of the system does not in itself necessarily provide access to export markets. In December of 2007, after inspection by the EU, trade in beef products from Brazil to the EU was severely restricted, due to "deficiencies in Brazil's animal health and traceability systems" (Reuters, December 19, 2007, EU tightens requirements for Brazilian beef, (http://www.alertnet.org/thenews/newsdesk/L19461466.htm). As of February 27, 2008, the EU significantly loosened its restrictions on Brazilian beef allowing for meat from bovine animals from 106 rural establishments to be exported to the EU. These establishments were found to be in compliance with traceability standards. As other establishments become compliant it is expected that they too will become able to export beef to the EU (press release, Embassy of Brazil in London, February 27, 2008 (http://www.brazil.org.uk/newsandmedia/pressreleases_files/20080227.html).

In the cases reviewed there is a blend of mandatory and voluntary standards or quality assurances operating in most schemes. In most cases the mandatory government driven program involves the traceability of animals from origin to slaughter in a packing plant. Further tracing from processor to consumer, while described as consumer driven, is usually established by industry groups, and is usually independently audited and associated with production standards of interest to consumers – animal welfare, animal feed, and environmental management. Countries that establish standards for their own production expect to be able to have similar standards adopted in exporting countries, are willing to suspend trade if such standards are not available and in some cases will pay premiums for detailed traceable standards.

6. BENEFITS AND COSTS OF A BEEF TRACEABILITY SYSTEM

The qualitative costs and benefits of a beef traceability system are described in Appendix 4, Table 4, which relate to the supply chain relationships shown in Appendix 8, Figure 1. The purpose of determining the qualitative costs and benefits of the beef supply chain is in part to identify all potential agents involved in the supply chain and to determine the impact of implementing traceability on individual stakeholders. Seventeen studies were used to analyze the qualitative benefits and costs which documented how costs and benefits were disaggregated between various stages and/or agents.

6.1 BENEFITS

There are six stages identified in the beef supply chain: farm, feedlot, slaughter, processing, distribution, and consumption. Agents at the farm stage include cow-calf producers, forage producers, dairy operations, and stocker operations; in this stage cattle may move to feedlots, slaughter, or distribution. At the feedlot stage agents consist of commercial feedlot or farmer feedlot. From the feedlot stage cattle may be moved to slaughter or distribution; it is also recognized that cattle may come from auction markets, interprovincial import, or cattle for export and be moved for slaughter. Agents at the slaughter stage may move beef towards processing or distribution and include abattoirs and cutting plants. In the processing stage beef goes to distribution via the processing and packing plants. Agents in the distribution stage include exporters, meat wholesalers, traditional butchers, restaurants, supermarkets, independent grocers, direct sale outlets, foodservice companies, farmer's markets, and imported meat. From the distribution stage beef flows along the supply chain toward the consumption; agents affected at this stage include the individual consumer and the government in the concern of public health and policy decisions.

The benefits of a beef traceability system can be summarized according to the three main objectives of firms as described by Golan et al. (2004): supply management, food safety and quality control, and product differentiation. Supply management is improved through efficiency gains from the farm to the retailer. At the farm stage traceability supplies producers with property protection which reduces monitoring costs; these reduced costs are then passed down the chain as overall efficiency gains.

Along with property protection agents at the farm and the feedlot stage are prone to less risk when traceability systems are in place when introducing new livestock to existing herds. Producers have a reduced incentive to cheat, on age verification and vaccination records for example, because with traceability subsequent agents can verify information and trace problems back to the source. There are also efficiency gains in cost reduction as traceability reduces information costs between agents and reduces transaction costs spent monitoring upstream suppliers, which may lower price. Overall, the benefits of efficiency gains in supply management are due to increased transparency at all stages.

The benefits of traceability for food safety and quality control are also present in all stages of the supply chain. For the farm, processor, slaughter, and distribution stages food safety and quality control minimizes liability of each individual agent and may reduce the incidence of recalls. In addition, by ensuring food safety and quality control producers and retailers can maintain consumer confidence in the case of a food safety violation. At the farm stage, agents have an added benefit of individual animal health monitoring through traceability systems; this may increase the productivity of these agents as traceability systems allow verifiable and complete records of vaccinations and production. With traceability there is reduced risk of allowing older or at risk cattle into the beef supply chain since records are verifiable; this is a benefit for both beef cattle producers and dairy producers to safely and honestly sell cull animals. Agents at the processing stage may benefit from reduced insurance premiums by the reduced risk associated with implementing traceability. Largely, traceability for food safety and quality control is a consumer benefit because they are assured safe food. This is also a government and public benefit of traceability as there may be reduced food borne illnesses which reduce societal and health costs. There are again some commonalities in the benefits of traceability for food safety and quality control in that there is increased transparency among supply chain agents.

Increased consumer demand due to product differentiation is a potential benefit for all agents up to the distribution stage. This increased ability to market beef with credence attributes, such as traceability, can only be done through record-keeping by agents as the product moves through the supply chain.

A potential but controversial benefit to producing agents in the supply chain is a price premium for producers and processors for products that are labelled as containing certain credence attributes (Meuwissen et al. 2003). Evidence supporting a price premium and benefit of traceability is uncertain for consumers because while consumers often state they would be willing to pay more for safer food, actual buying decisions show it is economic convenience that most affects purchasing decisions, not statement of safety or traceability on the label of a product (Meuwissen et al. 2003, Loureiro and Umberger 2007).

A common benefit of traceability appears to be increased transparency for all members of the beef supply chain. Transparency improves the efficiency of the movement of cattle and beef as well as ensuring verification and assurance to consumers regarding credence attributes. Improved efficiency of information relay improves the supply management ability of the agents and greater efficiency and lower costs may potentially be realized from farm to retail.

6.2 COSTS

The costs of a beef traceability system can also be divided according to Golan et al. (2004) into supply management, quality and safety control, and product differentiation categories. Costs of supply management include costs that reduce the efficiency of the movement of cattle or beef through the supply chain. Monitoring of upstream firms to ensure credible traceability methods may be a cost of supply management at all stages of the supply chain. Additional monitoring and enforcement costs would likely be incurred by the government. Food quality and safety control costs would include items such as equipment costs and facilities modifications, increased hours of labour due to increased time to ensure quality and safety, and audits, inspection fees, certification fees and administration costs of a quality and safety assurance program. Increased labour may be a cost at the farm, feedlot, slaughter and processing stages as more time would be needed for tagging, reading, and testing cattle or beef. However, some studies suggest traceability systems may actually reduce labour time in the distribution stage (Bracken and Matthews 2005). Consumers may face a cost of traceability in the form of a price premium (Meuwissen et al. 2003) or perhaps the loss of consumer privacy (Popper 2007). Costs of product differentiation are from additional advertising and promotion by firms to reassure consumers of the quality and safety of their product.

According to Loader and Hobbs (1996) a potential cost to auction markets would be the direct purchase of cattle from the farm to the slaughter stage, without passing through an auction, causing the auction market to lose commission money. Major costs of traceability systems vary according to the depth of modification and monitoring needed for particular agents and thus are difficult to establish.

6.3 QUALITATIVE COST-BENEFIT ANALYSIS

Determining whether benefits outweigh costs for a beef traceability program requires some guesswork, further research, and at this point a definite outcome is uncertain. However, based on the benefits and costs as described in the literature we can establish likely outcomes. There is some potential for benefits to outweigh costs in the farm stage, for the cow-calf producers, forage producers, dairy operations, and stocker operations, at larger scales (Bailey 2004) and if these producers are given a price premium (Fearne 1998). The ratio of benefits to costs is uncertain for commercial feedlots and farmer feedlots as there is contradictory evidence in the literature; Buhr (2003) states there is more efficiency gains at small scales, while Bailey (2004) and Golan et al. (2004) state annual costs decrease at large scales. There is also uncertainty for interprovincial import and for the auction markets, as costs may vary from no additional cost to thousands of dollars. At the feedlot stage there does appear to be greater benefits than costs for exporting agents as feedlot benefits are greater when exporting (Hobbs, Yeung and Kerr 2007). At the slaughter stage there is also uncertainty regarding efficient size of operation, but there appears to be greater benefit than cost in the minimization of safety or quality failures. During the processing stage there is greater benefit in improved ability to export products and increased credibility (Hobbs, Yeung and Kerr 2007), but still some uncertainty as costs vary. Benefits may be greater than cost in the distribution stage if there is export potential or a food recall.

Consumers may view a beef traceability system as beneficial as it provides safety and quality reassurance and product differentiation; however, according to Hobbs (2003) traceability alone is not valuable to most consumers and must be bundled with other attributes to be of value. The government or public sector may view a traceability system as beneficial as one national portal provides economies of scale to the industry and there is potential for a traceability program to act as an active surveillance for the beef industry for introduction of new diseases or other changes in quality or safety.

Implementing one national traceability system is efficient and facilitates interprovincial trade (Hobbs, Yeung and Kerr 2007). The national standardization of traceability could also potentially open international markets as a national program may be perceived as more credible than provincial or private standards.

A traceability system within the beef supply chain has many benefits and costs. In general, benefits of traceability are increased transparency in all stages of the supply chain, from the farm to retail. Costs of traceability take the form of monitoring and administration costs with monetary outlays in the form of required equipment and technology for traceability. These could be taken as costs necessary to reduce information asymmetry and increase transparency. Benefits and costs of implementing traceability can be divided into three categories provided by Golan et al. 2004, improvement of supply management, traceback to ensure food safety and quality control, and product differentiation for credence attributes.

7. EMPIRICAL DATA COLLECTED

This section of the report refers explicitly to the kinds of empirical data researchers have collected in previous attempts to understand, in most cases a priori, what the economic impact of introducing a traceability system might be. Although we have examined more studies a number of the studies that collected primary data are included in Appendix 5 Table 6. It is clear from the information provided in Table 6 that a number of studies have attempted to collect data on what consumers are interested in. A major function of traceable systems is to provide consumers with additional information at point of purchase, allowing them to maximize their utility. It is important that any marketer understand exactly what consumers want and, at least hypothetically, what they might be willing to pay for, prior to establishing a complex record keeping and verifiable system. The approach to establishing consumer willingness to pay for a traceable system is well understood and has been applied in a number of different jurisdictions (Sweden, Carlsson et al, 2005; U.S., Checketts, 2006 and Loureiro and Umberger, 2007 are two examples). Some studies mentioned in Table 6 refer explicitly to the proposed imposition of COOL legislation in the U.S., a closely related market requirement using similar tools to the studies identified above.

It is worth noting that no studies have looked explicitly at what consumers are willing to pay for traceability (verified) in food away from home purchases, although these continue to grow as a percentage of total food expenditures and in North America represent between 40 and 50% of total food expenditure by individuals.

The second major focus of the empirical studies have been to look at the supply chain issues associated with traceability programs on two grounds – either to assess in general terms how industry assesses existing systems and sees the benefits and costs of adopting such a system (GS1, Hobbs et al, 2007; Jones et al, 2004; various government reports) and/or to interview specific industry segments about actual costs associated with implementation of a traceable system (Bulut and Lawrence, 2007; Hanselka, 2004). This last area of research is one in which there does not appear to be a wealth of data either globally or nationally. An interesting study by Williamson et al (1996) has assessed the attitudes and methods used by quality auditors and it contains a useful instrument that could be of relevance in the Canadian context, since practitioners are key to the success of any system. A certain amount of information has been collected throughout Canada on the industry stakeholder interest in traceable systems but no data has been published on how industry stakeholders perceive their own abilities and constraints in adopting such a system or their perceptions of or actual costs associated with implementation. This particular item is of critical importance in designing the appropriate role of public organizations in supporting the development of traceable systems and/or regulating the existence of these programs. It is worth noting that Dessureault (2006) collected data on perceptions and costs of implementing traceability in the Canadian dairy processing industry – results suggest that there is enormous variability in perceptions of costs and benefits across the various firms responding to his survey. Clearly empirical analysis of these issues across other sectors would provide critical input to policy makers within Canada.

8. CANADIAN BEEF SUPPLY STRUCTURE

According to statistics from the Agriculture Division at Statistics Canada the number of cattle averaged 15.9 million between 2001 and 2007. The statistics show that the topology of firms providing breeding animals, raising feeders and slaughter cattle are not one homogeneous group. Firm size, measured as the number of animals per farm, and total production vary widely across provinces and stage of production. For example, about three-quarter of the cattle population are located in the Western Provinces (Manitoba, Saskatchewan, Alberta and British Columbia), one-quarter in Quebec and Ontario and the remainder in the Atlantic Provinces, see table 7. Moreover, cattle are traded across provinces and countries. For example, Alberta is a net importer of cattle from the other provinces: about two-thirds of all cattle traded across provinces are imported to Alberta, and about 7 per cent of total interprovincial export originates from said province. The second largest trader is Ontario; importing on average 16 per cent of total interprovincial trade volume. Tables 8 and 9 show interprovincial and international cattle trade figures for five-six month periods, July through December for 2002 to 2006. It is possible that the cattle imported to Alberta represent mostly slaughter cattle, whereas other provinces import a relatively larger share of feeder cattle. Furthermore, nearly 60 per cent of all ranches, farms and feedlots are located in the Western Provinces, whereas 18 and 8 per cent of all firms are located in Ontario and Quebec respectively in 2001 and 2006. Additionally, the size distribution of firms is relatively skewed: on average, feeder operations are about twice the size of cow-calf and cow-calf feeder and stocker/finisher operations for the period 2001 to 2007; see Table 11.

With regards to cattle slaughter and processing, there were 30 federally inspected cattle slaughter plants, according to AAFC (2007); see Table 12. Nearly 43 per cent of all plants were located in Western Canada of which 20 per cent in Alberta, and 27 per cent in Ontario and 27 per cent in Quebec. Total cattle slaughter averaged 3.6 million heads for the period 2002 to 2006, of which 6 and 94 per cent were slaughtered in provincially and federally inspected plants, respectively; see Tables 13 and 14. Hence, the vast majority of all cattle are slaughtered in federally inspected plants. Moreover, the capacity of the largest four plants averaged 178 thousand heads, with a combined market share average 86 per cent for the period 1998 to 2006.

In the Western Provinces, the combined market share of the four largest plants average 99 per cent; see Table 15. In Alberta alone, capacity of the federally inspected plants in 2006 was 63 per cent of national capacity, or 3.1 million head per year; see Table 16.

In summary, by the sheer nature and structure of the Canadian beef and cattle industry, it is likely that adoption of traceability might impact market participants very differently. Previous studies suggest that the cost impact of new regulations and voluntary quality controls are characterized by some degrees of economies of scale or scope, e.g. Hooker et al (2002), Ollinger et al (2004) and Jayasinghe-Mudalige and Henson (2007). For example, fixed costs associated with adoption of new technologies are less of a threat for larger volume firms, whereas they can stimulate exit pattern among smaller firms that are not able to access markets associated with price premium.

9. CONCLUSION

The objective of this report is to provide a literature review and case studies of existing traceability systems on the costs and benefits of food traceability systems, in particular traceability systems in the beef supply chain. The aim of the report is to identify gaps that may currently exist in the literature on traceability in the domestic beef supply chain, as well as provide possible directions for future research on traceability. Three main conclusions can be drawn from this study.

First, there is a lack of a common definition of traceability, as seen in Table 1. This lead to difficulties in interpreting and drawing conclusions from traceability studies in terms of finding similarities and differences and identifying quantifiable costs and benefits to potential stakeholders. This study adopts the CFIA's definition of traceability "The ability to trace and follow food, feed, food-producing animals or substances intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution. There are three recognized pillars to traceability: Animal or product identification; Animal or product movement; Premises identification."

The strengths and weaknesses of this definition has already been highlighted, however it is important to reiterate that while as this definition appears conformable to the EU's official definition of traceability, it may or may not be acceptable from the perspective of major Canadian beef and cattle trade partners such as the U.S., Japan, Korea and Taiwan.

Second, the literature reviewed in this report in general seems to address one or more of five key objectives; the impact of changing consumer behaviour on market participants, suppliers incentive to adopt or participate in traceability, impact of regulatory changes, supplier response to crisis and technical description of traceability systems. Several studies that address the first objective have also adopted one of EU's or a similar farm-to-fork definition of traceability. In particular, these studies tend to find that consumers to not value traceability per se but ascribe an economic value to product or process traits. Moreover, the review indicates that retailers may regard traceability as a means to increase product differentiation and enhance brand competition within stores. In a similar vein, studies indicate that supply chain improvement, food safety control and accessing foreign market segments are strong incentives for primary producers to participate in programs with traceability features. However there are very few studies that examine traceability, using the CFIA definition, empirically, before or after implementation. This likely reflects the fact that there are not very many systems established world wide – particularly from an industry wide perspective that do this. Individual retailers have established their own systems, traceable back to farm, for their own branding purposes. Governments have mandated, or assisted in the implementation of systems that go from farm to processors or packer, in the livestock case, or in a few cases to international buyers. A comprehensive analysis from farm to consumer, that quantifies true costs and benefits is lacking.

Third, case studies of existing traceability systems in Australia, the UK, Scotland, Brazil and Uruguay indicate that the pattern of development varies widely across sectors and regions. For example, in the Australian, Brazilian and Uruguayan cases, the systems are developed primarily to enhance or maintain export market accessibly whereas in cases of the UK and Japan, traceability can be said to restore or maintain domestic confidence among domestic consumers.

In conclusion, a traceability system by itself cannot provide value-added for all participants in an industry; it is merely a protocol for documenting and sharing information. Traceability systems through parts of a marketing chain can improve the industries' ability to respond to food safety incidents and allocate responsibility for any incidents that occur. This is in itself an economic benefit. The total scope of economic benefits cannot be addressed unless consumers become aware of and are influenced by the existence of a traceability system. A critical function of a traceability system could be to provide consumers with additional information at the point of purchase. In this vein, the type of information that could be made available to consumers in order to increase consumer welfare is a key aspect and an important issue for future research. Indeed, a successful program that peaks consumer interest and can enhance their eating experience can generate economic benefits to all sectors in the beef industry. Moreover, several international food retailers have developed traceability programs in the wake of several food safety crises, to comply with changing legislation and meet consumer demand. There is also no literature available on what consumers are willing to pay for traceability within the food away from home sector. There is a significant lack in the previously reviewed literature about the actual costs of implementing any traceable system. In some cases costs have been established through a hypothetical set of responses to surveys of industry players. In others the costs have been established for comparable systems established to deal with animal disease requirements or COOL legislation for a specific part of the marketing chain – from farm to processor for example. Costs of implementation are very different from costs of maintaining an established system and there are almost no studies that have dealt with this issue. It is impossible to establish what level of public involvement might be appropriate in establishing traceable systems when there is significant uncertainty about what consumers will pay for, in which markets, what international restrictions such as COOL are likely to be imposed and when and significant uncertainty about the possibility of animal disease outbreak. Significant research is required to quantify many of these aspects in the markets for Canadian products, both domestic and international.

A priority must be to establish a rigorous basis for measuring costs that do exist within the industry – perhaps in the context of the existing on-farm food safety protocols and the existing systems from farm to packer in livestock with rigorous measurements for following the system through the marketing chain to retailers and ultimately consumers. Hence, in order for the cattle and beef sector to remain competitive and ensure fair returns to all stakeholders in the supply chain, it is important to quantify the impact of new protocols as well as develop appropriate public policy strategies to meet aforementioned challenges.

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APPENDIX 1. DEFINITION OF TRACEABILITY

Table 1 Definitions of Traceability.

Definition	Source
The ability to follow an item, or a group of items whether animal, plant, food product or ingredient, from one point in the supply chain to another, wither backwards or forwards.	FSQPD of AAFC via Hobbs et al. 2007
A tool that will allow for the rapid identification of sites affected, preventing the spread to other sites and narrow as soon as possible disease or health problems.	Agri-Traçabilité Québec 2007 Traceability 101
Traceability system: the infrastructure required to deliver traceability including hardware, software and organizational infrastructure.	Alberta Agriculture and Food 2007
A tool or concept which may be used to gather information where appropriate, and carry out surveillance, isolation or even destruction of products or animals in the framework of public health (food safety) or animal health measures.	Ammendrup and Barcos 2006
The comprehensive concept of tracking the movement of identifiable products through the marketing chain. Meat traceability is the ability to follow products forward from their source animal through growth and feeding, slaughter, processing, and distribution, to the point of sale or consumption (or backwards: consumer to source animal).	Becker 2007
The ability to identify a unique batch of product and the raw materials used in its production and then follow that batch, through the production and/or distribution process, to the immediate customer.	Bracken and Matthews 2005 (GS1)
The ability to trace and follow food, feed, food-producing animals or substances intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution.	Aubin 2007 (CFIA)
The ability to trace the history, application or location of an entity by means of recorded identification.	Clemens 2003
Traceability (livestock): a way to track animal movements and identify cohorts in case of a disease outbreak or food-related problem and a way to track an animal's lineage to improve herd genetics.	Clemens 2003
A marketing tool to assure Japanese (and other) consumers about the source of meats they purchase.	Clemens 2003
Traceability/product tracing is the ability to follow the movement of food through specified stage(s) of production, processing and distribution	Codex Alimentarius Commission 2006

Definition	Source
A tool that may be applied within a broader food inspection and certification system as part of a risk management option for meeting specific food safety or fair trading practice objectives.	Codex Alimentarius Commission 2004 with FAO and WHO
Traceability (sometimes called identity preservation): the ability to track the inputs used to make food products backward and forward to/from their source at different levels of the marketing chain.	Dickinson, Hobbs and Bailey 2003
Traceability of beef requires a verifiable method to identify bovine animals, carcasses and cuts in all their packaging and transport/storage configurations at any point in the supply chain.	EAN International 2002
The ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution.	European Parliament and the Council of the EU 2002
The efficient and rapid tracking of physical product and traits from and to critical points of origin or destination in the food chain necessary to achieve specific food safety and, or, assurance goals.	Farm Foundation 2004
A record-keeping system designed to track the flow of product or product attributes through the production process or supply chain	Golan *et al.* 2004
A broad term that refers to systems that allow tracking, tracking and credible (transparent) quality verification	Hobbs 2006
The ability to trace the history, application or location of that which is under consideration. May refer to the origin of the materials and parts, the processing history, and the distribution and location of the product after delivery.	International Standards Organization 2000
The ability to maintain credible custody of identification for animals or animal products through various steps within the food chain from the farm to the retailer.	McKean 2001
A system that provides a set of data about the location of food and food ingredients along the supply chain. Data relate to both the "where" and the "when" issues.	Meuwissen *et al.* 2003
The ability to track a product batch and its history through the whole, or part, of a production chain from harvest through transport, storage, processing, distribution and sales (chain traceability); or internally in one of the steps in the chain, for example the production step (internal traceability)	Moe 1998
A tool to reach and keep consumers' confidence and that provides food agents the capacity to track food items efficiently, reducing losses.	Mora *et al.* 2006
The ability to locate an animal, commodity, food product or ingredient and follow its history in the supply chain forward (from source to consumer) or backward (from consumer to source).	OnTrace 2007
A system that is able to identify a product and trace its movement through its processing stages till the final consumer.	Opara and Mazaud 2001

Definition	Source
Individual companies are able to identify both suppliers and customers.	Peterson 2004
The history of a product in terms of the direct properties of that product and/or properties that are associated with that product once these products have been subject to particular value-adding processes using associated production means and in associated environmental conditions.	Regattieri *et al.* 2007
The ability to identify the origin of animals or meat as far back in the production sequence as necessary to ascertain ownership, identify parentage, improve palatability, assure safety and determine compliance in branded or source-verified beef programs	Smith *et al.* 2000
A system that allows for retailers and the supply chain to identify the source of contamination and thereby initiate procedures to remedy the situation and ensure food safety.	Smyth and Phillips 2002
The ability to follow movement of a food through specified stage(s) of processing, production, and distribution	Souza-Monteiro and Caswell 2004
The property of the result of a measurement or the value of a standard whereby it can be related to stated references, usually national or international standards, through an unbroken chain of comparisons all having stated uncertainties.	Standards Council of Canada 2001 CAN-P-43
The ability to document all relevant elements needed to determine the life movement history of an animal.	USDA 2007
The information necessary to describe the production history of a food crop, and any subsequent transformations or processes that the crop might be subject to on its journey from the grower to the consumer's plate.	Wilson and Clarke 1998

APPENDIX 2. LITERATURE SUMMARY

Table 2 Literature Summary.

NO.	AUTHOR	DEFINITION OF TRACEABILITY	CONTEXT	OBJECTIVE	METHODS	AGGREGATE SUMMARY
1	Alberta Agriculture and Food 2007	There are three pillars of traceability: (1) premise identification, (2) animal & product identification, and (3) animal & product movement. A traceability system is the infrastructure required to deliver traceability, including hardware, software, and organizational infrastructure.	Livestock, including poultry	To describe the agriculture and food traceability framework and traceability implementation plan in Alberta's food and agriculture industry. Provide a timeline for implementation.	Based on planning principles and goals in strategic management.	- Traceability is based on three pillars: (1) Premises Identification, (2) Animal & Product Identification, and (3) Animal & Product Movement tracking - Government of Alberta is working with industry to develop the infrastructure for premises identification for all farms by December 2007 - Three goals in strategic management: (1) develop a 3-year strategic plan and yearly operational plans/documents, (2) ensure successful implementation and change, (3) build and sustain high performance in planning, change, and implementation year to year
2	Alfnes and Rickertsen 2003	N/A	Beef	To estimate the consumers' valuation of the use of growth promoters by comparing participants' WTP for US beef produced with and without the use of growth-promoting hormones. To investigate the importance of European versus North American origin by comparing WTP	WTP experiment using Vickrey auctions for rib-eye steak with different attributes: Norwegian, Irish, US hormone-free, and US hormone-treated.	- On average, the bids were highest for the domestic beef, higher for Irish than for US beef, and lowest for US hormone-treated US beef - About 25% of participants bid zero for the US hormone-treated beef - The average participant is willing to pay NOK 2.48 more for Irish, NOK 9.88 more for domestic, and NOK 11.99 less for US hormone-treated beef than for US hormone-free beef - 72% of participants prefer US hormone-free to US hormone-treated beef, 18% are indifferent between these alternatives, and 10% prefer US hormone-treated beef - 11% of participants prefer US hormone-free to Irish beef, 37% are indifferent, and 52% prefer Irish beef

NO.	AUTHOR	DEFINITION OF TRACEABILITY	CONTEXT	OBJECTIVE	METHODS	AGGREGATE SUMMARY
				for Irish and US beef.		- 11% of participants prefer US hormone-free to domestic beef, 22% are indifferent, and 67% prefer domestic beef
3	Ammendrup and Barcos 2006	A tool to help countries meet their objectives of controlling, preventing and eradicating animal diseases.	Livestock	To describe the objectives of a traceability system, the level of depth sought, and the characteristics to consider.	Research of the factors that should be considered when implementing a traceability system; this includes literature reviews on the factors: farms, animal owners, animal stocks, movements, means of transport, documentation, legal framework, and establishments where animals are sold.	- Identification of animals and the establishments where they are kept or processed should be identified for traceability to work - Up-to-date records of disease and other health-related events and maintaining accessible data on laboratory results, movement of animals and their products is also essential - Implementation in the field must consider planning, training, legislation, financing, administration, timetable for implementation - The EU has laid down requirements for the identification and registration of bovine animals, pigs, sheep, and goats - Bovine animals require ear-tags with a country code and numeric code, cattle passports whenever the animal is used, individual information on each holding (ID code, date of birth, sex, breed or coat colour), and computerized national databases
4	Animal Health Australia 2003	N/A	Livestock	To determine the benefits of a national identification and traceability program and engage members and stakeholders in the implementation	Review of the benefits of animal identification and traceability and the actions taken by Animal Health Australia towards a national identification and traceability system.	- Benefits of a national animal health system: (1) improved control of animal disease, (2) improved traceability of animals to aid emergency response, (3) improved laboratory information systems, and (4) increased ability to differentiate animals and their products on animal health grounds - Current traceback processes are reliant on paper-based systems and are

NO.	AUTHOR	DEFINITION OF TRACEABILITY	CONTEXT	OBJECTIVE	METHODS	AGGREGATE SUMMARY
				of effective animal identification and traceability schemes in the interests of the national animal health system.		potentially inefficient in an emergency disease outbreak - Animals identified with individual animal tags whose transfer details have been consistently maintained within a national database could be traced through any number of transfers within seconds
5	Arana et al. 2002	N/A	Beef	To analyze the value of DNA markers in meat traceability, focusing on beef certification of *Ternera de Navarra* (Beef of Navarra) in Spain.	Muscle samples from 70 steers of *Ternera de Navarra* were obtained at the slaughterhouse and stored at -20°C; DNA was extracted from the meat of 33 animals and subjected to PCR reactions. Allele and genotype frequencies were determined using statistical techniques and simulations were carried out to validate the results obtained with the field data.	- The simple solution to assure total traceability would consist of creating a DNA bank for all the animals; a sample would be taken of all animals at the same time as the "passport" animal is identified - The simple solution is expensive, but a way to make DNA traceability affordable for the beef/commercial industry would be to take a biological sample for every carcass and store the DNA; the DNA profile would be done on meat in question - For DNA market methodology it is necessary to use a minimum of eight molecular markers, presenting a high degree of average heterozygosity in the population
	Babbar 1995	The ability to relate individual or nationally accepted systems of measurement through a chain of comparisons.	Manufacturing and technology	To determine whether traceability to the same source ensures statistical equality between high-precision laboratories making measurements on the same set of	Testing of three sets of hypotheses. The first is to test for between-laboratory differences based on measurements over time on a given set of gauge blocks. The second set is to test for between-laboratory differences	- Results show that in most cases primary laboratories, traceable to agencies that set the national standard for measurement in the US differ significantly in their measurements on the same block - These differences resulting calibration problems for secondary users of gauge blocks - Traceability alone does not ensure precision in measurement, let alone the

NO.	AUTHOR	DEFINITION OF TRACEABILITY	CONTEXT	OBJECTIVE	METHODS	AGGREGATE SUMMARY
				gauge blocks or, any tool or instrument used for calibration.	based on measurements across gauge blocks of different size from a given set at specific points in time. The third is a general hypothesis on traceability.	equality of measurement precision among laboratories traceable to the same source - Precision measurement is affected by calibration, the environment, operator, and procedure
6	Bailey 2004	*The ability to trace and follow a food, feed, food-producing animal or substance intended to be or expected to be incorporated into a food or feed, through all stages of production, processing and distribution* (EC 178/2002). *The efficient and rapid tracking of physical product and traits from and to critical points of origin or destination in the food chain necessary to achieve specific food safety and/or assurance goals* (Farm Foundation 2004)	Cattle	To discuss some of the potential reasons for implementing an animal ID system in the United States, specifically for BSE, and some of the possible benefits and costs associated with animal ID systems.	Literature review of the history of animal identification programs in the US and the costs and benefits of cattle identification programs.	- The ability to track animals for animal disease control and eradication was the principal reason for the development of the animal ID plans and programs in the US - The full implementation costs (all species with inter- and intra- state movements tracked) for the US Animal Identification Program (USAIP) were estimated over $500 million for the first six years of the program - Sparks Companies Inc. estimated capital investment to implement a source verification system for cattle would be approximately $140 million, with an annual variable cost of about $108 million - Buhr (2002) estimated the costs of implementing a farm-to-fork traceability system for a single supply chain in Europe to be $10-$12 million - Blasi et al. (2003) estimated the costs of implementing a RFID system in the beef supply chain dependent on size of operation: cow/calf operation $3.99-$24.49 per head, feedlot operation: $2.00-$5.40 per head
7	Bailey and Hayes	Can be used to	Livestock,	To provide	Review of the need	- Efforts to establish traceability began

NO.	AUTHOR	DEFINITION OF TRACEABILITY	CONTEXT	OBJECTIVE	METHODS	AGGREGATE SUMMARY
	2002	establish or affirm the reputations of producers and suppliers by communicating either positive or negative information to consumers.	specifically beef and pork	insight on the emerging issue of traceability and compare the current US traceability status to those in other countries.	for traceability programs, overview of the US red meat market, and a comparison of the structure of other traceability programs.	with the BSE scare in the UK in 1996 - After some other EU food scares, consumers lacked confidence in the safety of food - Denmark has a fully traceable hog plant, Sweden uses scanner information on retail pork packages to allow consumers to research the farm the animal was raised - The US beef and pork industries are becoming increasingly concentrated, however if there were development of niche markets among smaller producers they would become linked with processors
8	Bailey, Robb and Checketts 2005	Tracking methods for animals and meat.	Beef	To discuss the difficulties associated with a farm-to-fork beef traceability system in the U.S. and to determine if consumers are WTP for BSE testing and traceability.	A supermarket survey to determine WTP for traceability and enhanced BSE testing.	- The speed and volume of meat moving through large U.S. packing plants makes farm-to-fork traceability of individual cuts virtually impossible with current technology - Over 80% surveyed preferred traceability and/or guaranteed BSE testing over two-stage tracking, with 56% WTP at least 5% more for a hypothetical traceable/tested steak
9	Barcos 2001	*The ability to reconstruct the history, use or location of an activity, process, product, organization, person, system, or any combination of these, by means of registered identifications* (ISO 1998)	Animal products	To explore the variations in domestic livestock populations worldwide from 1961 to 1998 and to analyze the stages in the food chain where	Historical review of livestock populations and research on the supply chain of animal products.	- There is a rising trend for trade for chickens, pigs, and cattle - Areas where animals or animal products must be traced or tracked are through veterinary services, primary production, transportation, manufacturing, products, and trade - Individual identification techniques must be easy to use and convenient, easy to read, durable, tolerated by

NO.	AUTHOR	DEFINITION OF TRACEABILITY	CONTEXT	OBJECTIVE	METHODS	AGGREGATE SUMMARY
				traceability is applicable.		animals, harmless in food, tamper-proof, and have greater benefits than costs for the person who must bear the costs
10	Becker 2007	The comprehensive concept of tracking the movement of identifiable products through the marketing chain.	Meat	Who should pay the economic costs of a traceability system in the U.S.?	Assumptions and testimonies: (Keith Collins USDA chief economist and Ken Bull VP for Cattle Procurement, Excel Corp.) Model of Canadian cattle ID program (Julie Stitt, CCIA)	- Since the first case of BSE in the U.S. the USDA has committed $85 million for FY2006 to implementing an animal ID program capable of identifying all animals of interest within 48 hours - An animal ID system will incur many costs, estimated $122 million annually, with ID tags accounting for nearly $100 million - In Canada the cattle ID program was developed and implemented for less than C$4 million with a total annual cost of approximately C$1 million
11	Basarab, Milligan, and Thorlakson 1997	N/A	Beef	To establish a feedlot to slaughter information system using Allflex EID ear-tags and reading technology, to determine the traceback success rate of individual animal carcass data to the feedlot or the farm using Allflex EID and reading technology, and to determine the initial failure rate, drop-out rate and	Two trials of steers and heifers being assembled and processed. Trial one was of 832 steers assembled and processed at Lakeside Feeders and Cattleland Feedyards Ltd. Trial two was 3354 steers and heifers assembled and processed at Thorlakson Feedyards. Each animal was individually identified with a plastic visual tag upon entry into the	- In Trial one, complete data were collected on all but eight steers – two died and six became sick; initial failure rate for EID tags was 0.12%, the drop-out rate of EID tags in yearling steers during the 103 to 146 day finishing period was 0.0% whereas the drop-out rate of visual tags for the same period was 0.4%; all EID tags were recovered from the abattoir - The success rate of matching individual animal carcass data to feedlot data was 43.7% for the Allflex electronic information system at Lakeside Packers; the commercial linkage of individual animal pre- and post-slaughter data was unreliable - In Trial two the initial failure rate of EID tags was 0.21%, the drop-out rate of EID tags in yearling cattle 1 to 14

NO.	AUTHOR	DEFINITION OF TRACEABILITY	CONTEXT	OBJECTIVE	METHODS	AGGREGATE SUMMARY
				recovery rate of the Allflex electronic ear button.	feedlot. Feedlot data included visual tag number and EID tag number.	days before slaughter was 0.0% and 0.9% for visual plastic tags; 850 tags were lost at the abattoir, a recovery rate of 74.7% - The overall traceback success rate was 38.9% for individual carcass data to feedlot data and 46.4% for individual carcass data to herd of origin data
12	Bertolini, Bevilacqua, Massini 2006	The documented identification of the operations which lead to the production and sale of a product; also uses both Codex Alimentarius Commission (1999) and EC No 178/2002 definitions.	Food products	To present the application of 'Failure Mode Effect and Criticality Analysis' (FMECA) to the production process in the farming and food industries.	A review of the FMECA approach to product and/or production process traceability and a case study of an internal traceability system for durum wheat pasta production process.	- FMECA is a bottom-up approach that breaks down any system (product and/or production process) into its fundamental components to detect all potential failure modes and their effects - FMECA methodology in the food supply chain enables the critical points of the system to be identified, and allows improvements
13	Blancou 2001	N/A	Animals and animal products	To present a review of the history of traceability as applied to live animals and animal products from antiquity to the 19th Century.	Literature review on the history of animal traceability and identification.	- Historical reasons for animal identification are the ability to find animals in the event of loss or theft, to make economic choices regarding production or sectors of activity, and to enhance the value of livestock - Branding of valuable animals, particularly horses has been done since 356 BC - Identification for control of epizootics has been done since the 18th Century - The earliest evidence of concern over animal products was in the 14th Century
14	Bollen, Riden and Cox 2007	*The ability to track a product or batch and its history through the whole, or part, of a production system*	Fruit	To examine the role of fruit packhouses as a paradigm from which to	Research in an apple packhouse processing approximately 100 bins of locally grown apples per day for	- The packhouse is the major transformer of identifiable units (IUs) in a horticultural system, but has not yet acquired the role of an enabler of information transparency and

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		(Moe 1998)		understand the transformation of identifiable input and output units in agricultural supply systems.	export. Data were collected during production runs and bins were identified using RFID tags attached to the top board of each bin.	traceability - Major influences on the precision of traceability through a packhouse are mixing in the in-feed system to the grader, mixing in the packing system and the splitting of fruit stream to different outlets - Most packhouses have potential to make significant improvements to in-feed mixing
15	Bracken and Matthews 2005	The ability to identify a unique batch of product and the raw materials used in its production and then follow that batch, through the production and/or distribution process, to the immediate customer.	Beef	To demonstrate how to use the EAN.UCC Standards to meet the legislative requirements of EC 1760/2000 and to improve EAN Ireland's (GS1 Ireland) business operations.	The project was to focus from when the animal reaches slaughter to when the beef is retailed to customers. After slaughter each primal is marked with an EAN 128 barcode (contains all traceability information). When pre-packaged meat is prepared at store level, the EAN 128 barcode is scanned to transfer traceability information onto the pre-pack product. Pre-packaged meat is then allocated a unique FoodTrace number which links back to slaughter. Participants included a supermarket group and a food processor	- The FoodTrace system is beneficial to retailers as it provides re-assurance to consumers about the safety and quality of meat - Product recall time is reduced as well as labour costs to initiate a recall - The EAN.UCC system of bar coding and scanning reduces the likelihood of error - Up to 5 hours work per week per store on average has been saved with the introduction of the FoodTrace system - EAN.UCC System provides internationally recognized standards for globally unique identification of food and feed - EAN.UCC System enables fast and accurate exchange of information between all stages of food production, processing, and distribution - Three components of EAN.UCC System: (1) Identification Numbers, (2) Data Carriers, (3) Electronic Messages

NO.	AUTHOR	DEFINITION OF TRACEABILITY	CONTEXT	OBJECTIVE	METHODS	AGGREGATE SUMMARY
					among others.	
16	Brester, Marsh, and Atwood 2004 Distributional impacts of country-of-origin labeling in the US meat industry	N/A	Meat: beef, pork and poultry	To estimate short-run and long-run changes in equilibrium prices and quantities of meat and livestock in the beef, pork, and poultry sectors which would result from implementation of COOL.	The use of an equilibrium displacement model that incorporates estimated COOL costs, accounts for inter-relationships along the marketing chain for each meat sector, and allows for substitutability among meat products at the consumer level.	- Sparks Companies estimate COOL costs: $1.643 billion annual increase in operating costs to the beef industry ($805 million to retail, $500 million to packers, and $198 million to cow/calf) - These increase are a increase in costs relative to the total value of 1.24% at retail, 1.71% at wholesale, 0.50% at fed cattle, and 0.96% at feeder cattle - Sparks also estimates that COOL will generate $713 million additional costs for the pork industry - In the absence of demand increases producer surplus in the beef industry declines $647.8 million; consumer surplus declines by $795.5 million in the beef sector - To be no worse off in the long run an increase in demand in the beef sector must exceed 4.05%
18	Brester, Marsh, and Atwood 2004 Who will bear the costs of country-of-origin labeling?	N/A	Meat and livestock: beef, pork and poultry	To report the estimates of short and long run changes in market prices and quantities of meat and livestock that would result from the implementation of COOL.	Use of an economic model that incorporates estimated COOL costs, allows for substitutability of meat products at the consumer level	- Sparks companies estimate that COOL will result in a $1.653 billion annual increase in operating costs to the beef industry; $805 million to retail sectors, $500 million to packer sectors, $150 million to feedlot sectors, and $198 million to cow/calf sectors - If COOL induced demand increase do not occur then all sectors of beef and pork industries lose producer surplus
19	Buhr 2003 Traceability, trade, and COOL	Three components: (1) management of the physical supply chain, (2) management of the parallel information	Meat and Poultry	To provide case illustrations of the implementation of information	Investigation of six European organizations employing traceability programs	- Electronic information systems greatly improve the potential for identity preservation, management of the supply chain and firm level management

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		system to maintain traceability, and (3) organizational structures to manage and implement the production and information systems.		systems for support of traceability in Europe to be used as guidance for potential US traceability systems.	in meat or poultry. Site visits to farm, processing, and retail facilities. Interviews with key personnel at each stage.	- Traceability will likely lean to more closely coordinated supply chains - Greatest direct benefits appear from improvements in management and production efficiency (even though traceability is often consumer demanded)
20	Buhr 2003 Traceability and Information Technology in the Meat Supply Chain	N/A	Meat and Poultry	To clarify the economic reasons for traceability to provide guidance for US firms considering these systems by describing the implementation of traceability and information systems in the meat and poultry sector of Europe.	Investigation of six European organizations employing traceability programs in meat or poultry. Site visits to farm, processing, and retail facilities. Interviews with key personnel at each stage.	- Branding and product labeling can be used to improve information asymmetry between the final handler and the consumer - Traceability reduces the information asymmetry within the supply chain - The simpler the physical logistic control problem, the controllability, and observability of traits and inputs, the less valuable traceability - Internet-based systems reduce monitoring costs, improve information exchange, improve quality control, and reduce agency costs - Supply chains that have implemented traceability have tightly controlled vertical production systems - Traceability information systems will lead to tighter vertical relationships and more hierarchical governance structures
21	Bulut and Lawrence 2007	*The ability to trace the history, application, or location of an entity by means of recorded identifications* (ISO 9001:2000). Also definitions by Golan, Krissoff, and Kuchler	Meat, specifically beef	To study whether (and if so how) meat plants' traceability levels vary according to product specific, organizational, food safety	Literature review of traceability terms and background of the beef and cattle industry. Development of a survey instrument and hypotheses to	- Identity preservation has *ex ante* perspectives such as price premiums - The purpose of segregation is to ensure food safety - The purpose of traceability is considered to be identification of the source of contamination to help contain and remedy food safety problems; *ex*

NO.	AUTHOR	DEFINITION OF TRACEABILITY	CONTEXT	OBJECTIVE	METHODS	AGGREGATE SUMMARY
		2004, Smyth and Phillips 2002, Mennecke et al. 2006, Dickinson and Bailey 2002, EC 178/2002, and Bailey 2005.		related, and plant specific.	determine meat plants' traceability in Iowa.	*post* perspective - There is live animal and meat traceability in the cattle and beef industry - Traceability is voluntary beyond the record-keeping required by food safety regulation for US meat slaughter and processing plants - The weakest link in the US meat supply chain in terms of traceability is the meat slaughter and processing plants
22	Calder and Marr 1998	Aims of traceability: (1) allow animals to be identified individually and allow recording of birth, sire, dam, veterinary records, etc; (2) record information on all cattle movements; (3) facilitate official Government department inspections on farm; (4) serve as a farm management tool to deal with record keeping.	Beef	To prove that a full traceability system for beef is possible using EID technology and that beef producers are willing to voluntarily provide cattle history, records, and movement.	A summary of how the Scottish Borders TAG Initiative began. Review of the steps producers took, following the BSE crisis in the UK, in order to provide assurance to consumers. Includes a description of trials with electronic identification equipment.	- Participants of the Borders TAG Initiative have borne the on-farm costs themselves - Costs include extra tags for adult cattle and labour to tag cattle and test the equipment - Electronic tagging gives accurate, user friendly identification of cattle - The central database is vital - Participants claim the system provides assurance to customers by providing entire animal history which has may add value to the product - Producers are willing to supply all required information to guarantee the integrity of their product
23	Can-Trace 2006	*The ability to trace the history, application or location of that which is under consideration* (ISO 9000:2000); traceability is composed of two components: tracking[1] and tracing[2].	Beef, pork, produce, and seafood	To provide background information on the Canadian Food Traceability Standard and a quick reference guide on the data attributes needed by each role in	Can-Trace has added enhancements and modifications to version 1.0 of the standard, based on stakeholder change requests submitted over the previous year.	- In a one-up/one-down model, no single supply chain partner holds all the information - The Canadian Food Traceability Data Standard is voluntary, is "whole chain" in application, references data requirements not technology or systems specifications, is based on global standards (GS1 and ISO), and is meant to complement existing systems

NO.	AUTHOR	DEFINITION OF TRACEABILITY	CONTEXT	OBJECTIVE	METHODS	AGGREGATE SUMMARY
				the supply chain and commodity group; define the minimum data that is needed to support a one-up/one-down traceability model.		- In order to track and trace a product through the whole supply chain every raw material harvested from farm or sea and every food product moving from one level to another in the chain must be uniquely identified - Each participant is required to record and archive data at each step in the supply chain - Each stakeholder must pass on information
24	Caporale et al. 2001	*The ability to trace the history, application, or location of an entity by means of recorded identifications* (U.S. Environmental Protection Agency); the ability to document all relevant elements – movements, processes, controls – needed to define an animal/animal product life history.	Animal products	To analyze the differences between traceback and traceability systems and to describe some applications of animal traceback systems and the principal characteristics of an animal identification and registration system.	Literature review of traceability definitions, animal identification systems, traceability of animals and animal products, and the importance of traceability to manage food risks,	- Traceability systems have a broader scope than traceback systems, which have been implemented for the purposes of animal health, surveillance, and for control measures against animal disease - Animal identification and registration is essential for any traceability system for animals and animal products - An integrated production chain control system should be able to identify and document: all materials and ingredients used, production processes, personnel involved, and final products - Large scale electronic identification technologies can facilitate the exchange of data needed for complete traceability
25	Checketts 2006	N/A	Beef	To examine the acceptability of BSE testing within a two-step tracking system where the BSE test is used to bridge the gap	Literature review of BSE in the US. Survey of consumer preferences with regards to BSE testing and beef traceability.	- Steak with enhanced characteristics at the same price, such as traceability and guaranteed BSE-tested is favoured by 86% of respondents over the typical USDA inspected steak - 57% of respondents would pay a 5% premium for a traceable steak, 72% would pay a 5% premium for

NO.	AUTHOR	DEFINITION OF TRACEABILITY	CONTEXT	OBJECTIVE	METHODS	AGGREGATE SUMMARY
				between farm-to-packing plant and packing plant-to-retail traceability.		guaranteed BSE-tested steak, and 76% would pay a 5% premium for steak with both characteristics
26	Clemens 2003	*The ability to trace the history, application, or location of that which is under consideration* (ISO); livestock traceability: a way to track animal movements and identify cohorts in case of a disease outbreak or food-related problem and a way to track an animal's lineage to improve herd genetics.	Meat	To examine the demand for consumer assurance programs and traceability from the perspective of Japanese meat importers, processors, and retailers.	Discusses Japan's history of food safety crises, consumer assurance programs, potential demand for assurance programs for imported products, and the ability of exporters to provide these assurances. Information was largely obtained during meetings with Japanese meat importers, processors, retailers, restaurant operators, government officials, and other Japanese meat supply chain experts.	- In early 2003 the Japanese government proposed the Beef Traceability Law which requires traceability from production through "distribution to consumption" - Japanese supermarkets have taken the role of assuring consumers of food safety and quality - Jusco supermarkets have implemented a consumer assurance system which allows consumers to read and print out an official BSE testing, a production record certificate (traceability), and the consumer can see a photograph of the producer that delivered the animal to the slaughter plant, all in the store, prior to purchase - Japan is implementing full traceability systems only for high-value meats, such as domestic Wagyu beef - Japanese buyers say they would purchase more US beef if they could obtain it at lower prices; US beef exporters are not likely to recoup costs of traceability
27	Clemens and Babcock 2002	N/A	Beef	To determine the additional costs of producing beef for the EU market; where producers are marketing their non-treated cattle	USDA guidelines, interview with producers	- The additional costs of producing and exporting non-hormone treated beef to the EU market prohibit all but a small volume of trade - Producers of certified non-treated beef have been forced to find other markets for their beef - The costs of the NHTC program

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				and beef; and if they are receiving adequate premium to cover additional costs.		require that producers obtain a larger premium for their non-hormone treated beef than do non-certified producers, all else being equal
28	Cox, Chicksand and Yang 2007	N/A	Beef	To show that a proactive sourcing strategy can be just as important as a proactive marketing strategy in achieving sustainable competitive advantage.	Reports on research carried out in the UK beef industry. Use of multi-case, multi-site approach. Interviews with participants at each stage of the supply chain.	- Current supply chain theories rarely consider security of primary material supply as a major risk to a firm's marketing activities and overall competitive strategy - Dispersed primary beef production requires a long fabrication time and complex disassembling and reassembling processing - Structural changes within the UK beef industry have reduced the long-term sustainability of high quality beef farming businesses, exposing these businesses to risk in the future - Brand ownership and contracts create property rights for their owner, which creates a relatively permanent power resource in market struggle with customers and competitors
29	Dalvit, De Marchi and Cassandro 2007	The ability to maintain the identification of animal or animal products, all along the production chain; also McKean (2001), EC 178/2002, and ISO 8402 (1994) definitions.	Livestock products	To provide a review of the major advances made in individual, breed, and species genetic identification in the past years, focusing on advantages and disadvantages and on their real	Literature review on definitions of traceability, European legislation on traceability, conventional and geographical traceability, and genetic traceability.	- Traceability of livestock products in an essential tool to safeguard public and animal health and provide consumers with product assurance - Traceability based only on batch codes or paper documents can be easy to counterfeit - Genetic traceability uses DNA to determine identification – to an individual animal, breed, or species - DNA based techniques are costly, but would be affordable when used for verification purposes on particular

NO.	AUTHOR	DEFINITION OF TRACEABILITY	CONTEXT	OBJECTIVE	METHODS	AGGREGATE SUMMARY
				future applications for animal productions.		occasions.
30	Davies 2004	*The ability to follow the movement of food through specified stage(s) of production, processing and distribution* (EC 178/2002)	Food	To follow the progression of traceability systems in Europe and determine problems with current systems.	Using industry information and the results of an ID Track survey.	- Most food manufacturers are reluctant to invest in traceability unless they can see some profit from it - In the food industry profit is concentrated and producers get a relatively small profit, however, they will likely pay the most
31	de Jonge et al. 2008	N/A	Food	To examine the generalizability of the research framework on consumer confidence in food can be applied to an international context.	Comparison of consumer confidence in the safety of food in the Netherland to Canada; a cross-sectional survey was conducted in the two countries by a professional market research agency. Data was analyzed using structural equation modeling.	- Canadian consumers seemed less confident about the safety of food in general when compared to Dutch consumers; Canadians seemed concerned about production and health related issues - Trust in farmers was significantly higher in Canada when compared to the Netherlands, as was perceived competence of the government and retailers - In Canada beef issues were recalled more often, while poultry issues were recalled more often in the Netherlands; this resulted in BSE issues being more salient in Canada and AI issues being more salient in the Netherlands
32	Dessureault 2006	*The ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of*	Dairy	To understand how variables related to regulations, recall improvement, market response and supply chain improvement	The use of sampling adequacy measures, statistical tests and econometric models. Statistical inference to confirm or reject the hypotheses stated for the variable of the	- Market access motivation (to meet customer requirements) was only the 8th most important reason to implement traceability while supply chain-based motivation (improve inventory management) is ranked 12th - Overall, dairy processors perceive the potential impacts of traceability

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		production, processing an distribution (Food Standards Agency 2004)		impact the perceived net benefits of traceability.	ordered probit model. Postal survey to collect the primary data.	positively; only production costs has a negative mean score - Most of the variables do not significantly impact positive net benefits (PNB) - The implementation of HACCP while traceability is performed is a firm characteristic that has a positive relationship with PNB, however this relationship is not statistically significant - The implementation of traceability to access new markets increases the probability of perceiving benefits equal to costs by 27.4% ($p<0.1$) - Dairy processing plants that have adopted traceability to access new markets are 26.0% less likely to perceive that the benefits from traceability are much greater than the costs ($p<0.1$) - Dairy processing plants that have adopted traceability to obtain a higher price for products increases the probability of perceiving that benefits are much greater than costs by 29.1% ($p<0.1$) - Plants that have implemented traceability for supply chain purposes are more likely to perceive that benefits are much greater than costs; however, the perceived supply chain benefits have a positive by non-significant relationship with the PNB
33	Dickinson and Bailey 2005	N/A	Meat	To determine willingness to pay for red meat	Willingness-to-pay (WTP) experiments of 11-14 participants;	- Among individual characteristics traceability alone was significantly less valued than either food safety or

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				traceability and traceability-provided characteristics for ham and beef in the US and major competitor markets (Canada, UK, and Japan)	sandwiches with ham were auctioned according to their characteristics.	animal assurances in the US and Canada; there were no significant differences in average bids in the UK and Japan - At the time of the experiment only the UK and Japan had experienced verified incidences of BSE - The WTP for the combined attributes (animal welfare, meat safety, traceability) is the highest; there may be diminishing marginal utility for traceability and other extrinsic meat characteristics that can be provided by traceable systems - 9% to 48% of participants were not WTP any positive amount for traceability alone - Suggested cost of approximately $0.04/lb of beef at the retail level for traceability
34	Dickinson and Bailey 2003 **abstract only*	Traceable product systems provide a tool to track the inputs of a final good throughout the entire production chain; this increases information to consumers, speeds product recall, and helps identify inefficiency in the product chain.	Meat	To determine the willingness to pay for traceability and related product characteristics.	Comparable auctions of red meat products in the U.S., Canada, and the U.K., and Japan	- Subjects are willing to pay a nontrivial premium for traceability, but the same subjects show even higher WTP for traceability-provided characteristics like additional meat safety and humane animal treatment guarantees - Producers can implement a traceable meat system profitably by matching verifiable characteristics to consumer preferences
35	Dickinson and Bailey 2002	The ability to track the inputs used to make food products backward to their source at different	Meat	To present initial evidence on US consumers' WTP for traceability, transparency, and	Controlled laboratory experiments where consumers bid in a demand-revealing auction on meat	- The average subject is WTP nontrivial amounts of money to upgrade the meat in a sandwich of approximately a $3.00 value - Average WTP to upgrade the roast

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		levels of the marketing chain.		other assurances (TTA) characteristics in beef and pork	sandwich upgrades. Participants were given a free lunch and $15; they could then place auction bids to upgrade their sandwich to one with different meat attributes.	beef sandwich is $0.23 for basic traceability, $0.50 for assurances on animal treatment, $0.63 for extra assurances of food safety, and $1.06 for all three upgrades; for pork the same respective upgrades were valued on average at $0.50, $0.53, $0.59, and $1.14 - Bids for beef traceability are statistically lower than bids for both animal treatment assurances and for increased food safety - The average bid for all upgrades is less than the sum of individual upgrades, suggesting a decreasing marginal WTP
36	Dickinson, Hobbs and Bailey 2003	The ability to track the inputs used to produce food products backward and forward to /from their source at different levels of the marketing chain.	Meat	To examine consumer WTP in Canada and the US for traceability, transparency, and other assurances (TTA) characteristics in red-meat products.	Laboratory auction experiments were conducted for ham and beef at Utah State University and the University of Saskatchewan. Subjects were given a free lunch and $15 ($20 in Canada) at the beginning of the experiment; they were then allowed to bid on what they were WTP to upgrade their existing sandwich for a sandwich with additional attributes.	- Average US bids to upgrade from the beef baseline sandwich were US $0.48 for humane animal treatment assurance, $0.60 for food safety assurance, $0.21 for traceability, and $1.05 for all three combined; for ham the average bids, respective to above, were US $0.60, $0.69, $0.54, and $1.29 - Average Canadian bids to upgrade from the beef baseline sandwich were CND $0.95 for humane animal treatment assurance, $0.90 for food safety assurance, $0.45 for traceability, and $1.85 for all three combined; for ham the average bids, respective to above, were CND $0.65, $0.65, $0.35, and $1.05 - Traceability was the least valued characteristic, suggesting it should be bundled with other characteristics that can be verified with traceability

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37	Disney et al. 2001	N/A	Beef and swine	To provide a conceptual benefit-cost framework for evaluating the economic usefulness of improved animal identification systems designed to reduce the consequences of foreign animal disease	A study of animal identification in Belgium (swine) and the United States (cattle and swine). An animal identification and traceback survey involving nineteen Federal animal health managers to acquire basic inputs for the illustrative benefit-cost analysis.	- For cattle, in the U.S.A., improved levels of animal identification may provide sufficient economic benefits in terms of reduced consequences of foreign animal disease to justify improvements - For swine, the economic benefits of reduced FAD consequences are not sufficient to justify improvements - When ID is not present in cattle it may take 1 to 13 days to track the animal back to the last farm ownership with a 49% to 100% probability of it being the correct farm - $48 million difference in costs for tracing cattle or steer with a paper trail only compared with an ear tag and paper; $120 million for swine
38	Fallon 2001	N/A	Poultry and poultry products	To describe the industrial poultry production responsible for the majority of poultry meat, table eggs, and poultry traded as livestock or meat.	Review of industry information (exports, breeding companies), legal requirements for traceability in the EU, and the reasons for tracing poultry and poultry products.	- Since each flock/batch of birds has similar status and the existing systems are well developed, individual bird identification does not appear to offer any advantages - The identity of eggs from a farm can be maintained by inkjet identification codes on each shell - Commercial stock farmers are paid on the basis of the number, weight and grade of the birds after processing; identification must be maintained in the processing establishment at least until birds are weighed and graded
39	Farm Foundation 2004	The efficient and rapid tracking of physical product and traits from and to critical points of origin or destination in	Food in general, more specifically animal products and	To define the forces motivating the adoption of traceability and assurance	Literature review and Farm Foundation Traceability and Assurance Panel member reviews.	- Traceability and assurance supply chains are not “one size fits all”; there will be different costs and benefits - Resistance to mandatory traceability systems are from producers’

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		the food chain necessary to achieve specific food safety and/or assurance goals.	grains	protocols and to explore the implications for the various sectors of the United States food system.		uncertainty regarding the costs and benefits they will incur - Government involvement in the costs of traceability is based on the argument that traceability is a public good - There is a reallocation of risk and liability (to producers) in systems using traceability and assurance protocols
40	Fearne 1998	N/A	Beef	To describe the evolution of supply chain partnerships in the British beef industry, driven by changing consumer demand, food safety legislation, a concentrated and competitive retail sector and the BSE crisis. To illustrate why partnership schemes have developed from breeders to retail.	A case study of the UK beef industry. Information was collected from survey of more than 2,000 farmers and semi-structured interviews with some of the country's largest beef processors and meat buyers from the major supermarkets, over a period of six months (August 1997 to February 1998)	- The UK has the lowest per capita consumption of beef in northern Europe - Increased competition among food retailers resulting in increased vertical coordination of the supply chain - Over two thirds of beef producers feel that quality assurance is important - Tracesafe is a farmer owned traceability and quality assurance scheme which targets consumers willing to pay a premium for these attributes - Marks and Spencers sell only Scotbeef, J. Sainsbury sells beef by Anglo Beef Producers, Tesco's Producer Group is able to trace all the beef they sell, and Asda's Beef Bond helps develop regional identity
41	Fearne and Hughes 2000	N/A	Produce	To present recent evidence of supply chain developments in the UK fresh produce industry.	Structured interviews with managing directors of some of the UK's most successful fresh produce suppliers – importers (fruit) and pre-packers – to	- The implementation of efficient consumer response (ECR) and category management (CM) programs by major retailers has resulted in the examination, by retailers, of their suppliers; this helped retailers identify the level of commitment from their fresh produce suppliers

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					establish how they perceive the relationship between suppliers and retailers and to identify some examples of best practice in the industry.	- Key elements that distinguish successful companies from the rest are: strategic orientation, organizational structure and business culture, ability to exploit market information, and ability to innovate - The tensions that exist in the UK's fresh produce industry stem from a fragmented supply base with excess capacity and oversupply of raw material, given the static demand for traditional fresh fruits and vegetables
42	Folinas, Ianikas and Manos 2006	*The ability to trace the history, application or location of an entity by means of recorded information* (ISO 8402:1994). *The ability to trace and follow a food, feed, food producing animal or substance through all stages of production and distribution* (EC 178/2002)	Food	To identify the needs in data that are considered fundamental for efficient food traceability and to introduce a generic framework (architecture) of traceability data management that will act as a guideline for all entities/food business operators involved.	Review of the main developments in the food sector and EU legal requirements regarding traceability systems; data related to the effectiveness and efficiency of food supply chains traceability schemes are identified and categorized. The use of a four-step data management framework is introduced aimed at improving traceability through the internet.	- There are two types of traceability: logistics traceability follows only the physical movement of the product and treats food as a commodity and qualitative traceability associates additional information relating to product quality and consumer safety - One of the major weaknesses of the agricultural industry is the information gap that exists among entities in the agri-business supply chains, originated by unwillingness to share information or by inability to do so (lack of appropriate technology) - An integrated traceability system must be able to file and communicate information regarding product quality and origin, and consumer safety; required features are: adequate "filtering" of information, information extracting from databases that exist for supporting food quality and safety standards, harmonization with international codification standards EAN-UCC, and harmonization with

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						internet standards and up to date technologies
43	Food Standards Agency 2002	*The ability to trace and follow a food, feed, food-producing animal or substance … through all stages of production, processing and distribution* (EU General Food Law Regulation); *the ability to trace the history, application or location of an entity by means of recorded information* (ISO 8402: 1994)	Food	To have an overview of traceability in order to come to a view with regard to the role of traceability systems both in connection with food safety and also to protect other interests of consumers in relation to food.	The FSA collected information from industry stakeholders and other traceability organizations in Europe on legislation, characteristics, and consumer interests.	- Consumers gain mostly hidden benefits from traceability - The most complete mandatory traceability system enables beef on sale within the EU to be traced back to the county of birth - The basic characteristics of traceability systems are: identification of units/batches of all ingredients and products, information on when and where they are moved or transformed, and a system linking these data - IT traceability systems are more efficient, effective, and secure than paper-based - The cost of implementation of traceability systems is likely to vary largely between business and sectors depending on the type of technology adopted
44	Frohberg, Grote and Winter 2006	*The ability to trace and follow a food, feed, food-producing animal or substance intended to be or expected to be incorporated into a food or feed, through all stages of production, processing and distribution* (EC 178/2002)	Food, specifically fishery products and fresh vegetables	To determine the effects of increasing food safety standards, regulations related to traceability, product certification, environmental standards and other regulations have on developing countries.	Literature review: define and classify different kinds of existing standards and regulations in the food sector, analyze the international framework which influences the national standard-setting process, and case studies of several countries in the field of fishery products and fresh	- Generally, standards have a stronger impact on the fishery sector than on the horticultural sector, sometimes resulting in import bans from developing countries - Authorities and enterprises in some countries act pro-actively while others wait until the standards become official law in their country before complying; there is competitive advantage to the pro-active behaviour (Tanzania vs. Kenya in Nile Perch exports) - There are often distributional aspects of compliance costs where small

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					vegetables from African countries.	suppliers may face substantial costs they cannot afford - Public and private management and governance problems lead to poor compliance of countries
45	Gardner Pinfold Consulting Economists 2007	Traceability systems are record keeping systems that are primarily used to help keep information related to products with different attributes separate from one another	Cattle, sheep, hogs	To provide the Food Safety and Quality Policy Directorate (FSQPD) with a detailed and expert analysis of the costs of traceability.	Literature review on traceability systems in Canada and globally. Consultation with producers, feedlot owners, slaughterhouses, auction barns, transportation companies, and government agencies that are implementing traceability systems in Canada or in the process. Analyses of identified costs from the literature review and interview a sample of producers and operators.	- Categories of cost: facilities modification, RFID equipment (including RFID tags, tag applicators, RFID readers), data accumulation, transfer, and storage equipment, labour (including livestock tagging, tag reading and data transfer), program administrative costs, animal movement costs - Estimated costs of traceability to cattle operators: $5.68 per head per year to $10.35 per head per year - Estimated start-up costs for beef operators: $3,388 to $6,522 - Estimated annual national cost of traceability of producers of beef: $85,557,840 to $155,902,050 (for 15,063,000 head) - National annual costs to auction barn, feedlot, and slaughterhouse operators were also estimated
46	Gellynyck et al. 2004?	The information necessary to describe the production history of a food crop and any subsequent transformation or process the crop might undergo on its journey from the grower to the consumer's plate (Wilson and Clarke	Meat	To explore differences in general food safety and traceability costs and to assess consumer segments related to meat quality perception and their possible	Literature review of traceability in food chains; qualitative and exploratory research to identify costs, with interviews of 17 food companies in Belgium and a survey of 170 meat consumers in Belgium.	- Smaller, traditional shops are more concerned with quality in general - Food safety is more important to sectors such as dairy, meat or fish as they have higher food safety risks - Compared to 2001, there is a clear increase in overall meat quality perception - The perceived need for a traceability system remains the highest in the case of meat mixtures compared with 2001

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		1998). Companies must be able to identify the suppliers of its raw materials and the customer of its end products on a transaction basis.		interest in functional and process attributes associated with traceability systems as well as the evolution compared to 2001.		- Individuals who consume meat the least frequently regarded the introduction of traceability in the meat chain as the most urgent
47	Giraud and Halawany 2006	France, Germany, Hungary, Italy, Malta, Slovenia and Spain: the origin or provenance of the product, the ingredients (processing), food scares and control. Greece, Lithuania, Norway, Poland and the Netherlands: the ability to trace; participants did not always link the term to food (Norway).	Food	To get a deeper understanding of the role of the "ability-to-trace" in consumer decision-making process with respect to food; to measure consumers' acceptability for food traceability; to check the differences of these matters across twelve European countries in order to highlight any specificity.	A survey in 2005 on consumers' perception of food traceability by means of discussions of focus groups involving twelve European countries. Three different topics were discussed: food purchase and relevant information displayed on food labeling, food traceability with honey and beef meat as concrete applications, and actual traceability systems as well as future systems.	- European consumers are still not ready to accept sophisticated systems and supports of traceability; they need to be informed more in be more in touch with the markets - In Greece and Malta, participants asked for more strict regulation to help develop traceability and prevent frauds - In France and Italy participants prefer to use traditional and already known systems; trust of farmers and shopkeepers - In almost all countries participants were not likely to express a positive WTP for traced products - Participants in southern European countries (France, Italy, Malta, Slovenia and Spain) were more aware of the term 'traceability' when compared to northern countries - In France, Italy, Malta, Spain, Hungary, and Norway consumers relate the utility of traceability to the concept of safety, while in Greece and Lithuania it is related to quality and in Poland it is related to control and withdrawal of infected batches of food
48	Golan et al. 2004	Traceability systems	Fresh	To provide a	Research into the	- US traceability systems are motivated

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		are a tool to help firms manage the flow of inputs and products to improve efficiency, product differentiation, food safety, and product quality.	produce, grains and oilseeds, cattle and beef	framework to determine whether the private sector provides enough traceability to meet social objectives, and if not, what policy tools would be best targeted to increasing the supply of traceability.	market studies literature, interviews with industry experts, and on-site interviews with owners, plant supervisors, and/or quality control managers in fruit and vegetable packing and processing plants; beef slaughter plants; grain elevators, mills and food manufacturing plants; and food distribution centers.	by economic incentives; benefits include lower-cost distribution systems, reduced recall expenses, and expanded sales of high-value products - Traceability alone is not beneficial, but it can verify credence attributes and link to food safety systems - Producers in the meat sector have developed traceability systems to improve product flow and limit quality and safety failures - Alliances, associations, cooperatives, and marketing groups of the cattle/beef industry help establish and enforce quality and safety standards - When the cost of distributing unsafe food increases (e.g. fines, plant closures) so do the benefits of traceability systems
49	Golan et al. 2003 Traceability for food safety and quality assurance: Mandatory systems miss the mark	Record-keeping systems that are primarily used to help keep foods with different attributes separate from one another.	Food	To determine if or when mandatory traceability is a useful and appropriate policy choice.	Discussion of market failure due to inadequate supply of traceability, attribute-specific traceability and consumer choice, and the inefficiency of mandatory traceability as a policy option	- If costs and benefits at the margin included in private firms' calculations are the same as social costs and benefits, the market supply of traceability will be optimal: the social net benefits of traceability systems will be maximized - When consumers cannot discern the true value of a product producers have an incentive to provide lower-quality, higher-risk foods - Mandatory traceability systems may be necessary to encourage the development of differentiated markets and protect consumers from fraud and producers from unfair competition, but may not be the most efficient policy for all foods

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						- Mandatory systems that allow only one template fail to allow for variation across systems and are likely to impose costs that are not justified by efficiency gains
50	Golan et al. 2003 Traceability in the US food supply: Dead end or superhighway?	N/A	Food	To discuss the motives US firms have for establishing traceability systems, even through the US does not mandate system-wide traceability.	Review of why firms have traceability, how costs and benefits are balanced in private traceability systems, and how firms are building a traceability superhighway.	- Food suppliers have three motives for establishing product tracing systems: (1) to improve supply-side management, (2) to differentiate and market foods with subtle or undetectable quality attributes, and (3) to facilitate traceback for food safety and quality - Breadth is the amount of information in the traceability system records and given the huge number of attributes that could describe a food product, full traceability is an unreachable goal - The depth of a traceability system is how far back or forward the system tracks; most businesses have one-forward, one-back traceability which is monitored electronically for larger firms - Precision is the degree of assurance that the tracing system can pinpoint a certain product's movement; usually involves an acceptable error rate - Firms balance traceability costs and benefits such that private systems reflect technological limits and consumer preference; mandatory traceability may be a policy option when private systems do not reach the social optimum
51	Golan et al. 2000	N/A	Meat and poultry	To provide information on	Conducted a Social Accounting Matrix	- Every dollar of income saved by preventing premature deaths from

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				the market mechanisms through which costs and benefits of the HACCP program affect the economy (through reductions in foodborne illnesses).	(SAM) model to extend the sector-specific cost-benefit analysis of the HACCP program to account for the economy wide impact of the program on both producers and consumers.	foodborne illness resulted in an economy-wide income gain of $1.92 - Every dollar saved through reduced foodborne illnesses resulted in an economy-wide income *loss* of $0.27 (household pay medical expenses) to $0.32 (public/private medical insurance) - Every dollar spent on HACCP implementation resulted in an economy-wide loss of $0.35 (increased costs of beef and poultry production due to HACCP were passed on to the consumer)
52	Golan, Krissoff, and Kuchler 2005	*The ability to trace the history, application or location of that which is under consideration* (ISO).	Food in general.	To examine the US food traceability systems.	Research of market studies literature, interviews with industry experts and site visits to interview supply participants.	- Traceability systems can be defined in terms of breadth (amount of information collected), depth (how far back/forward the system tracks information), and precision (the degree of assurance the traceability system provides) - Firms have three primary objectives in using traceability systems: (1) improve supply management, (2) facilitate traceback for food safety and quality, and (3) differentiate and market foods with subtle or undetectable quality attributes
53	Golan, Krissoff and Kuchler 2002	Record-keeping systems that are used primarily to help keep foods with different attributes separate from one another.	Food	To determine the public and private motives for traceability in food marketing and determine which is potentially more efficient.	Discussion of private and public motivations for traceability and the benefits and costs of mandatory traceability systems.	- Private sector food suppliers have three motives for establishing traceability systems: (1) to differentiate and market foods with subtle or undetectable quality attributes, (2) to facilitate traceback for food safety and quality, and (3) to improve supply-side management - Credence attributes can be content

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						attributes that affect the actual physical properties of a product, or process attributes which refer to the characteristics of the production process - A government may have three reasons for considering mandatory traceability systems: (1) to facilitate and monitor traceback to enhance food safety, (2) to address consumer information about food safety and quality, and (3) to protect consumers from fraud and producers from unfair competition - Mandatory traceability for all foods is unlikely to be the most efficient mechanism for verifying quality and credence attributes
54	Goldsmith 2004	Markets that allow a buyer to identify an input's journey through the supply chain.	Food	To discuss why and how commodities are often preferred by end users and thereby are a signal of a properly performing economy, not a market "failure."	Semi-structured interviews with senior executives of ten American and Mexican food firms.	- Six specific factors affect the use and development of identity preservation systems: biotechnology, precision agriculture, measurement technology, food safety, competition, and the role of nontraditional players - The US struggles to develop food markets that pay significant premiums where identity is preserved - For commodity transactions the identity of the supplier is not important and differentiation is a cost not a benefit - Higher valued products are often bundled within private quality systems while lower valued goods are often bundled within the public quality system - While more vertical information in the agri-food supply chain is seemingly better, no entity, from first handler to final customer seems willing to pay the

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						price
55	Gracia and Zeballos 2005		Beef	To analyze consumer and retailer attitudes toward a mandatory traceability and labeling system in the beef supply chain in the EU.	Two surveys of consumers and retailers of beef, in Spain in 2002.	- Consumer responses were broken into three segments regarding the mandatory traceability and labeling system in the EU: (1) enforced but costly requirement, (2) beneficial requirement, and (3) Unnecessary requirement - Consumers from (1) had the highest beef consumption level and are more concerned about food and healthy diets; consumers from (2) are least likely to be interested in traceability and labeling and show the lowest confidence in beef safety; consumers from (3) (over 50% of consumers) perceived that traceability will have some benefits and some large costs - 34.7% of retailers perceived that traceability does not provide benefits or is an unnecessary requirement; these were typically small businesses, but included many beef retailers - 65% of retailers perceived traceability as being beneficial for the beef sector; these were typically larger business owners
56	GS1 2006	*The ability to trace the history, application or location of that which is under consideration* (ISO 9001:2000)	Rasting: Beef Westfleisch: Beef , pork, poultry	To present the traceability implementation case study of Rasting Westfleisch in Germany.	A review of the processes used by two German meat companies which have implemented GS1's traceability system.	- Rasting produces over 60,000 tonnes of meat products per year; Westfleisch produces over 600,000 tonnes of meat per year - Live animals come with an eartag and passport; once slaughtered and quartered or halved, each piece of meat is identified with a GS1-128 label; a new set of labels is created during each stage of cutting, processing, and packaging

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						- It took Rasting 36 hours to recall products during the dioxin crisis in 1999 - Westfleisch uses a multi-level batch system and can recall products within minutes
57	Hagdrup 2004	Meat can be traced backwards or forwards from/to individual animal, herd, abattoir/cutting plant, or country of origin, in the marketing chain.	Meat (beef and pork)	To determine the methods of traceability throughout the marketing chains for beef and pork.	A review of the methods used by companies and the EU legislation to ensure traceability.	- When cattle are supplied to the Abattoir they must have two ear tags, all information on the animal must be updated in the central database, each animal is issued an animal passport - Data on the live animal will be transferred to the carcass at the slaughterhouse - Traceability of meat and meat products becomes increasingly difficult with divergence of production, many manual processes, and transfers of the product - Retail beef for EU countries must be labeled with reference numbers linking the animal to all previous steps and locations in the supply chain
58	Hahn and Green 2000	N/A	Meat	To determine whether or not margins for one meat affect margins for others and whether fixed proportions or variable proportions are valid in the transformation of wholesale meat into retail meat.	Development of a dynamic econometric model of whole-sale-retail price interactions for beef, pork, and chicken using monthly USDA data. Literature review of econometric price transmissions studies and applied studies of consumer demand for food.	- Meat retailing appears to be a joint cost activity - Meat retailing technology appears to require fixed proportions between meat input and meat output
59	Hanselka 2003	N/A	Beef	To provide a full	Telephone interviews	- Total weighted average costs of COOL

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				beef industry cost assessment for implementing COOL regulations; to use the weighted average cost estimates calculated to determine the magnitude of increases in demand for retail beef, wholesale beef, fed cattle and feeder cattle needed to negate the increased cost of COOL implementation.	and mailed surveys were sent to US cattle back grounders/ stockers, cattle feeders, meat packers/processors, and retail distributors and stores to determine costs estimates of COOL. A weighted average cost estimate was calculated and used to determine demand changes. Changes in producer and consumer surplus were also calculated to determine overall social welfare.	for retail chain stores and distributors $0.0833 per pound of beef sold; given the amount of beef sold by the retail sector, this results in a $818 million cost to the retail industry in 2003 - Total weighted average costs of COOL for meat packer and processors is $16.99 per head of cattle slaughtered or processed; total cost of COOL to this industry was $603 million in 2003 - Total weighted average costs of COOL for cattle feeders is $12.95 per head of cattle fed; total cost of COOL to this industry was $356.9 million in 2003 - Total weighted average costs of COOL for cattle backgrounders and stockers is $3.90 per head; total cost of COOL to this industry was $97.1 million in 2003 - Consumer demand must increase by 1.15% at the retail level for the producer to be no worse off
60	Hobbs 1996 A transaction cost analysis of quality, traceability and animal welfare issues in UK beef retailing	To be able to follow the animal back to the farm of origin.	Beef	To investigate the hypothesis that a retailer's choice of beef supplier is influenced by the transaction costs incurred in different supply relationships and to measure the importance of transaction costs in assuring quality consistency,	Interview of supermarket retailing and meat processing industry representatives to choose four attributes (origin assurance, traceability, consistent quality, and price). Postal survey of individuals using a simple additive model and the use of conjoint analysis to measure	- Long term stable relationships between retailers and processors would reduce the transaction costs incurred by the retailer - Traceability of cattle to the farm of origin was second in importance - Since the 1990 Food Safety Act retailers have incurred higher monitoring costs to ensure traceable products; however formal vertical coordination lower monitoring costs - Monitoring costs from auction markets may be too high to be feasible - Strategic alliance partnerships between the farm group, the processors and the

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				traceability, and farm animal welfare.	the relative importance of selected transaction costs in the beef purchasing decisions of retailers.	retailers would improve the two-way flow of information and ensure retailers receive a supply of beef with desired quality and animal welfare characteristics - Initial transaction costs of establishing a strategic supply relationship could be high, but in the long run information and monitoring costs would be reduced
61	Hobbs 2003 Consumer demand for traceability	There are three main functions of traceability: (1) facilitate the traceback of products or animals in the event of a food safety problem, (2) enhance the effectiveness of Tort Liability law as an incentive for firms to produce safe food, and (3) pre-purchase quality verification to reduce information costs for consumers through labeling the presence of credence attributes.	Meat and livestock	To provide a preliminary analysis of traceability systems and the potential value placed on traceability information vs. specific quality assurances by Canadian consumers.	Experimental auctions to collect bids on meat characteristics involving consumers in western and eastern Canada.	- Traceability, by itself, may not deliver much value to most consumers - Quality assurances with respect to specific credence attributes, with traceability, have more appeal - *Ex post* reactive traceability systems may limit the costs from a food safety problem and maintain consumer confidence in the industry, but do little to reduce consumer information asymmetry - Mandatory retail labeling of traceability and product origin information will likely impose significant costs on the industry, lead to international trade tensions, all without obvious direct consumer benefits
62	Hobbs 2003 Traceability in meat supply chains	Part of a strategy to reduce the risk or minimize the impact of a food borne disease problem and part of a larger quality assurance strategy, facilitating the verification of specific	Meat and livestock	To examine the economic incentives for implementing traceability systems in the meat and livestock sector. To evaluate	Experimental auctions of beef and ham sandwiches in Saskatoon, SK and Guelph, ON in 2002.	- For both beef and ham traceability to the farm of origin without additional quality assurances elicited the lowest average willingness to pay - Quality verification with respect to credence attributes such as an additional food safety assurance or an animal welfare assurance elicited higher bids

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		quality attributes.		Canadian consumers' willingness to pay for traceability, food safety and on-farm production information for beef and ham products.		- Traceability with positive quality assurances yielded the highest bids - A decreasing marginal willingness to pay for the attributes; the average bid for the "all inclusive" sandwich was less than the sum of the bids for individual attributes - A federal government agency was found to be the most trusted source to provide information on assurances and traceability
63	Hobbs 2004	Can refer to simple traceback systems but can also be applied to programs that provide identity preservation and quality assurances throughout the supply chain.	Meat	To examine the economic incentives for implementing traceability systems in the Canadian meat and livestock sector.	Review of voluntary private and public sector traceability programs. Experimental auctions to assess the willingness to pay of Canadian consumers for traceability assurance, food safety assurance and on-farm production method assurance for beef and ham.	- Respondents of the experimental auctions were willing to pay non-trivial amounts for traceability assurance - When traceability is combined with additional assurances there was more value to the consumers than traceability alone - Willingness to pay for traceability and quality assurance were higher for beef ($0.83) than for pork ($0.28)
64	Hobbs 2004	A system that allows the traceback of products or animals through the supply chain.	Food, specifically beef	To explore the role of food traceability systems in resolving information asymmetry.	The author provides a model of the traceability system, distinguishing between ex post and ex ante verification systems; an overview of the private and public traceability initiatives in Canada and the EU.	- Ex post traceability arises to reduce the costs and market externality impacts of a food safety problem and reduce the costs and market externality impacts of a food safety problem and to strengthen liability incentives - The CCA formed the CCIA, which introduced mandatory identification of all Canadian cattle and bison since July 2002 as a risk-reduction strategy necessary to maintain consumer confidence and protect market share

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						domestically and internationally
65	Hobbs 2006	Refers to systems that allow tracking, tracking and credible (transparent) quality verification. Also includes definitions from: ISO 9000:2000; Smith et al 2005.	Food	To provide a review of recent literature dealing with the economic and supply chain management implications of traceability.	Literature review of the definitions, scope and functions of traceability systems. Keywords included: traceability; food; quality assurance; consumers; producers.	- There are 3 dimensions of private sector traceability systems: breadth, depth, precision - Traceability systems improve supply-side cost management and demand-side product differentiation, and also reduce the social costs of food safety problems (public sector goals) - Some benefits to adopting traceability include more efficient management of supply chain relationships and logistics, limiting the scope and costs of product recalls, facilitating product differentiation in response to consumer demand for credence attributes - Some costs of traceability include implementation costs (identification tags, hardware/capital costs, transforming processes, segregation costs, less flexibility) and ongoing maintenance costs (audits, record-keeping, labour costs, etc) - Technology to deliver full chain traceability has greatly improved and ranges from plastic bar-coded ear-tags to DNA technologies
66	Hobbs and Kerr 2006	N/A	Food (agricultural products)	To develop a model that incorporates consumer concerns into an international trade model and compares the result with the standard	Literature review and the use of a P-Q model.	- The model that underpins the WTO assumes that consumers have perfect, costless information about the goods they consume; this is not true in the case of credence attributes - A trade policy response to increase consumer protection is to impose an import embargo on GM foods (credence attribute) - Labeling is a way to deal with

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				treatment.		consumer concerns about credence attributes - Labeling is never an inferior policy to an embargo for importers, therefore it is in exporters interest to remove barriers to their use in international trade law
67	Hobbs and Sanderson 2007	Roles of traceability systems: improved inventory and logistics management, improved management of food recalls in the event of a food safety problem, limiting the broader impacts of food safety or herd health problems, strengthening due diligence and liability incentives, and demand side incentives	Beef	To explore the issue of full-chain traceability and process verification in the Canadian beef sector and evaluate whether the current cattle ID program should be extended to a traceability system.	A literature review and in-depth semi-structured interviews with 12 industry stakeholders and experts were used to gather information.	- Full traceability (farm to fork) is technologically feasible, but must also be economically feasible for implementation - If economic incentives are sufficiently strong in demand from the marketplace will traceability be economically feasible - Audits and verification methods are needed to reduce the incidence of 'free-riders' - Sharing production information (e.g. vaccines administered) has the potential to deliver cost savings, but verification is important since there may be incentives to misrepresent this information
68	Hobbs et al. 2005 Traceability in the Canadian red meat sector: Do consumers care?	The ability to follow the movement of food through specified stages of production, processing, and distribution. Sometimes refers to simple traceback systems and also applied to programs that provide identity preservation and quality assurances	Meat and livestock	To determine if traceability can add value to quality assurance by examining economic incentives for implementing traceability systems in the meat and livestock sector, distinguishing	Literature review on economic motivations for traceability. Experimental auctions on beef and pork (regression analysis).	- Consumers are willing to pay nontrivial amounts for traceability assurance (higher for beef than pork) - When traceability is bundled with other assurances it is more valuable to consumers than traceability alone - Traceability may act as a credibility signal to consumers

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		throughout the supply chain		between *ex post* traceability and *ex ante* quality verification.		
69	Hobbs, Yeung and Kerr 2007	The ability to follow an item, or a group of items, whether animal, plant, food product or ingredient, from one point in the supply chain to another, either backwards or forwards (FSQPD of AAFC)	Livestock (sheep, hogs, dairy, and cattle sectors)	To explore examples of potential benefits of a single national livestock traceability system and to gather information on the likely magnitude and distribution of these benefits.	In-depth semi-structured interviews with industry representatives (producers, auctions and markets, industry associations, packers and service providers) and a review of traceability literature.	- Largest direct benefits from a national, single portal traceability system are related to risk reduction/risk management - Enabling benefits relate to improved operational efficiencies and information flows - There is reduced incentive for producers to cheat due to age and record verification - Reduced information asymmetry may lead to benefits for producers, feedlots, and packers - $30/head premium for reputation for safe exports to Japan
70	Hooker, Nayga, and Siebert 1999	The ability to trace a final product back to the producer and vice versa; farm to table.	Beef	To assess the economic implications of changes in the slaughter-processing stage(s) suggesting potential hurdles to the development of "farm to table" food safety systems.	Independent surveys (by mail) of beef slaughter and meat processing plants in Australia and the United Stated in 1999; conducted by researchers at Texas A&M University.	Australia: - Most opposition for a full traceback system by slaughter-processing plants - 19 plants offer suppliers premiums for certain quality characteristics of the livestock (18 do not offer premiums, 4 did not reply) - Average cost of QA adoption: A$8000 (not including management time) - Input prices were considered the least important cost United States (Texas) - Only 4% of customers demand the tracing of raw ingredients that make up the final product; 56% require state or federal inspection - About 20% (of 65) small meat processors had implemented HACCP

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						in 1999 and 66% would be in 2000 - About 30% of firms will discontinue some products due to HACCP
71	Houston 2001	N/A	Cattle and beef	To describe the computerized database system that records the details of individual cattle, cattle holdings, cattle movements, and cattle tests, that is in use in Northern Ireland.	Discussion of the cattle database system in Northern Ireland.	- The identification, registration and movement records of cattle in Northern Ireland have been computerized since 1988 - Compulsory cattle identification and registration; cattle must be identified within 20 days of birth with a unique number pertaining to herd of birth - The first computerized system was based on a mainframe computer, located at Veterinary Headquarters in Belfast and maintained by government officials - Computerized systems offer confirmation of movement wherever an database terminal existed - With the computerized system forward and backward tracing was possible overnight and was highly cost-effective in rapidly identifying possible disease spread and implementing the follow-up testing regime - Ireland's second computerized system (APHIS) is PC-based , allow meat hygiene functionality (slaughterhouses) and movement control functionality
72	Jones et al. 2005	The ability to trace and follow a food, feed, food producing animal or ingredients through all stages of production and distribution.	Food	To outline the characteristics of radio frequency identification (RFID) technology and	Review from trade and practitioner sources and retail examples of using RFID.	- In 2003 Wal-Mart instructed its top 100 suppliers to place RFID tags on all pallets and cases by January 2005 - Perceived benefits of using RFID: tighter control and management of the supply chain and of inventory

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				discuss some of its perceived benefits and challenges for food retailers in the UK.		management; attendant costs savings, reduced labour costs, improvements in customer service, reductions in shrinkage, and improved tracking of consumer purchasing behavior - RFID will facilitate traceability - Challenges of RFID: establishing RFID infrastructure throughout the supply chain, cost of equipment (tags, readers), and training time/costs for retailers, suppliers and distributors
73	Jones et al. 2004	N/A	Food	To determine the current implemented levels of traceability and assurance protocols and to consider some of the issues regarding the benefits, costs and constraints of implementing these protocols.	Surveys and focus interviews where conducted during the 2004 IAMA World Forum and Symposium conference in Switzerland. Participants were industry members from various countries.	- Most of the participating companies had at least some traceability and assurance protocols implemented within their operations - The lack of synchronization of traceability and assurance protocols globally was a significant constraint deterring companies from implementing protocols - The majority of participants considered the private sector to hold primary responsibility for food quality with the public sector providing oversight responsibility.
74	Kehagia et al. 2007	*The ability to trace the history, application and location of that which is under consideration* (ISO 2007). *The ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a*	Food, specifically meat and honey	To provide an understanding of food traceability by European consumers' by exploring their perceptions: the definition of the term, their expectations of traceability and differences in	Literature review of traceability and focus groups of consumers in 12 countries (Spain, Greece, France, Germany, the Netherlands, Italy, Malta, Slovenia, Hungary, Poland, Norway, and Lithuania).	- The term traceability was found to be confusing to some consumers; those who were familiar with it linked it to the origin, production process and product information of food - Benefits of food traceability were agreed upon in all participating countries except Poland and Lithuania where the transparency of such information was mistrusted - In Spain, the Netherlands, Italy, and Hungary traceability was expected to

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		food or feed, through all stages of production, processing and distribution (EC 17/8/2002). Other definitions from Dickinson and Bailey 2002, Hobbs et al. 2005, Gellynck and Verbeke 2001, Wilson and Clarke 1998, and Opara and Mazaud 2001.		foodstuffs by product types, and their views on the importance of labels.		be a way of enhancing consumers' confidence in the safety of a food product - Consumers in Spain and Italy perceived traceability as a tool for product differentiation - Respondents in Spain and Norway argued that traceability was more beneficial to producers and controllers - Information such as origin, price and expiry date was mostly preferred by consumers across all countries for both meat and honey - Labels were considered the best way to communicate traceability to consumers as long as they did not contain an overload of information
75	Kelepouris, Pramatari and Doukidis 2007	*The ability to trace the history, application or location of an entity, by means of recorded identifications* (ISO 1995); *the ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing, and distribution* (EU 2002).	Food	To study the main requirements of traceability and examine how the technology of radio frequency identification (RFID) technology can address these requirements; and to suggest an information infrastructure for enabling traceability in a supply chain.	Model traceability using data reference information throughout the supply chain.	- There is a trade-off between traceability resolution and related costs a firm must suffer; the most balanced seems to be identification at the case or pallet level - If RFID tags on the packages of each lot are used there is no need for supply partners to synchronize their data as they can then use the EPC for identification without data inconsistency - RFID tags are efficient and may reduce labour costs - The costs and risks of RFID rise as there is fully infrastructure implementation; an efficient infrastructure must be used to reduce the costs of multi-partner implementation - The use of a centralized information

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						model would save companies from investments on expensive information systems that support traceability
76	Lawrence 2002	To enhance Australian and New Zealand beef products in terms of integrity and value to the end user, or customer. To use information infrastructure to trace cattle to the seller's farm if problems arise.	Beef	To give an overview of the beef sector and quality assurance (QA) programs in Australia and New Zealand.	Observations of the beef sector and QA programs in Australia and New Zealand. Comparisons of the systems in the two countries.	- Meat Standards Australia grading provides a trace-back system on a "as needed" basis; processing plants take blood samples and if a consumer has a complaint tissue from the product can be DNA matched to the blood; this costs about AU$30-AU$40 - Richmond Farm Assurance program pays New Zealand producers a premium if their product is sold to them; audits cost NZ$300 per farm
77	Leat, Marr, and Ritchie 1998	To be able to follow a food and its component parts back up the food production and marketing chain.	Food	To summarize how the Scottish agri-food industry has been developing farm and quality assurance activities since the early 1990s in order to strengthen its competitive position.	Review of the Common Agricultural Policy (1992), the Food Safety Act (1990), certification bodies in Europe, a literature review, and a review of the conference presentations on Food Traceability – What? Why? How?	Food traceability is essential: - to provide consumer assurance about the sources and safety of food - to allow identification of the source of infected or substandard product - for disease control and residue monitoring - for support measure verification - to satisfy the requirements of labeling regulations - in the beef market, to enable the lifting of export bans on British beef and beef products
78	Leier-McHugh 2002	N/A	Food	To address some of the trends in food and product testing that have been observed in the testing market; to discuss how testing need to be real time, accurate and	A review of the tools and testing used for traceability of food ingredients.	- Testing is done to ensure that the final food product is safe to ingest and labeled correctly - HACCP and ISO protocols have increased the ability for food to be traced - To detect genetically engineered (GE) proteins include immunoassay, ELISA and PCR methods can be used - Identity preservation (IP) is a system

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				reliable as well as cost effective.		that provides a comprehensive record for a product form the seed to the finished product - Testing methods and technologies support IP and can act as an indicator to potential safety issues
79	Liddell and Bailey 2001	The ability to track the inputs used to make food products backward to their source at different levels of the marketing chain.	Pork	To compare the traceability, transparency and assurance (TTA) systems for pork between the US, some of its major trading partners, and competitors in world pork markets.	Literature review of the TTA systems in various countries.	- Three reasons why the US pork industry should be concerned that it is lagging its competitors in terms of TTA: (1) consumers are becoming more concerned about the inputs used to produce food, (2)competitors may be able to successfully differentiate their pork products based on TTA, and (3) domestic and foreign pork consumers may be willing to pay for TTA; potential market opportunity loss if the US pork industry does not develop TTA - The US pork industry is lagging its principal competitors and some of its largest customers in terms of developing TTA programs - The principal weakness of the US TTA program for pork is at the producer level
80	Lindgreen and Hingley 2003	N/A	Meat	To discuss the measures that Tesco has taken to provide appropriate and immediate food safety information to consumers.	Case study of how Tesco (the largest food retailer in the UK) has responded to consumer concerns of food safety scares; interviews with Tesco and four of its meat suppliers. Also a literature review of consumer food	- Tesco has sought to simplify the meat supply chain by purchasing directly from suppliers using a centralized distribution system - The relationships between Tesco and meat suppliers become long-term and must allow for transparency, communication, and trust - Tesco view EU law as a baseline for assurance and add Tesco standards to their meat supply chain

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					scares.	- Tesco meat suppliers are required to be members of a recognized assurance scheme - Strict guidelines are provided on housing and feeding facilities, diet, medical treatment, surgery, transportation, traceability of movements, staff involved in animal care, and inspections of Tesco personnel and independent inspectors - Tesco policies: Animal Welfare, Animal Feeds, Animal Medicines, Pathogen Reduction - There is cost savings with closer cooperation between Tesco and the suppliers
81	Loader and Hobbs 1996	N/A	Beef	To analyze the likely impact of the recent BSE crisis on the UK beef supply chain and to explore the costs and benefits of the crisis.	A review of the "new institutional economics" literature and a discussion of its application to the British or European beef industry.	- The BSE scare in the UK has raised awareness of food safety and farming practices to new levels - Closer vertical coordination in the beef supply chain may reduce the transaction costs which have been a result of food scares - A benefit of the BSE crisis may be a UK beef industry with more quality assurance, better product differentiation and branding, market segmentation, and satisfied consumers
82	Loureiro and Umberger 2007	*The ability to identify the origin of animals or meat as far back in the production sequence as necessary to ascertain ownership, identify parentage, assure safety and determine compliance*	Beef	To analyze US consumers' relative preferences and WTP for meat attributes such as country-of-origin labeling (COOL), traceability, and	Literature review on traceability, COOL, and National Animal Identification System (NAIS); mail survey for an attribute based choice alternative experiment (WTP) for two ribeye steaks.	- From the 5000 surveys mailed, 632 were returned completed and analyzed - $2.568 per pound of steak is the premium that makes consumers indifferent between the two levels of utility, associated with no COOL and the presence of a label with COOL information - The label that certifies the steak has

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		in branded or source-verified beef programs (Smith et al. 2000).		food safety inspections.		been inspected by USDA has the highest premium of $8.068 per pound - Traceability and guaranteed tender carry premiums of $1.899 and $0.953 per pound respectively - Since food safety certification was valued the highest, the authors interpret that consumers strongly value the current USDA-FSIS inspection standards
83	Lusk and Anderson 2004	N/A	Beef, pork, lamb, fish, fruits and vegetables, and peanuts	To determine how the costs of country-of-origin labeling (COOL) will be distributed across the livestock sector and how producer and consumer welfare will be affected; investigates the degree to which consumer demand will need to increase to offset COOL costs.	Review of existing estimates of the cost of COOL, sensitivity analysis to determine how the incidence of costs affects the welfare of market participants.	- VanSickle et al. (2003) estimated that record-keeping costs associated with COOL to be between $69.86 million and $193.43 million - Sparks Companies, Inc. (2003) estimated COOL will increase total costs by $3.66 to $5.60 billion, not including lamb and peanut sectors - Hayes and Meyer (2003) estimated full traceability would raise farm-level production costs for pork by $10.22/head - As the costs of COOL are shifted from the producer to the processor and retailer, producers are made increasingly better off while consumers are made increasingly worse off - An increase in aggregate consumer demand of 2% to 3% is likely sufficient to offset lost producer welfare due to COOL costs - There are several cases where it appears that all producers (beef, pork, chicken) benefit from COOL; this does not imply that aggregate welfare increases

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						- Most likely beneficiaries of COOL will be chicken producers
84	Madec et al. 2001	Meat from retail may be traced back along the supply chain. Traceability is required for modern animal breeding purposes and for effective generalized prophylaxis and disease control.	Pig/pork	To describe methods of pig identification and examples of traceability systems for pigs in various countries	Literature review of pig identification and pig traceability systems in France, the Netherlands, Denmark, and the United States.	- Good animal identification is permanent, low cost, easy to apply, and works at a distance - An identification system must use a life number, be tamper proof, adaptable to automatic coding, safe for the consumer, not damage or cause excessive pain to the animal, and remain cost effective - Injectable transponders have been used in pig production will ease of injection and low loss rate, however the transponders may become lost or separate from the pig during slaughter
85	Maldini et al. 2006	N/A	Fish and seafood	To assess the potential use of the DNA marker technology to determine fish and seafood species in processed commercial products and domestic stocks.	Samples of different unknown fish and seafood species were collected from frozen processed panels imported by Italian fish-trading factories; unprocessed fish were used as reference samples. DNA was extracted from the samples for identification.	- Amplified Fragment Length Polymorphisms (AFLPs) (a PCR-based molecular marker) appear to be very informative markers for species identification and authenticity testing of unknown fish and seafood species - Traceability in aquacultural practices should not be utilized only for food purposes but should also be extended to the correct identification of strains and genetic lineages
86	Manning 2003	If there is a problem with the product it can be traced back to the source.	Beef	To investigate the beef supply chain from producers to consumers and to identify ways of promoting quality, consistency,	Comparative research on food safety and quality systems and traceability in UK, Eire, Sweden, USA, and Canada. Comparison of government grading,	- Canadian marketing by CCA use the tagging/identification scheme of a bar-coded tag and is working on an electronic tagging scheme; Electronic (CVS) grading is being developed to produce a more accurate grading process using digital images to determine fat cover and marbling

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				traceability, productivity, and animal welfare.	marketing, and production systems.	- The KK club in Europe offer beef with traceability for an export market; SCAN, the brand name of Swedish Meats is produced
87	Martin, Grier, and Dessureault 2004	The ability to trace back where a problem was started.	Beef	To compare the evolution of the Canadian beef industry with the U.S. industry with what has occurred in the cow-herd and production of beef since the middle of the 20th century.	Literature review.	- Future opportunities lie in branding and product differentiation, not in bulk low cost production - Need to enhance market access between Canada and the United States - Quality control will become more important; people in the supply chain need to be rewarded for delivering uniqueness – total vertical integration or dedicated supply chains that look at the value of the final customer and work back is needed - Traceability will soon be the minimum requirement for branded products
88	McGrann and Wiseman 2001	Tracing a product or animal forward or tracking a product or animal back.	Animal	To identify the fundamental requirements of a new information infrastructure for transnational animal tracking and tracing systems for use within the EU.	Review of literature and legislation on animal traceability, primarily in the EU.	- A prerequisite for effective traceability is a system of unique and secure identification based on tamper-proof/tamper-evident identifiers linked directly to a database - The database must be capable of supporting animal identification, health records, and traceability to the holder of origin - Harmonization of agreed traceability and animal movement standards must be made compulsory throughout the world for more efficient trade
89	McKean 2001	The ability to maintain a credible custody of identification for animals or animal products through various steps within the	Food	To determine the importance of traceability of animals and animal products in food	A review of the requirements of traceability systems in Europe.	- Traceability of animals and animal products can be subdivided into: country of origin, retail labeled, processor origin, and farm-to-retail identity - For specialty markets to expand,

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		food chain from the farm to the retailer.		production and marketing as these have been removed from direct consumer control.		formalized, credible and verifiable production and processing standards must be devised, implemented and monitored - Traceability is limited to identity and reputation of the processor or retail establishment - Credible and cost-efficient production and marketing systems that can guarantee specific increased product safety and quality attributes may be more appealing to consumers than more generalized safety and quality systems
90	Mennecke et al. 2006	The ability to retrieve the history, treatment, and location of the animal that a cut of meat comes from, through a record-keeping and audit system or registered identification program.	Beef	To examine the relative utilities of a set of beef steak characteristics among consumers.	Survey of students from the programs College of Business and College of Agriculture. Results were then analyzed using conjoint analysis.	- Region of origin is the most important characteristic, followed by animal breed, traceability, the animal feed used, and beef quality - The cost of cut, farm ownership, the non-use of growth promoters, and whether the product is guaranteed tender were the least important factors - The ideal steak for the aggregate group is from a locally produced choice Angus, fed a mixture of grain and grass that is traceable to the farm of origin - If the steak is not produced locally, order of state preference from most to least is: Iowa, Texas, Nebraska, and Kansas
91	Meuwissen et al 2003	A system that provides a set of data about the location of food and food ingredients along the supply chain.	Meat	To analyze the status and perspectives of traceability systems and certification	Description of purposes, requirements, status, and perspectives of traceability systems and certification	- Potential costs of traceability systems include: implementation (transforming processes, less flexibility, automation, extra storage, production materials, personnel and documentation) and maintenance (audits)

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				schemes, and to review their potential costs and benefits.	schemes and an overview of producers' potential costs and benefits.	- Potential benefits of traceability systems include: increased transparency, reduced risk of liability claims, more effective recalls, more effective logistics, enhanced control of livestock epidemics, positive effect on trade, enhanced license to produce, and price premium - Technical development will likely improve compliance and usability of traceability systems; RFIDs may soon replace traditional eartags for identification
92	Mitic 2006	N/A	Food products	To describe the new Global Traceability Standard by GS1.	Discussion of GS1 Traceability Standard.	- GS1 Standards are used in over 150 countries around the world by the majority of supply chain partners - The Standard defines the minimum requirements and business rules to be followed when designing and implementing a traceability system
93	Moe 1998	*The ability to trace the history, application or location of an entity by means of recorded identification* (ISO 8402:1995).	Food manufacturing	To outline the fundamental theoretical issues of traceability and discuss more practical traceability strategies.	Review and discussion of traceability systems and traceability stratagies.	- The term traceability can be used in four distinct contexts: product, data, calibration, IT and programming - Product traceability is based on the ability to identify products uniquely - Chain traceability establishes the basis for efficient recall procedures, allows for better quality and process control, allows potential for marketing of special product features, and meets current requirements - Internal traceability allows possibility for improved process control, better planning to optimize the use of raw material for each product type, and allows avoidance of uneconomic mixing of high and low quality raw

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						materials.
94	Mora et al. 2006	A tool that provides food agents the capacity to track food items efficiently, reducing losses and especially to restore consumers' confidence. Other definitions mentioned: EC 178/2002, ISO 8402.	Beef	To investigate the perception of Italian and Spanish consumers on the issue of beef traceability.	Conduct six focus groups of consumers in Spain and Italy and analyze the results in the framework of an EU project (TRACE – Tracing the origin of food).	- For labeled information to be effective it must be read, processed, understood, and accepted by consumers - Origin, price, and expiry date are the attributes strongly perceived by both Italian and Spanish participants - Country of origin is the most considered attribute for beef in both countries; national origin is preferred in Italy and certain foreign products (Argentina beef) were preferred in Spain; price seemed more important for Spanish participants - Italians perceive traceability utility oriented to assess origin and authenticity, while Spanish expectations are linked to a major level of risk detection and for the control of the product and production process - RFID was not well accepted; traditional methods of information provision was preferred in both countries
95	Mousavi et al. 2005	N/A	Meat	To develop a functional prototype conveyor system that is capable of tracing and tracking meat cuts within a boning hall.	A detailed boning hall process analysis, development of beads for the bead-driven conveyor and methods of inserting and removing beads from a stream of beads in a channel, investigation and validation of a low-cost RFID system, development of a	- All trialed RFID tags were readable after being exposed to -20°C (chilled environment) to +80°C (washing and hygiene activities) - The Meatrac project was developed and designed to incorporate a novel conveying technology, noncollision RFID system, and state-of-the-art control and information system which has provided 100% traceability for prime cuts of meat in an abattoir and boning hall

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					control system capable of routing products in a bead-driven conveyor and human machine interfaces, design and implementation of a comprehensive database management.	
96	Mousavi et al. 2002	N/A	Meat	To review research and development activities, and to offer a practical solution, for traceability and trackability in the meat industry.	To review research and development activities for traceability and trackability in the meat industry and to introduce the use of software/hardware, logistics and technical requirements for tracking material in a production process.	- There are two main categories of traceability techniques: (1) using traceability equipment attached to the piece of meat, such as readable tags; (2) traceability of material within the framework of material handling devices and automation - Some degree of standardization and automation is needed to minimize human errors - From the proposed system each prime cut will have a unique identity that can be accessed along the system
97	Mus 2006	A method that enables tracking of inputs and outputs in all stages of the supply chain and is able to trace a product and its components back to the source of origin in the case of a contamination problem	Livestock, specifically beef	To determine the costs and benefits of traceability for small and medium sized enterprises and whether or not they would benefit from applying traceability in an integrated food and supply chain.	A literature review of existing traceability and identification systems. A cost-benefit analysis of traceability for small and medium enterprises from farm to fork, including ranch, stockyard, feedlot, and packer.	- Traceability is a significant tool to assure consumers about food safety and enable firms to differentiate their products - Firms can benefit from economies of scale to improve production efficiency - Traceability contributes positively to the economic welfare of consumers in short and long run - Traceability cost from farm to fork will range from $0.042 to $0.102 per pound
98	Peterson 2004	*The ability to follow*	Food, with	To review the	Review of the legal	- Data carriers are used to keep track of

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		the movement of a food through specified stage(s) of production, processing and distribution (Codex Alimentarius 2004). *The ability to trace the history, application or location of that which is under consideration* (ISO 2002). *The ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed through all stages of production, processing and distribution* (EC 178/2002)	emphasis on seafood	status of food traceability in the EU and US, with special emphasis on seafood and fishery products; focus will be on the legal basis, technical aspects and practical applications of traceability.	basis for traceability in the EU and US, current tracing methods and code systems, and seafood applications of traceability.	items within a food supply chain - Data can be retrieved from RFID tags without the tag being in sight of a reader - Most RFID tags can carry more data than barcodes, but RFID systems are more costly that barcodes - RFID technology is being implemented in Wal-Mart, Metro-group, and Tesco stores; RFID use in the seafood industry has only just begun - Benefits of implementing RFID technology according to Wal-Mart: it eliminates manual data entry and manual business process transactions - The driving force in the EU for implementing legal requirements for traceability are the various food scares that have led to skepticism in food products among consumers - In the US the driving force for implementing legal requirements for traceability has been to minimize future terrorist attacks through the food chain
99	Pettite 2001	Refer to the definition of EC 178/2002.	Animal products and livestock	To examine the impact of recent food scares in the UK, where scrutiny of the food industry has led to the introduction of new controls at all stages of production.	Review of traceability, tracing systems, and traceability technology used in Great Britain.	- Great Britain's cattle tracing system has a centralized database of cattle, with each individual being issued an identity document which is surrendered at slaughter - In Great Britain's system: when a newborn calf is ear-tagged the birth is registered on the central database which then issues a paper passport; the paper passport accompanies the calf throughout life

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						- The Scottish Borders Traceability and Assurance Group (TAG) uses a full traceability system for cattle based on RFID ear-tags and complies with standards of the International Organization for Standardization (ISO) - Legislative controls requiring the traceability of livestock have enabled producers to benefit from increased trade - Large supermarket retailers in the UK have become powerful operators in deciding the future direction of food production; farmers who once would have expected a price premium for differentiated products typically do not, and producers of items that do not have additional standards face a closed market
100	Popper 2007	From farm (plant or animal) to fork, foods have a clear, verifiable record that tracks through all stages of cultivation, production, supplying, transporting, processing, and distribution. To work effectively, traceability means knowing the origin and exchange points of raw materials, processing plants, distributors, transporters and their routes, warehouses,	Food	To explore the potential impacts of the global food system's new and expanding national and international governmental traceability requirements on individuals' control of information about their locations and movements.	Review of traceability systems in the global food chain.	- Traceability often captures people's whereabouts and so it affects owners, and consumers - Workers are most likely to find their privacy compromised, owners' needs and risks will receive the greatest attention, and consumer benefit will remain at its margins - Owners buy traceability technology as a way to improve both oversight and productivity - Traceability may be one of the requirements needed to re-open closed trade borders due to animal disease, such as BSE - AIM Global (RFID industry trade association) says consumers should have the right to know whether

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		packagers, packing materials, and retailers.				products contain RFID tags, to have them removed or deactivated, to know when, where, how, and why the tags are being read and who is reading them
101	Pouliot and Sumner 2007	The ability to trace the history of a product's origin including the identity of the farms and the marketing firms along a supply chain.	Food safety	To develop a model of how traceability causes the degree of food safety to increase and to explore the relationships between traceability and the provision of food safety.	Development of a formal model of how, by making liability feasible, traceability causes the degree of food safety to increase. Traceability is made exogenous when applying the model.	- Improved food safety from increased traceability increases consumers' willingness to pay for a safer product - Consumers gain from increased traceability to the marketers by having better chances of receiving compensation in case of a food safety event and by consuming safer food - Additional traceability from the marketers to the farms does not increase consumers' compensation because it does not change the marketers' liability - Additional traceability to the farms allows marketers to impose liability costs on farms and creates incentives for farms to supply safer food - With more traceability marketers and farms receive a premium for supplying safer food - Downstream firms may use traceability to shift liability upstream and reduce the chance of food safety problems
102	Regattieri, Gamveri, and Manzini 2007	The history of a product in terms of the direct properties of that product and/or properties that are associated with that product one these products have been subjected to particular	Food, with a case study on Parmigiano Reggiano (an Italian cheese)	To analyze legal and regulatory aspects of food traceability, and to provide a general framework for the identification of fundamental	Literature review concerning traceability from both a general and food processing sector point of view. Presentation of the characteristics, properties, and	- A product traceability system is fundamentally based on 4 pillars: product identification, data to trace, product routing, and traceability tools - The European Article Numbering (EAN) association has made some effort toward standardization by introducing several codes (e.g. EAN/UCC GLN)

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		value-adding processes using associated production means in associated environmental conditions. Also uses ISO (1994) and EC 178/2002 definitions.		mainstays and functionalities in an effective traceability system.	modern technical solutions for an effective traceability system. Project based on RFID technology which focuses on the traceability system developed for Parmigiano Reggiano cheese.	- The automation, high speed, and precision of bar coding permits simpler, economical, and exact traceability systems - RFID systems reduce labour costs, speed up identification time, improve knowledge of customer behaviour, and improve management of product recalls - Limitations to RFID are higher tag costs - Introducing a traceability system to Parmigiano Reggiano costs approximately 0.07€/kg more (0.5% increase in cost); this marginal increase is due to the high price of the cheese and the link between TAG and the whole cheese
103	Resende Filho 2006	Traceability systems have been used as a tool to accomplish predetermined objectives regarding security improvement, quality control, fraud detection, fulfillment of consumer demands, compliance with international market standards and management of complex logistical chains (EAN International 2003 and Moe 1998)	Cattle and beef	To study two types of traceability systems: (1) a beef traceability system is modeled as a device to reduce the anonymity of fed cattle suppliers; (2) the economic value of a national cattle traceability system (NAIS) in the US.	The first essay (of three) adapts a two-step procedure used by Grossman and Hart (1983) to model and solve a Principal-Agent model where the beef traceability system is in place. In the second essay the economic value of the NAIS is measured with food safety indices based on the number of references published in newspaper articles and constructed individually for beef,	- A meat traceability system may have economic value for a meat packer - Traceability from the slaughter floor to the fabrication floor costs about $0.11 per head if expected traceback success rate is 38.9%; the cost would be about $0.656 per head if the traceback success were 95% - The value of traceability for a meat packing plant was calculated to be $1.54 per head due to incentives for using needle-free injection techniques - The NAIS might be an effective devise reducing the risk of occurrence of dangerous residues in meat product - The US government will need to subsidize the NAIS implementation and maintain it to make it economically feasible if it is assumed

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					pork, and poultry.	that most benefits with the NAIS implementation will come from its potential for inducing increased demand for beef and pork
104	Resende-Filho and Buhr 2007	Systems that can help track product distribution and target recalls.	Meat and livestock	To consider the economic modeling of traceability as a tool to improve recall processes from food borne pathogens (specifically E. coli in ground beef). To illustrate the trade-offs of traceability with a numerical simulation based on prior study estimates.	Interview of two firms: one a meat processing company and the other a dry grain products manufacturing company. The firms then conducted 4 mock recalls per year and estimated the associated costs. Review of previous site visits to European firms (Buhr). Development of models for traceability which are combined and simulated using Palisade's @Risk software in MSExcel. The model is simulated under two broad categories: (1) assuming no traceability which remains the baseline and (2) assuming there are means of tracing products after they leave the firm.	Meat processing plant: - Primary cost of the recall was loss of product sales, second was the cost of labour for managing the recall - Electronic systems improve the cross-referencing of shipping records Grain products manufacturing plant: - Quality control identified nearly all products; improvements would not affect recalls from consumer to processor European firms: - *Ex post* assessment of an actual recall revealed a cost saving from traceability of over $100,000 in a veal firm Risk analysis - The potential for no recall (low probability of illness) would result in a large undervaluation of traceability for recall purposes in the case of E. coli. - The baseline simulation has expected investment in traceability of about $0.11/lb of ground beef produced - The mean value of traceability increases for the 28 day shelf-life by about double the 14 day shelf-life case - For simulations at each stage of the production process (farm, processing, retail) there is suggestion of a substitution effect between quality control systems and the value of traceability (could be complimentary) - A firm investing in improved carcass

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						quality would find it beneficial to only invest in traceability up to about $0.06/lb compared to $0.11/lb without the improved quality control
105	Riden and Bollen 2007	N/A	Fruit	To investigate four concepts of traceability for horticultural packing operations: precision of traceability, packs per bin for tracking, bins per pack for tracing, and purity to describe the likely sampling accuracy of packs in an audit or monitoring system.	Research was conducted in an apple packhouse that processed approximately 100 bins of locally grown apples per day for export. The mixing of fruit as it moves through the packhouse is determined with models and the effect of mixing on traceability is dependent on other parameters, such as size of input units.	- The average number of packs per bin increases with increasing levels of infeed mixing - The precision of traceability is the ratio between identifiable units (IUs) at two points in the supply system - Tripling input size improved the precision of tracing in terms of bins or triple bins per pack - Improvements in the precision of tracing gained from a change in granularity will always have an associated counter effect on the precision of tracking - The highest purity (99%) was achieved most often from the highest percentage cupstream, lowest infeed mixing and smallest pack size
106	Rude, Carlberg and Pellow 2007	N/A	Beef	To determine the impact of border disruptions on Canadian cattle and beef production and prices, to measure the degree to which adding domestic slaughter capacity is effective in offsetting price declines that	Development of a synthetic model that is calibrated to historic data and used to gauge the impacts of changing slaughter capacity, commercial grade beef import competition, and export potential for lower quality cyst on the Canadian cattle and beef sector. Data was based on literature and industry	- The closure of the US border to exports of Canadian live cattle causes excess supply in Canadian slaughter plants which results in cull cattle prices 53% below baseline, steer prices 35% below baseline, and feeder prices 40% below baseline - In the first year of a border closure slaughter of fed animals increases by 32%, beef packers' margins increase and the price of low quality beef prices decline by 9% - With fed cattle trade with the US in the third year of the simulation fed cattle prices only decline by 1%, there are

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				result from a border closure, and to examine how prices are affected by the ability to sell low quality beef into international markets.	members.	lower margins for fed cattle packers and lower slaughter numbers cause exports of live steers and heifers to resume - A reduced slaughter capacity of 20% reduces cull prices 11% below baseline and fed cattle prices 8% below baseline - Added processing capacity reduces reliance on American packers, but there is still vulnerability unless Canada can freely export high and low quality beef
107	Sanderson and Hobbs 2006	*The ability to trace the history, application or location of a product or ingredient, including the processing history and the location of the product after delivery* (Golan et al. 2004: ISO 9000:2000)	Beef	To evaluate the feasibility and implications of extending the current cattle identification system to full chain traceability; to explore potential 'network effects' of combining traceability/source verification with more complete process information management systems; and to draw insights from existing traceability and process verification	Literature review, insights from the Network externalities (economics) literature; Information collection from semi-structured telephone interviews with key industry stakeholders, technology providers and experts in Canada and the US. Twelve in-depth interviews with cow/calf producers, technology providers, industry associations, and value chain specialists in Canada and the US.	- Roles of traceability systems include: improved inventory and logistics management, improved management of food recalls in the event of a food safety problem, limiting the broader (public) impacts of food safety or herd health problems, strengthening due diligence and liability incentives, and demand-side incentives - Traceability is of more value to consumers when it is bundled with credible quality assurances - The CCIA ensures cattle identification (through RFID tags) and traceback for the purpose of animal disease control and food safety from the producer through to the packing plant - CLIA is concerned with traceability of live animals for the purpose of disease control, while Can-Trace (a voluntary whole-chain traceability standard) is concerned with food safety for all food products from "farm to fork" - The US is developing a national

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				systems/ technologies currently in use in Canada and elsewhere.		tracking system for livestock that can contain a disease outbreak within 48 hours - Most major packers in the US and Canada are not currently doing individual ID - For traceability systems to be effective and useful to the industry they must be functional, reliable, and credible
108	Schofield 2002	N/A	Food	To describe where the proposals of two regulations to deal with the labeling and traceability of genetically modified organisms (GMOs) are in the EU system, the issues and the problems industry will face if they are implemented in their present format.	Discussion of how EU regulations on labeling and traceability of genetically modified organisms affect US food industries.	- Detectability of GMOs is not possible in some primary food derivatives (oil) and in many secondary derivatives (caramel) - Separating a product from the bulk commodity stream makes economic sense only if the product has enhanced value for a downstream customer (processor or consumer) - Identity preservation (IP) systems are in sue for a number of non-GM products - Price premiums given by the North American Grain Export Association for IP grains range from 15-20% for certified seed to over 200% for certain grains and oilseeds destined for health food markets - The Organization for Economic Cooperation and Development (OECD) estimated costs for IP herbicide-resistant non-GM soybean from Brazil to be US $27 per tonne, a 10% price premium
109	Schwagele 2005	*The ability to follow the movement of food through specified stage(s) of production,*	Meat, meat products, and animal feeds	To provide an overview on the EU legislation on traceability and	Review of EU legislation and methods used for traceability in meat	- Species identification may be done using protein, fatty acids and DNA based methods - Traceability methods may be used to

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		processing and distribution (EC 178/2002)		the technologies needed to implement this system for meat and meat products.	and meat products.	ensure authenticity, geographical origin, and to detect fraud - 'Tracer substances' can be used to ensure traceability through processing stages
110	Senneset et al. 2007	N/A	Farmed salmon	To report from a research project where implementation in a value chain for farmed salmon is used to investigate the challenges in implementing electronic chain traceability.	Survey of 8 farmed salmon companies. A complete value chain for farmed salmon was established, then the status of each company regarding their readiness to implement electronic traceability was analyzed. The final level of implementation in each company was compared with the level of implementation readiness at the start of the project.	- An international standard, often referred to as the TraceFish standard describes the principles of traceability for the fish farming and fishing industries - No chain traceability software system was in use at the start of the project and automatic data recording was only used at dispatch by two companies - Full online implementation of the TELOP Trace software concept was made in two companies
111	Simpson, Muggoch and Leat 1998	N/A	Beef and lamb	To outline the Scotch Quality Beef and Lamb Association (SQBLA) approach to quality assurance and product traceability.	Review of literature and regulations on the traceability and quality assurance schemes used in Scotland's beef and lamb sector.	- SQBLA assesses producers to guarantee quality assurance (QA) aspects and assist in product traceability - Scotch Beef Club members are restaurants who name their suppliers of Scotch beef and lamb - Scotbeef is a member of SQBLA and uses their own "Beeftrack" scheme to ensure traceability through to the final consumer - Beeftrack allows traceability tagging

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						to stay with the meat throughout processing and has introduced programs and scanning procedures which allow the identification of product in primal joints, retail packs, and bulk containers
112	Smith and Saunders 2005	Traceability of a food consists of development of "an information trail that follows the food product's physical trail."	Livestock, poultry, and meat	To investigate how the U.S. can develop traceability systems for food, in particular livestock and poultry as they are lagging behind many countries in this area of the food industry.	Literature review to compare current traceability and identification systems in the US to those in the international community.	Traceability can, could, or will eventually be used: - To ascertain origin and ownership and to deter theft and misrepresentation of animals and meat - For surveillance, control and eradication of foreign animal diseases - For biosecurity protection of the national livestock population - For compliance with requirements of international customers - For compliance with country-of-origin-labeling requirements - For improvement of supply-side management, distribution/delivery systems and inventory controls - To facilitate value-based marketing - To facilitate value-added marketing - To isolate the source and extent of quality-control and food-safety problems - To minimize product recalls and make crisis management protocols more effective
113	Smith et al. 2000	The ability to identify animals according to their origin, as far back in the production sequence as is necessary to accomplish the	Beef	To describe the importance of traceability in the US beef industry and determine how beef traceability can	Literature review of traceability and animal identification methods, primarily in the USA, but also in the EU, Australia, and South America.	- The USA beef industry is being converted from "production-driven" to "consumer-driven" - Complete traceability, from animal to enduser, is possible in the USA if fabrication and processing are slow enough

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		intended purpose.		be accomplished in the USA.		- The additional costs of new facilities, additional workers, equipment, and production breaks may be tenfold - Individual animal identification (IAID) is often lost after the point of slaughter when the head and hide of the animal are removed; IAID could be maintained using sequence slaughter order or carcass tagging - AgInfoLink uses EID tags and internet capabilities to accomplish IAID from birth to slaughter; $2.75 for an AllFlex USA ear tag, $1.50 enrollment fee, $1,000 for an ear tag reader, and no charge for the AgInfoLink software program
114	Smith et al. 2005	The ability to identify farm animals (livestock and poultry) and their products (especially their meat), according to their origin, as far back in the production sequence as is necessary to ascertain ownership, identify parentage, improve palatability, assure food safety, and/or assure compliance; also ISO, WTO, Codex Alimentarius, and Sparks (2002) definitions	Livestock, poultry, and meat	To describe how the US is developing, implementing, and maintaining traceability systems.	Review of US animal traceability and identification literature.	Traceability can be used: - To ascertain origin and ownership, and to deter theft - For surveillance, control and eradication of foreign animal diseases - For biosecurity protection - For compliance with requirements of international customers - For compliance with country-of-origin labeling requirements - For improvement of supply-side management, distribution/delivery systems and inventory controls - To facilitate value-based and value-added marketing - To isolate the source and extent of quality control and food safety - To minimize product recalls and make crisis management protocols more effective
115	Smyth and	Systems that focus on	Grains and	To review	Survey of literature	- Costs will outweigh the benefits of an

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	Phillips 2002	ensuring food safety.	oilseeds	existing product differentiation systems as lessons for government and industry; examination of identity preserved production and marketing, segregation, and traceability.	on identity preserved production and marketing, segregation, and traceability.	on-farm HACCP-based food safety system - Premiums may be available initially to attract producers to the traceability program, such as in the Scottish Quality Cereals program where 1 GBP was offered as a premium to attract producers of malting barley for the first year of the program; this was discontinued in the second year as there was enough supply of high quality malt barley; other producers may have no choice but to join the program to ensure market access
116	Sodano and Verneau 2004	N/A	Food	To study firms' strategic responses to traceability in order to assess its effectiveness as a food safety tool and its role in driving the evolution of structures and strategies within the food system.	Discussion of the effectiveness of traceability in achieving food safety goals, the private and national costs and benefits of traceability, and a case study of the Italian processed tomato sector.	- Mandatory traceability can lower firms' incentives to invest in private labeling and certification systems as well as in internal quality control systems - Traceability reduces problems of asymmetric information, and therefore the need of certification; lowers the consumers' safety risk perception and therefore their demand of assurance; and weakens the power of other legal tools, such as tort liability, therefore reduces incentives for firms to reduce food safety problems - Private labels can exploit the larger benefits from the "transaction-cost reduction effect" of traceability giving them an advantage over national brands
117	Sofos 2008	N/A	Meat	To provide additional information and specifics under	Literature review of meat safety issues.	- Microbial hazards and associated issues will continue being major challenges to meat safety in the future - Management of meat safety risks

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				major current and future meat safety challenges.		should be based on an integrated effort and approach that applies to all sectors, from the producer through the processor, distributor, packer, retailer, food service worker, and consumer - Consumer education and environmental pollution issues should be major targets to improve meat and food safety
118	Souza-Monteiro and Caswell 2004	*The ability to follow the movement of a food through specifies stage(s) of processing, production, and distribution* (EC 178/2002).	Beef	To compare the economic impact of mandatory and voluntary beef traceability systems in the EU, Japan, Australia, Brazil, Argentina, Canada, and the United States, in terms of the systems' breadth, depth, and precision.	Literature review of academic, government and legislative documents on traceability.	- The EU and Japan have mandatory traceability; all beef produced domestically must be traceable backward and foreword from retail to farm of origin - Japan is using DNA samples to confirm accuracy of databases and they have the strongest system for relaying information to consumers - Australia and Brazil have plans for general mandatory traceability; it is mandatory for exported beef only - Canada has a mandatory animal identification system for all animals moving away from the farm of origin - Argentina has a mandatory traceability system for exported beef only; domestic animals only have to be identified if there are produced in regions where animal diseases persist - Traceability is voluntary in the U.S.
119	Sparling and Sterling	N/A	Food	To discuss and present a framework for further exploitation of the business value of	Discussion of earlier work done by the authors.	- Costs of whole-chain traceability: technology (software, services, hardware), database changes and systems integration, implementation and training, and on-going maintenance and support - Quantifiable benefits: regulatory

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				traceability in the food sector.		benefits, recall and risk management benefits, supply chain process benefits, market and customer response benefits - Qualitative benefits: impact on reputation and perception related to reduced risks - Usually benefits outweigh the costs when tallied for an entire chain, but not necessarily at each level; redistribution of costs and/or benefits may be necessary to ensure participation of all stakeholders
120	Sparling et al. 2006	Traceability systems are record-keeping systems designed to track the flow of product or product attributes through the production process or supply chain.	Dairy	To examine traceability in the Canadian dairy-processing industries in order to better understand the drivers behind the implementation of product traceability in the Canadian dairy-processing sector. To examine the challenges facing managers during implementation, and the costs and benefits experienced by firms implementing traceability.	Two phases of data collection from April 2004 to January 2005. (1) Involved six in-depth, semi-structured interviews (mail survey) with quality-assurance managers at dairy processing facilities in Ontario and Manitoba (10 facility pilot study). (2) Final postal survey of 386 processing facilities across Canada in late 2004; generated 130 responses, a 34% response rate.	- Almost 91% of the respondents to the survey had implemented a system of product traceability - For those with traceability, 89% were able to track their products fully to the level of retail distribution - 66.1% of the cases used manual traceability and 33.9% used computer/electronic traceability - Less than 23% of plants that had implemented traceability had experience a product recall and/or withdrawal in the three years prior - 35% have experienced a product recall and/or withdrawal after implementation - Important costs incurred during implementation were inspections/ audits, laboratory testing, and the time of supervisors, production workers, and managerial /administrative staff - 66.4% of plants had not experienced any change in production costs as a result of implementing product traceability; 26.4% felt costs increased,

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						and 7.3% felt costs decreased - 60% considered that benefits of implementing traceability exceeded costs - 27.8% considered that benefits of traceability exceeded expectations
121	Spriggs, Hobbs and Fearne 2000	N/A	Beef	To determine whether there are differences in the attitudes of beef producers in Canada and the UK to issues of (horizontal and vertical) coordination and quality assurance.	Literature review of vertical and horizontal coordination in the agri-food sectors. Random sample mail surveys (three part questionnaire) of beef finishers in Canada and the UK in late 1997 and early 1998.	- 16% of Canadian respondents indicated they had introduced cattle traceability compared with 27% of UK respondents - 3% of Canadians had joined a producer group vs. 12% of the UK respondents - 33% of UK respondents characterized buyer-seller relationships as "buyer-dominated" vs. 18% in Canada; 53% of Canadian respondents characterized this relationship as "equally beneficial" vs. 34% for UK - 50% of UK respondents agreed that the main purpose of a quality assurance scheme is to convince consumers that beef is safe; for the same statement 53% of Canadians agreed the main purpose was to ensure only the highest quality of beef is sold
122	Stanford et al. 2001	N/A	Cattle and small ruminants	To identify potential cost effective methods for animal identification and describe the benefits and costs of such systems; there is a focus on Canadian animal	Review of the success rate and benefits and costs of various animal identification methods.	- Canada's national cattle identification program will have annual operating and administrative costs of CAN$0.20 per head, excluding ear tags (2001) - Annual cost of the UK cattle passport system (central database) is approximately $13.60 per head, excluding tags - A national, paperless tracking system in the Netherlands costs approximately $6.50 per head excluding tags

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				identification systems.		- The CCIA traceback system has implemented Internet-based technologies with annual operating and administration costs estimated at $6.20 per head, excluding tags - To 2001 government funding for the development of a system for individual animal identification and traceback was $1.5 million - The visual CCIA system ensures traceability of cattle from carcass inspection back to the farm of origin - Electronic identification (EID) would increase the speed and accuracy of information flow and offer increased protection from fraud, the cost of these systems outweighs the utility (2001) - EID costs will decrease over time, as will other methods such as DNA fingerprinting and retinal scanning
123	Starbird and Amanor-Boadu 2006	N/A	Food	To determine how inspection and the liability function of traceability influence the supplier's willingness to deliver safe food.	Build on existing literature by developing a model to show how inspection and traceability systems interact to motivate the supplier to deliver safe food.	- Anything that reduces the probability or cost of food safety incidences reduces the incentives for suppliers to deliver safe food - The traceability system provides an incentive only if safety failures can occur, can generate a cost, and the cost can be allocated to the responsible supplier - Safety failures occur only if contaminated lots pass inspection; they will only pass inspection if there is an inspection error - A traceability system that allocates safety failure costs to suppliers increases the incentive to supply safer food

NO.	AUTHOR	DEFINITION OF TRACEABILITY	CONTEXT	OBJECTIVE	METHODS	AGGREGATE SUMMARY
124	Talbot 2004	N/A	Meat	To discuss how electronic and biological tracking technologies could safeguard the nation's food.	Literature and industry review of the beef industry.	- An American company swift is using retinal scanning technology to track its animals from feedlot to slaughter - Maple Leaf Foods Canada markets pork that is tracked using DNA-testing at a cost of $40 per test
125	USDA Animal and Health Plant Inspection Service 2007	The ability to document all relevant elements needed to determine the life movement history of an animal.	Animals	To identify significant opportunities and strategies for advancing the US animal disease traceability infrastructure.	Discussion of NAIS traceability strategies, NAIS budget summaries and plans, and the projected timelines and outcomes of the program.	- The long-term goal of the National Animal Identification System (NAIS) is for 48-hour animal disease traceability - NAIS has a plan consisting of 7 strategies to facilitate animal disease traceability in the US - The most efficient, cost-effective approach for advancing the traceability infrastructure is to capitalize on existing resources such as animal health programs and personnel and animal disease information databases
126	Valeeva et al. 2005	N/A	Dairy	To quantify the importance of attributes for improving food safety in the supply chain, using the dairy production chain for fluid pasteurized milk as a case study.	Use of adaptive conjoint analysis as a technique for measuring consumers' tradeoffs among multi-attributed products. The production chain was divided into 4 blocks: "feed", "farm", "dairy processing", and "consumer". ACA system collects individual respondents' preference survey	Chemical Hazards - Finished compound feed identification and traceability had a 2.66% relative importance (12th out of 15) - Feed ingredient identification and traceability scored 2.62% (13th of 15) - Delivered raw milk identification and traceability scored 2.61% (14th of 15) Microbial hazards - Finished product identification and traceability scored 1.58% (6th of 15) Individual chain participants attach a high importance to the products supplied by the preceding chain participants. These attributes include requirements for feed and animal traceability, milking of cows, the storage of antibiotics, and general

NO.	AUTHOR	DEFINITION OF TRACEABILITY	CONTEXT	OBJECTIVE	METHODS	AGGREGATE SUMMARY
					data in a computer-interactive interview mode.	farmer education and training.
127	van Dorp 2003	N/A	Beef	To discuss the emergence of the exchange of product information and traceability information for the beef supply chain.	Overview of tracking and tracing and a review of the evolution of requirements on product information in the Dutch beef sector.	- There are three layers to supply chain integration: item coding, information architecture, and planning and control - Since the emergence of BSE there is increased desire to exchange additional product information in the supply chain - The additional information indicates which countries the animals are born, reared, slaughtered, cut (and/or deboned), including a traceability reference number
128	van Dorp 2002	Comprehensive chart of traceability definitions. Included are ISO 1994, Moe 1998, Wilson and Clarke 1998 and others.	Supply chains	To present a structure for development and contemporary practices of tracking and tracing.	Literature review of traceability definitions, discussion of the business scope of supply chains and development structure of traceability.	- Tracking and tracing transcends company borders and extends to include all entities of the supply chain, as well as external stakeholders of the environment - Item coding is held responsible for basic forward and backward traceability, the organization of Information Architecture is additionally held responsible for the exchange of certified information on product of material lost and the organization of planning and control is held responsible for extended process control and optimization
129	van Rijswijk and Frewer 2006	N/A	Food	To provide insight into how traceability information can offer guarantees of food quality and safety, and	163 consumers from four European countries (Germany, France, Italy, and Spain) participated in focus groups to rate 15 product attributes	- 69% of participants referred to both quality and safety as being related to traceability - Consumers strongly related the concepts of quality and safety - 38% of participants considered quality more important than safety, 37%

NO.	AUTHOR	DEFINITION OF TRACEABILITY	CONTEXT	OBJECTIVE	METHODS	AGGREGATE SUMMARY
				contribute towards increased consumer confidence.	regarding their importance to traceability. Some questions were also asked in semi-structured follow up interviews.	considered safety more important than quality, and 25% did not indicate one was more important than the other - In Italy strong links between traceability and safety were observed - The results do not support a strong divide in preferences for food quality and food safety across Northern and Southern EU member states, as was hypothesized
130	Viaene and Verbeke 1998	A system that tracks products through the entire supply chain	Meat, specifically poultry	To discuss the restoration of consumer confidence in the Belgian meat industry through Sanitel, a traceability system, and how similar systems are needed for effective supply chain and quality management	An overview of Belgium's poultry sector and their traceability system, Sanitel.	- As well as meeting the objectives of disease and movement control and labeling requirements, each Sanitel system provides the opportunity to add value to products to better meet consumer demand - Current focus is on consultations throughout the supply chain, involving representatives from government, veterinarians, farmers and farm organizations, the feed industry, and slaughterhouses
131	Wall 1995	N/A	Materials	To discuss the concept of materials traceability.	Discussion.	- Materials traceability can target priority areas and show positive results from the start - Each critical control point holds the potential to influence the efficiency of the process and the quality of the product - Investment in materials traceability is a wise business decision when customers are increasing their demands for proof-of-quality
132	Ward, Bailey and Jensen 2005	Traceability is essential for dealing with BSE	Beef	To determine if traceability	Experimental auctions were used to	- Participants concerned about food safety needed smaller bribes to switch

NO.	AUTHOR	DEFINITION OF TRACEABILITY	CONTEXT	OBJECTIVE	METHODS	AGGREGATE SUMMARY
		and other animal disease control and eradication issues, addressing bio-terrorism concerns in the food chain, and narrowing the focus (limiting) of food recalls.		systems for beef can help preserve consumer demand following the discovery of BSE	examine the WTA of US consumers for non-traceable beef from the US and Canada both before the BSE case in December 2003 and after the US BSE announcement.	their sandwich before the US case of BSE - Both traceability and country-of-origin information or knowing the beef was produced domestically were more acceptable to participants than simply knowing the meat was inspected - Traceability makes Canadian beef more acceptable than if it is non-traceable - A large percent of US consumers would support and be WTP for a mandatory animal ID system
133	Wiemers 2003	N/A	Animal	To discuss the importance of animal identification and traceability systems in protecting American livestock from foreign animal diseases.	Discussion of the need for and challenges of national animal identification.	- A national animal identification strategy is needed to track animal movement to maintain the health of the national herd so responses to national biosecurity threats are swift, response to a foreign animal disease outbreak is swift, trade continues, diseases are eradiated and controlled, and animal identification crises are avoided - Challenges for a National Animal Identification Program are tradition of livestock producers, cost (how much and who pays), data issues, and producer acceptance issues - Overall identification cost per animal is estimated at $6.50-$8.80
134	Wilson and Clarke 1998	Food traceability is the information necessary to describe the production history of a food crop, and any subsequent transformations or processes that the crop	Food	To describe a possible mechanism for the design and development of a software system that will become the de facto	A descriptive review of the Food Trak system and its benefits.	- The ability to collect food traceability information in "real time" provides benefits to the food industry such as assurance of product quality, quick identification of problems, and consumer confidence - Food Trak method uses a central database and the world wide web

NO.	AUTHOR	DEFINITION OF TRACEABILITY	CONTEXT	OBJECTIVE	METHODS	AGGREGATE SUMMARY
		might be subject to on its journey from the grower to the consumer's plate.		industry standard for the collation, location and dissemination of traceability data.		accumulate data - A traceability record has 5 sections: location, input, process, monitor, and output - Benefits of Food Trak: one point of data entry, no duplication cost/effort, efficient and secure, easy to use, affordable and fair, demonstration of quality husbandry and management, access to markets and ability to compete on quality, provision of due diligence information
135	Young and Hobbs 2002	N/A	Agri-food industry	To investigate some of the issues arising from these developments and implications for the respective roles of producers, their associations, and government.	A review of agricultural markets, linkages in the supply chain, product differentiation,	- There are efficiency gains in some industries due to closer vertical coordination, but large contractors may lose their market power to depress prices paid for inputs, and make other contract conditions disadvantageous for producers - Increased product differentiation is a notable development with closer vertical coordination - Closer vertical coordination of the agri-food sector has been accompanied by rationalization and increasing concentration in the input supply; may need government interaction

[1] Tracking is the ability to follow the path of a specified unit and/or lot of trade items downstream through the supply chain as it moves between trading partners. (p.12)

[2] Tracing is the ability to identify the origin of a particular unit located within the supply chain by reference to records held upstream in the supply chain. (p.12)

APPENDIX 3. OVERVIEW OF SELECTED EXISTING TRACEABILITY SYSTEMS

Table 3 Existing Traceability Systems.

COUNTRY	LEGISLATION OR CERTIFICATION	DEFINITION	SYSTEM TYPE	STAGES	SUCCESS OR PROGRESS
Australia Programs: **(A**) National Vendor Declaration (NVD) and Waybill **(B)** National Feedlot Accreditation Scheme (NFAS) **(C)** EAN numbering/ DNA sampling	**I.** National Livestock Identification System (NLIS) **II.** Property Identification Code (PIC) and Tail Tag System	Traceability / product tracing: *the ability to follow the movement of a food through specified stage(s) of production, processing, and distribution* (Codex Alimentarius Commission 2004).	**I. Mandatory** (since 1 July 2005; voluntary from 1999 to 2005): Government legislated for international market competitiveness [11, 12] **II. Mandatory** (since the 1960s): Government legislated and based on a unique identification number assigned to each farm or parcel of land [12] **(A) Mandatory for export**: Producer led, underpinned by state legislation; the NVD is independently audited under the Livestock Production Assurance (LPA) scheme (which is a voluntary program) [12] **(B) Mandatory for export**: Industry self-regulating quality assurance scheme; mandatory for feedlots producing grain fed beef for export markets [12] **(C) Voluntary**: Producer led; collection of DNA samples on farm so that animals can be traced from meat samples [12]	**I.** Under NLIS all cattle at birth are issued a lifetime identification number that is embedded in a radio-frequency chip; traceability is to property of birth.[12] **II.** PIC tail tags are applied at the time of future and subsequent sales and are an additional source for traceback, but are unique only to a lot or pen of cattle.[12, 18] **(A)** NVD is a mechanism for the transfer of information on the history of livestock consigned for sale or slaughter.[12] **(B)** All grain-fed cattle in Australia destined for export must be individually identified with a unique identification number when they enter a feedlot and movements on and off the feedlot must be recorded.[11] **(C)** Producers using EAN technology assign each animal with a unique EAN compliant number based on the PIC and sequence number and linked to the NLIS number; DNA hair samples are collected and can be matched to DNA from meat	Meat and Livestock Australia is the governing body of beef markets in Australia. NLIS became mandatory in Australia in 2005 to maintain competitive advantage.[11]

COUNTRY	LEGISLATION OR CERTIFICATION	DEFINITION	SYSTEM TYPE	STAGES	SUCCESS OR PROGRESS
				samples.[12]	
England – Tesco Supermarkets Programs: **(A)** Producer Club **(B)** Assurance Schemes, either Farm Assured British Beef and Lamb (FABBL), Scottish Quality Beef and Lamb Assocication (SQBLA) or Farm Quality Assurance Scheme (FQAS) (Northern Ireland)	**I.** Tesco Codes of Practice **II.** Tesco's Livestock Codes of Practice **III.** Fair Trading Act: Supermarkets' Code of Practice (2002)	*Traceability is the ability to trace and follow food, feed, food-producing animals or substances intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution* (EC Regulation No. 178/2002).	**I. Mandatory**: Retail driven; Tesco Club Members must follow Codes of Practice [9] **II. Mandatory**: Retail driven; all meat suppliers must be a member of the Livestock Codes of Practice [16] **III. Mandatory**: Initiated by industry; Governs Tesco's relations with suppliers [15] **(A) Voluntary**: Led by Tesco with producer committees; producers who are Club members are not under contract but must commit at least 50% of their stock [6] **(B) Mandatory**: Producer led schemes [10] are voluntary, but Tesco (and all other major supermarkets [6]) require that beef suppliers must be member of a recognized assurance scheme [9]	**I.** The EU regulations are baselines to Tesco Codes of Practice, including traceability requirements.[9] **II.** Used to ensure animal welfare and whole life traceability where possible, may include feed and breeder stock.[16] **III.** Outlines the regulations for trading between the four largest UK supermarkets (Tesco, Asda, Sainsbury, and Safeway) and their suppliers.[15] **(A)** Ensures that all the meat Tesco sells comes from animals that can be traced back to the farm where they were born and where they have been reared.[6] **(B)** Assurance Schemes provide origin/traceability information [10] from farm through to retail store.[6]	90% of Tesco fresh pork, beef and chicken come from British farms.[16] To supply to Tesco it is mandatory that producers be part of the Producer Club and follow Tesco Codes of Practice.[6]
Japan Programs: **(A**) Jusco Supermarkets (Aeon Company Ltd): National Feedlot	**I.** The Law Relating to Special BSE Countermeasures (July 2002) **II.** The Beef Traceability Law	Traceability / Product Tracing: the ability to ensure, at any stage(s) of the food chain, the	**I. Mandatory**: Government regulated [4] **II. Mandatory**: Government regulated; Ministry of Agriculture, Forestry, and Fisheries [4]	**I.** Traceback of all cattle from the feedlot to the packing plant; unique identification number on the ear tag of each animal.[4] **II.** Traceability from	'Story Meats' provide quality and safety assurance to consumers in addition to government programs. Story Meats are

COUNTRY	LEGISLATION OR CERTIFICATION	DEFINITION	SYSTEM TYPE	STAGES	SUCCESS OR PROGRESS
Accreditation Scheme[10] **(B)** Jusco Supermarkets: Wagyu beef consumer assurance[10] **(C)** Ito Yokado Supermarket	(2003)	path of a food and the relevant information of the food are known, including product identification and where and when it came from and where and when it was sent and the other product information if appropriate (Codex Alimentarius Commission 2004).	**(A) Voluntary**: Retail driven; certificate of assurance from the Australian Feedlot Association for Aeon's Tasmanian (Australian) beef (TruValue Brand) [4] **(B) Voluntary**: Retail driven; BSE testing certificate, production record certificate, photograph of the producer (TruValue Brand) [4] **(C) Voluntary**: Retail driven; point of sale information is posted, including photographs of producers and information on the type of animal [4]	production through distribution to consumption; an internet based system [4]. **(A**) Ensures that beef is free of growth promotants, therapeutic antibiotics, bone meal feed materials, and any genetically modified feed materials.[4] **(B)** Meat is traceable from the supermarket to the producer of which the calf was born, feedlot, slaughter plant, processing plant, and meat inspector, information on the animal's diet is also provided.[4] **(C)** The location of where the animal is produced is provided on the label.[4]	successful in Japan due to a general mistrust of the government over food safety. Story Meats and assurance labeling has expanded in Japan and some products receive a price premium for this information.[4]
Scotland Programs: **(A)** Scottish Borders Tag (Traceability and Assurance Group); **(B)** Scotch Quality Beef and Lamb Association (SQBLA); **(C)** Scotbeef's BeefTrack™ (a member of SQBLA); **(D)** The Guild of Scotch Quality Meat Suppliers; **(E)** Scotch Beef Club	**I.** The Cattle Identification (Scotland) Regulations 2007 **II.** The British Cattle Movement Service (BCMS) of the Rural Payments Agency (RPA): The Cattle Tracing System (Great Britain, since 28 September 1998) **III.** Scottish Food Quality Certification	*Traceability is the ability to trace and follow food, feed, food-producing animals or substances intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution* (EC	**I. & II. Mandatory**: Government regulated. **III. Voluntary**: formed in 1995 to give credibility to the quality and farm assurance schemes already formed (i.e. SQBLA) **(A) Voluntary**: Producer led initiative **(B) Voluntary**: Consumer driven [8] **(C) Voluntary**: Consumer driven **(D) Voluntary**: Retail	**I.** Regulations on cattle identification in Scotland; came into force on 06 April 2007.[17] **II.** Provides traceability of cattle from birth to death.[5] **(A)** Full traceability and assurance program; individual animal identification, information on cattle movements, and official government department inspections on farm (UK Ministry of Agriculture, Fisheries, and Food).[2]	**(B)** In 1998 SQBLA involved over 7,000 farms all Scottish livestock markets, 20 meat plants, 2,000 butchers, and 850 restaurants [14].

COUNTRY	LEGISLATION OR CERTIFICATION	DEFINITION	SYSTEM TYPE	STAGES	SUCCESS OR PROGRESS
	Ltd. (SFQC), accredited by EN45011[8]	Regulation No. 178/2002).	driven **(E) Voluntary**: Retail driven	**(B)** With the use of Cattle Control Documents (CCD) all movement are recorded since July 1996;[14] quality assurance from farmers to retailers.[14] **(C)** Identification of individual animals, producers, producer's farm, welfare, environment and animal health management, identification of raw material and food safety management through to the final consumer, since 1992.[13,14] **(D)** Full traceability from the live animal to the batches of meat.[14] **(E)** Group of restaurants that are able to trace Scotch Lamb and Beef to their suppliers.[14]	
Uruguay Programs: **(A)** Sistema de Indentificacion y Registro Animal (Animal Identification and Record System); **(B)** Certified Natural Meat Program of Uruguay, created by INAC (National Meat Institute of Uruguay)	**I.** DICOSE (Division de Controlar de Semovientes) Traceability System[1] **II.** International Certification bodies, including USDA Process Verified Certified Natural Beef Label [1,3]	Traceability / product tracing: *the ability to follow the movement of a food through specified stage(s) of production, processing, and distribution* (Codex Alimentarius Commission 2004).	**I. Mandatory** (since 1973): developed by the Ministry of Livestock, Agriculture, and Fisheries to help eradicate FMD and trace animals back to their origin [7] **II. Voluntary**: Retail driven **(A) Mandatory** (since September 2006): Government led; all individual animals must be identified [1] **(B) Voluntary** (since	**I.** Under DICOSE animals can be traced back to their farm of origin through region codes, movement and sales records and police authentication of all sales documents.[1] Animals are traceable to their origins up until carcass disassembly where cuts can then be traced to a lot number. Plants hope to implement post-plant traceability by 2010.[1] **II.** Traceability from farm of origin to slaughter.[1] **(A)** This program ensures	**I.**: Acceptance of DICOSE traceability system and the Uruguayan ban on growth hormones has provided access to EU markets [1]. **(B)**: From 2004 to June 2006 certified farms have increased 56 to 277, animals in certified farms have increased 90,000 to 550,000, certified slaughterhouses have increased 1 to 10, and

COUNTRY	LEGISLATION OR CERTIFICATION	DEFINITION	SYSTEM TYPE	STAGES	SUCCESS OR PROGRESS
			2001): led by independent certification bodies; animals marketed (farmers and slaughter plants) under the program are source verified, have no added hormones, are not fed antibiotics, no animal proteins in feed, are grass fed, and on open range [3]	individual animal identification (each animal receives one visual tag and one RFID tag at birth), farm identification, recorded information, and ownership and cattle movement records.[1] **(B)** Main components of the program are food safety, traceability, animal welfare, and environmental sustainability.[1]	exports have increased 0 to 482 metric tons [1].

[1] Boland, Fox and Perez 2007.
[2] Calder and Marr. 1998.
[3] Certified Natural Meat Program of Uruguay. www.uruguaymeat.gub.uy/english/home.php
[4] Clemens 2003.
[5] DEFRA: Livestock movements, ID and tracing: cattle. http://www.defra.gov.uk/animalh/id-move/cattle/index.htm
[6] Fearne 1998.
[7] Krissoff, Bohman and Caswell 2002.
[8] Leat, Marr, and Ritchie 1998.
[9] Lindgreen and Hingley 2003.
[10] McEachern and Schroeder 2004.
[11] Meat and Livestock Australia 2004. http://www.safemeat.com.au/NR/rdonlyres/84B70E46-174F-4C4F-8DAC-CAF50A48ED7B/0/beefsafetybrochure.pdf
[12] Safe Meat 2007. http://www.safemeat.com.au/English/Traceability/
[13] Scotbeef Ltd. 2008. www.scotbeef-online.co/uk
[14] Simpson, Muggoch, and Leat. 1998.
[15] Talking Tesco: How we compete. http://www.tesco.com/talkingtesco/suppliers/
[16] Tesco: Livestock 2006.
[17] The Scottish Government, Agriculture. http://www.scotland.gov.uk/Topics/Agriculture/animal-welfare/Diseases/IDtraceability/cattleid
[18] Tonsor and Schroeder 2004.

APPENDIX 4. COSTS AND BENEFITS OF TRACEABILITY

Table 4 Qualitative Benefits and Costs of a Traceability System.

STAGE: FARM – cattle may go to feedlot, slaughter, or distribution			
AGENTS	**BENEFITS AS IN THE LITERATURE**	**COSTS AS IN THE LITERATURE**	**BENEFICIAL**
Cow-calf producers Forage producers	- Increased transparency[15] - Increased consumer demand with product differentiation[1,9,10,11,12] - Reduced risk of liability claims[4] - Price premium (?)[15] - Improved monitoring and control of individual animal health[1,12] - Tesco's Producer Club provides a stable and guaranteed market for producers[7] - Foster participation in the eradication of endemic diseases[6] - Property protection[9,14,17] - Verification of credence attributes[9] - Improve operational efficiency through better planning for capacity utilization, capital investment, and spending plans[9] - Greater ability to sell stock by assuring low probability of disease[1] - Maintaining consumer confidence during food safety scares[12] - Reduced incentives to cheat[12]	- Facilities modification[8] - RFID tags (cost of animal identification[6,9]), applicator, readers[7] - RFID data accumulator and database software[8] - Labour: RFID application, reading, data accumulation, training and recordkeeping[8] - Internet services[8] - Auditing fees[4,13,15] - Organization fees[4] - Cost of product differentiation[10] - May be used to place liability for unhealthy or low-quality animals[9] - Program administration fees[8]	**Uncertain/ potential:** disease and animal health monitoring[1], if producers are given a price premium[7], risk reduction, maintaining consumer confidence, and in the event of a recall[8], annual costs decrease at large scales[2], and through reduced foreign animal disease[6]
Dairy operations	- All of the above producer benefits - Increased opportunity to market old/unproductive cows[13]	- All of the above producer costs	**Yes/potential:** as stated for producers
Stocker operations	- All of the above producer benefits - Assess and manage the risks associated with introducing livestock to herds[1]	- All of the above producer costs - Monitoring upstream firms[13]	**Yes/potential:** as stated for producers

	- Greater ability to sell stock by assuring low probability of disease[1] - Reduced information asymmetry of quality[12]		
STAGE: FEEDLOT – cattle may go to slaughter or distribution			
AGENTS	**BENEFITS AS IN THE LITERATURE**	**COSTS AS IN THE LITERATURE**	**BENEFICIAL**
Commercial feedlot Farmer feedlot	- Assess and manage the risks associated with introducing livestock to herds[1] - Greater ability to sell stock by assuring low probability of disease[1] - Reduced risk of liability claims[4] - Reduced information asymmetry of quality[12]	- RFID readers[8] - Data accumulator and database software[8] - Labour: training[8] - Tag loss replacement[8] - Program administration fees[8] - Monitoring upstream firms[13]	**Uncertain:** may be more efficient at small scales[4,] annual costs decrease at large scales[2,9]
Auction markets	- Assess and manage the risks associated with introducing livestock to herds[1] - Reduced information asymmetry of quality[12]	- Facilities modification[8] - RFID readers[8] - RFID data accumulator and database software[8] - Labour: training[8] - Internet services[8] - Program administration fees[8] - Monitoring upstream firms[13] - May result in auction markets becoming obsolete (transparent price-setters)[13]	**Uncertain:** costs can vary widely from $0 to thousands of dollars[11]
Interprovincial import	- Assess and manage risks associated with introducing livestock to herds[1]		**Uncertain**
Export	- Increased cross border trade and increased market access[12,16,17]		**Yes:** above feedlot benefits are greater if exporting[12]
STAGE: SLAUGHTER – beef may go to processing or distribution			
AGENTS	**BENEFITS AS IN THE LITERATURE**	**COSTS AS IN THE LITERATURE**	**BENEFICIAL**

Abattoirs Cutting plants	- Reduces recall costs and amounts recalled[4] - Assures quality control and food safety[14] - Increase efficiency in tracking the flow of products; coordinates production[9] - Reduces the costs of containing a food safety problem if one occurs[4] - Reduced information asymmetry of quality[12] - Reduces the transaction costs in monitoring the activities of upstream suppliers[10,12]	- Facilities modification (for EU certification or not)[5,8] - RFID readers[8] - RFID data accumulator and database software[8] - Labour: training[8] - Internet services[8] - Inspection fee[5] - Production chain changes, additional employees[4] - Program administration fees[8] - Licensing fees[13] - Monitoring upstream firms[13]	**Uncertain:** may be more efficient at small scales[4], annual costs decrease at large scales[2] **Yes:** minimize the extent of safety or quality failures[9]
STAGE: PROCESSING – beef goes to distribution			
AGENTS	**BENEFITS AS IN THE LITERATURE**	**COSTS AS IN THE LITERATURE**	**BENEFICIAL**
Processing plants Packing plants	- Reduces the costs of containing a food safety problem if one occurs[4] - Identifies all sources of product and may reduce recall costs and amounts recalled[4,10] - Increase efficiency in tracking the flow of products; coordinates production[9] - Reduce transaction costs in monitoring the activities of upstream suppliers[10,12] - Reduces the facility's insurance premiums[12]	- Facilities modification for EU certification[5] - Inspection fee[5] - Scanners, production chain changes, additional employees[4] - Licensing fees[13] - Monitoring upstream firms[13]	**Yes:** improved ability to export product, increased credibility[12] **Uncertain:** costs vary[11]
STAGE: DISTRIBUTION			
AGENTS	**BENEFITS AS IN THE LITERATURE**	**COSTS AS IN THE LITERATURE**	**BENEFICIAL**
Export	- Improved trade relations and increased cross border trade[16] - Increase market access to importing countries requiring traceability[17]	- Additional Residue Testing Program fee ($30,000/5years) and testing costs(EU export)[5] - Gross trade losses[6]	**Yes:** benefits are greater if exporting[12]
Meat wholesalers Traditional butcher	- Labour savings of up to 5 hours per week with Food Trace[3]	- Advertising and promotion expenditures to reassure consumers of quality and	**Yes:** in the event of a

Restaurants Supermarkets Independent grocers Direct sale outlets Foodservice co.	- Identifies all sources of product and may reduce recall costs and amounts recalled[4,10] - Maintain consumer/buyer confidence[10] - Reduce transaction costs in monitoring the activities of upstream suppliers[10] - May reduce risk exposure[10]	safety[13] - Information costs for consumers; the product quality[13] - Monitoring upstream firms[13]	recall[10]
Farmer's market	- Generates a common bond of safety and quality credibility[14]		**Uncertain**
Imported meat	- Reduced transaction costs of monitoring exporting firms - Increased trade	- Monitoring upstream firms[13] (international or domestic)	**Uncertain**
STAGE: CONSUMER			
AGENTS	**BENEFITS AS IN THE LITERATURE**	**COSTS AS IN THE LITERATURE**	**BENEFICIAL**
Consumer	- Food safety and quality control[10] - Reduced information costs[10] - Quality and credence attributes assurance[10] - Focus of the industry on consumer requirements[13]	- Price premium (?)[15] - Consumer privacy[16]	**Yes:** food safety and product differentiation[12], consumer reassurance[3] **No:** traceability *alone* is not valuable to most consumers[10]
Government or Public	- Reduction of foodborne illnesses[17] - Faster identification of the emergence and spread of new threats to animal and human health[12,17] - Prevent entry of foreign animal disease[14] - Reduce the risk of slaughter of older or at risk cattle[13] - Reduced societal costs in case of a food safety event through reduced medical costs and reduced lost productivity[11] - Research to improve industry quality[12]	- Implementing one national traceability portal[12] - Monitoring and enforcement[13]	**Yes:** public health and food safety (society), one national portal provides economies of scale[12] **Potential:** as an industry-wide active surveillance[1]

	- One national system is efficient and facilitates interprovincial trade[12]		

[1] Animal Health Australia. 2003.
[2] Bailey, D. 2004.
[3] Bracken, J. and G. Matthews. 2005.
[4] Buhr, B. 2003.
[5] Clemens, R and B. Babcock. 2002.
[6] Disney, W., j. Green, K. Forsythe, J. Wiemers, and S. Weber. 2001.
[7] Fearne, A. 1998.
[8] Gardner Pinfold Consulting Economists Limited. 2007.
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[10] Hobbs, J. 2003.
[11] Hobbs, J. and K. Sanderson. 2007.
[12] Hobbs, J., M. Yeung, and W. Kerr. 2007.
[13] Loader, R. and J. Hobbs. 1996.
[14] McKean, J. 2001.
[15] Meuwissen, M., A. Velthuis, H. Hogeveen, and R. Huirne. 2003.
[16] Popper, D. 2007.
[17] Souza-Monteiro, D. and J. Caswell. 2004.

Table 5. Selected Studies that Provide Quantitative Direct Cost Estimates of Traceability.

Type of regulation	*Administration: Recordkeeping; Planning; Testing*	*Capital outlays (cost of installation; cost of equip.; downtime; transportation costs); Cost of meeting standards (property, plant and equipment)*	*Source*
HACCP	Average 52 days training; each plant hires on average 3.7 extra workers to remain in regulatory compliance	Up to US $ 281,500	Ollinger et al (2004)
Traceability	Data entry: 2 records/minute, 11 entries/animal = 0.10/ animal; tag cost 1.00		Disney et al (2001)
Traceability	Ear tags $2.65-3.00 *Farmer total est: C$5.68-10.35 (per head)* *Slaughter total est: C$0.01-0.03*	Slaughter/processing: 1,800-5,500 RFID reader, computer and software: $4,400-15,000; Training: 30 min/employee	Gardner (2007)
Traceability	Tags $1/head; RFID $2-3/head National ID: 122 M/yr – 540M/5yrs, and 175M first year Canada cattle ID: $4M and $1M/year	COOL: 1-3 billion cattle and beef; 20-25 M per plant to as low as 70-193 M/yr	Becker (2007)

APPENDIX 5.SURVEY INSTRUMENTS

Table 6 Survey Instruments Summary.

Title	Author	Survey/Report	Summary
Food supply chain dynamics and quality certification – Review report	Aragrande *et al.* 2005	Report	- Annex A gives a description of quality assurance/sustainability labels and certification schemes in Europe - http://foodqualityschemes.jrc.es/en/documents/ReviewReport_000.pdf
Risk aspects of meat production – results of an expert survey	Branscheid, Röbken, and Wicke 2004*	Neither	-
Meat slaughter and processing plants' traceability levels, evidence from Iowa	Bulut and Lawrence 2007	Both	- Mail survey of 46 questions to 194 licensee plants listed with Iowa Department of Agriculture Meat and Poultry Bureau - Raw data results: plant characteristics, frequency of mock trials for traceability, depth and precision of traceability
Consumer preferences for food product quality attributes from Swedish agriculture	Carlsson, Frykblom, and Lagerkvist 2005	Report	- A choice experiment testing the marginal willingness to pay for existing and non-existing public and private attributes from Swedish agriculture (product markets: chicken, beef, pig, egg, milk, and grain)
Two-step tracking, traceability, or BSE testing: which do U.S. beef consumers prefer?	Checketts 2006	Both	- Voluntary survey in grocery stores; $5 gift certificate for participating - Steak with traceability and guaranteed BSE-tested characteristics in favoured by 86% of respondents - 57% will pay a 5% premium for a traceable steak, 72% will pay a 5% premium for a BSE-tested steak, and 76% will pay a 5% premium for a steak with both characteristics
Consumer confidence in the safety of food in Canada and the Netherlands: the	de Jonge and Goddard 2007	Survey and submitted report	- A cross sectional internet survey conducted in the Netherlands and Canada; volunteers were 16 years or older - 1136 individuals completed the questionnaire - General consumer confidence in food was determined through general trust, food attitudes, perceived safety of meat, attitudes towards eating

Title	Author	Survey/Report	Summary
validation of a generic framework			beef, trust in the food industry, animal production concerns, and recall of media coverage on BSE
Traceability systems in the German food industry – towards a typology	Gampl 2003	Report and survey results	- Survey of traceability assurance programs for pork - Telephone survey in September 2002 of 17 associations of the German food industry
Consumers' perceptions of food traceability in Europe	Giraud 2006	Report	- Survey of consumers' perception of food traceability by means of discussions of focus groups involving twelve European countries
Exposium GS1 – Europeans and Traceability	GS1	Survey (partial) and results	- Survey of 5 European countries (France, Germany, UK, Italy, Spain) - Questions on: the use and priorities of traceability, the perceived risks of traceability, confidence, responsibilities, and guarantees, and awareness and perceptions of RFID
Economic impact of country-of-origin labeling in the U.S. beef industry	Hanselka 2004	Both	- Questionnaire survey for retail chain stores and distributors, meat packers and processors, cattle feedlots, and cattle backgrounders and stockers - The study estimates that COOL will cost the beef industry a total of $1.87 billion: $818 million (or $0.0833/pound) to the retail sector, $603 million (or $16.99/head) to the packer/processor sector, $356 million (or $12.94/head) to the feedlot sector, and $97 million (or $3.89/head) to the cow/calf producer
Identification and analysis of the current and potential benefits of a national livestock traceability system in Canada	Hobbs, Yeung and Kerr 2007	Both	- Interviews were conducted to determine the perspectives of industry stakeholders on a national traceability system for Canada - Stakeholders, from different parts of the country, included producers, auctions and markets, industry associations, packers and service providers - Current and potential benefits were determined for producers, the Agrifood industry and supply chain, and society through questions pertaining to risk, governance, marketing enhancing abilities, supply chain, and production management
Establishing trust through traceability	IBM Global Business	Report	- Food product safety issues are driving Consumer Product (CP) companies to create traceability systems

Title	Author	Survey/Report	Summary
	Services		- If CP companies create Full Value Traceability they will be better able to protect their brands from contaminations, recalls and private label competition - Full Value Traceability will also help CP companies restore consumer confidence and enter new, high-value markets
Consumer perceptions of food safety and quality Wave 2 Tracking 2006	Ipsos-Reid Corporation for Agriculture and Agri-Food Canada 2006	Both	- 20 minute telephone questionnaire - Market research study to benchmark (2004) Canadian consumer perceptions, attitudes and behaviours related to food safety and quality (2006) - 7% want more information on food traceability (14% in Quebec) - 31% of consumers are familiar with traceability (2006); was 36% (2004) - 27% say a traceability system in Canada would greatly increase confidence in food safety - Relevant survey questions: 17, 19, 20, 21
Traceability and assurance protocols in the global food system	Jones et al. 2004	Report	- A survey designed to address several issues on traceability and assurance protocols - 17 industry members participated in the focus interviews during the 2004 IAMA World Forum and Symposium conference
Estimating consumer willingness to pay for country-of-origin labeling	Loureiro and Umberger 2003	Report, results, selected questions	- A consumer survey (in grocery stores) to determine the willingness to pay of consumers for mandatory country-of-origin labeling - Consumers are WTP an average of $184 per household annually for mandatory COOL
Assessing consumer preferences for country-of-origin labeling	Loureiro and Umberger 2005	Report	- Household consumer survey by mail - While consumers are concerned about the safety of food the willingness to pay for certified US products is relatively small
A choice experiment model for beef: What US consumer responses tell us about relative	Loureiro and Umberger 2007	Report, results, choice experiment example	- Choice experiments were used to analyze US consumers' relative preferences and willingness to pay for labeled meat attributes - Indication of origin may become a signal of enhanced quality if the source of origin is associated with higher food safety or quality - Household consumer survey sent by mail to 5000 representative

Title	Author	Survey/Report	Summary
preferences for food safety, country-of-origin labeling and traceability			households - The survey collected information on purchasing behaviour and attitudes about beef products, beef qualities that consumers find most desirable, food safety attitudes, questions involving a choice modeling experiment, and socio-demographics
British Columbia industry traceability survey (with AAFC)	Meyers Norris Penny	None	- Survey was conducted from October 2005 to January 2006 - Interviewed 45 respondents (processors, primary producers, wholesale distributors, and retailers) - From farm to fork: committing to traceability and trackability systems (MNP) - BC has not used or released the results for this survey yet
Livestock Traceability Situation Analysis	New Zealand Trade & Enterprise	Both	- 9 New Zealand food product companies where solicited by telephone, then delivered a follow-up market research questionnaire - Companies included meat processors, wholesalers and retailers in the supply chain - 90% of responses regarded food traceability as an "opportunity to develop new markets"
	Supermarket News (Michael Garry)*	None	-
Food safety technologies and HACCP compliance: a survey of meat slaughter and processing plants	USDA - ERS	Both	- Increased time, costs, and labour towards Pathogen Reduction/HACCP compliance - 24% said yield was reduced after PR/HACCP rule, 73% said it was unchanged, 2% said yield increased
Requirements for New Animal Products Traceability Systems	Wondu Business and Technology Services	Both	- Online international survey of industry stakeholders (28 surveys, 25% response = 7 responses) - 80% of industry stakeholders are dissatisfied with their current traceability system - 60% of respondents agreed that the cost of compliance with a

Title	Author	Survey/Report	Summary
			traceability system is a major factor in deciding whether to have one

APPENDIX 6. CANADA CATTLE/BEEF STATISTICS

Table 7 Cattle Inventory by Province (thousand of head).

	Jul 1 2001	*Jul 1 2002*	*Jul 1 2003*	*Jul 1 2004*	*Jul 1 2005*	*Jul 1 2006*	*Jul 1 2007*
NFL & LAB	9.5	9.4	10.1	10.7	11.4	11.9	12.5
PEI	85.0	85.0	85.5	86.0	86.5	87.0	90.0
NS	108.5	107.0	107.0	106.0	105.5	104.0	102.0
NB	91.5	91.0	91.5	92.0	92.0	89.5	87.0
Atl. Prov.	294.5	**292.4**	**294.1**	**294.7**	**295.4**	**292.4**	**291.5**
QC	1,360.0	1,657.0	1,420.0	1,515.0	1,455.0	1,425.0	1,395.0
ON	2,130.0	2,585.4	2,160.9	2,180.3	2,154.6	2,032.6	1,953.5
East.Prov.	**3,784.5**	**4,583.7**	**3,875.0**	**4,610.7**	**3,905.0**	**3,750.0**	**3,640.0**
MN	1,425.0	1,470.0	1,590.0	1,730.0	1,735.0	1,680.0	1,540.0
SK	2,900.0	2,940.0	3,220.0	3,540.0	3,625.0	3,450.0	3,430.0
AB	6,500.0	6,387.0	6,100.0	6,400.0	6,700.0	6,300.0	6,470.0
BC	815.0	836.5	885.0	950.0	915.0	820.0	805.0
West.Prov	**11,640.0**	**11,633.5**	**11,795.0**	**12,620.0**	**12,975.0**	**12,250.0**	**12,245.0**
Canada	**15,424.5**	**15,420.9**	**15,670.0**	**16,610.0**	**16,880.0**	**16,000.0**	**15,885.0**

Source: Statistics Canada, Agriculture Division 2007

Table 8 Interprovincial Cattle Trade (thousand of head).

	NWFL&LAB	*PEI*	*NS*	*NB*	*QC*	*ON*	*MN*	*SK*	*AB*	*BC*	*Canada*
July-Dec 2002											
import	0.0	1.9	0.0	0.2	54.6	198.5	56.9	167.8	459.4	41.0	**980.3**
export	0.0	0.0	3.0	4.1	35.2	30.2	181.5	361.1	243.2	122.0	**980.3**
July-Dec 2003											
import	0.0	1.9	0.0	0.1	60.1	132.0	39.4	57.4	530.4	13.5	**834.8**
export	0.0	0.0	1.3	2.3	10.8	0.1	206.5	386.8	55.0	172.0	**834.8**
July-Dec 2004											
import	0.0	1.2	0.0	0.0	58.0	146.9	33.3	59.1	791.2	27.0	**1116.7**
export	0.0	0.0	1.1	2.1	30.1	0.1	282.7	491.4	58.9	250.3	**1116.7**
July-Dec 2005											
import	0.0	1.5	0.0	0.1	82.2	180.8	39.9	69.9	641.3	25.6	**1041.3**
export	0.0	0.0	1.1	2.9	31.5	25.5	175.2	492.5	68.2	244.4	**1041.3**
July-Dec 2006											
import	0.0	0.9	0.0	0.0	77.6	161.9	45.8	71.2	723.2	20.6	**1101.2**
export	0.0	0.0	1.1	2.5	36.2	4.8	280.0	484.4	78.6	213.6	**1101.2**

Source: Statistics Canada, Agriculture Division 2007

Table 9 International Cattle Trade (thousand of head).

	NWFL&LAB	PEI	NS	NB	QC	ON	MN	SK	AB	BC	Canada
July-Dec 2002											
import	0.0	0.0	0.0	0.0	32.6	8.7	0.1	0.0	2.3	6.3	**50.0**
export	0.0	1.4	0.1	1.8	56.0	115.6	145.9	277.0	278.0	76.5	**952.3**
July-Dec 2003											
import	0.0	0.0	0.0	0.0	8.7	0.4	0.1	0.0	0.0	0.0	**9.2**
export	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
July-Dec 2004											
import	0.0	0.0	0.0	0.0	4.9	4.5	0.0	0.0	0.0	0.0	**9.4**
export	0.0	0.0	1.1	2.1	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
July-Dec 2005											
import	0.0	0.0	0.0	0.0	6.2	1.8	0.0	0.0	0.0	0.0	**8.0**
export	0.0	0.0	0.0	0.2	15.3	35.2	110.5	177.4	213.4	6.9	**558.9**
July-Dec 2006											
import	0.0	0.0	0.0	0.0	10.7	6.3	0.1	0.1	0.0	0.1	**17.3**
export	0.0	0.0	0.0	0.1	15.8	23.2	88.8	75.9	278.1	22.0	**503.9**

Source: Statistics Canada, Agriculture Division 2007

Table 10 Beef Cattle Ranches and Farms, Including Feedlots.

	2001	% of total farms	2006	% of total farms
Canada	67,903	27.5	61,013	26.6
British Columbia	4,849	23.9	4,167	21.0
Alberta	23,017	42.9	20,514	41.5
Saskatchewan	12,194	24.1	12,235	27.6
Manitoba	7,185	34.1	6,593	34.6
Ontario	13,439	22.5	11,042	19.3
Quebec	5,046	15.7	4,693	15.3
New Brunswick	731	24.1	547	19.7
Nova Scotia	832	21.2	717	18.9
Prince Edward Island	478	25.9	381	22.4
Nfld & Labrador	75	11.7	54	9.7

Source: Statistics Canada 2007

Table 11 Cattle Inventory by Sector.

Cow-Calf Operations in Canada							
	Jul 1 2001	**Jul 1 2002**	**Jul 1 2003**	**Jul 1 2004**	**Jul 1 2005**	**Jul 1 2006**	**Jul 1 2007**
Total Cattle	9,113,900	9,111,000	9,169,000	9,368,600	9,660,900	9,198,100	8,917,200
Number of Farms	72,495	71,990	74,610	74,280	73,470	71,200	68,935
Average # head per farm	126	127	123	126	131	129	129
Cow-calf feeders + Stocker/Finish Operations in Canada							
	Jul 1 2001	**Jul 1 2002**	**Jul 1 2003**	**Jul 1 2004**	**Jul 1 2005**	**Jul 1 2006**	**Jul 1 2007**
Total Cattle	2,258,500	2,403,100	2,595,200	3,205,200	3,232,300	2,866,100	3,043,300
Number of Farms	20,645	19,880	16,665	19,620	18,460	16,935	16,705
Average # head per farm	109	121	156	163	175	169	182
Feed Operations in Canada							
	Jul 1 2001	**Jul 1 2002**	**Jul 1 2003**	**Jul 1 2004**	**Jul 1 2005**	**Jul 1 2006**	**Jul 1 2007**
Total Cattle	1,582,000	1,499,300	1,460,000	1,537,500	1,530,500	1,641,200	1,717,000
Number of Farms	4,730	4,425	4,715	4,560	4,265	4,335	4,085
Average # head per farm	334	339	310	337	359	379	420

Source: AAFC 2008

Table 12 Federally Inspected Cattle Slaughter Plants.

Name	***Location***
Provinces: BC/AB	
Rangeland Beef Processor Inc.	Salmon Arm, BC
Lawrence Meat Packing Co. Ltd.	Peace River, BC
Pitt Meadows Meat Ltd.	Pitt Meadows, BC
Medallion Meats Corporation	Falkland, BC
Lacombe Meat Research Centre	Lacombe, AB
Lakeside Feeders Partnership/Lakeside Packers	Brooks, AB
Cargill Limited	High River, AB
Sunterra Meats Ltd.	Innisfail, AB
XL Foods Inc. (XL Beef)	Calgary, AB
Bouvry Export Calgary Ltd.	Fort Macleod, AB
Provinces: SK/MN	
XL Foods Ltd. (XL Beef)	Moose Jaw, SK
Natural Valley Farms Inc.	Neudorf, SK
Winkler Meats Ltd.	Winkler, MN
Province: ON	
Canada Custom Slaughtering Inc.	Toronto
Elbee Meat Packers Ltd. - St. Helen's	Toronto
Cargill Canada (2005) G.P. (Better Beef)	Guelph
Tri-Pet Holdings Inc. (Ryding-Regency)	Toronto

University of Guelph	Guelph
Gencor Foods Inc.	Kitchener
St. Ann's Foods Inc.	St. Ann's
948685 Ontario Ltd. - Norval Meats	Grey County
Province: QC	
Les Abbattoirs Z. Billette Inc.	St-Louis de Gonzague
Levinoff-Colbex	Saint-Cyrville de Wendover
Viande Richelieu Inc.	Massueville
Firme Roger Dubreuil Inc.	Sainte-Henedine
Jacques Forget Ltee	St-Louis de Terrebonne
Abattoir de Luceville Inc.	Luceville
Les Viandes de la Petite-Nation Inc.	St-Andre Avelin
Viandes Giroux (1997) Inc.	East Angus
Provinces: Atlantic	
Atlantic Beef Products Inc.	Albany,PEI

Source: AAFC 2007 (Table 23)

Table 13 Cattle Slaughtered in Federally Inspected Establishments

YEAR	*AB*	*BC,SK&MB*	*ON*	*QC & ATL*	*CANADA*
2006	2,111,995	286,299	673,539	244,991	3,316,824
2005	2,416,643	332,405	649,880	258,807	3,657,735
2004	2,599,181	225,570	637,819	247,218	3,709,788
2003	2,030,887	164,781	543,580	184,227	2,923,475
2002	2,336,856	199,995	544,586	215,770	3,297,207

Source: AAFC 2007 (Table 20)

Table 14 Cattle Slaughtered in Provincially Inspected Establishments.

YEAR	*BC*	*AB*	*SK*	*MB*	*ON*	*ATL*	*CANADA*
2006	13,454	36,724	3,468	20,475	118,096	12,661	232,159
2005	14,687	42,944	7,025	25,452	139,944	14,884	274,125
2004	14,249	45,451	5,548	26,240	134,039	13,375	261,793
2003	10,369	36,238	3,828	18,700	97,653	8,684	185,296
2002	10,045	30,724	3,550	9,665	91,402	7,225	159,801

Source: AAFC 2007 (Table 20)

Table 15 Distribution of Cattle Slaughter Activity in Federal Establishments.

BC/AB									
year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
# of plants	11	9	8	8	8	9	10	10	11
average kill	192,308	260,779	286,655	290,967	329,389	226,273	252,394	238,915	190,870
top 4 plants	98%	98%	99%	99%	99%	99%	99%	99%	99%
SK/MN									
year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
# of plants	4	4	4	4	4	2	2	2	3
average kill	45,155	44,353	43,138	44,221	49,238	NA	NA	NA	NA
top 4 plants	100%	100%	100%	100%	100%	100%	100%	100%	100%
ONTARIO									
year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
# of plants	8	8	7	6	5	5	7	7	8
average kill	70,667	72,103	77,589	81,555	109,149	109,235	89,904	92,386	83,681
top 4 plants	97%	98%	99%	99%	99%	99%	99%	95%	95%
QUEBEC									
year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
# of plants	15	14	10	10	9	8	9	8	8
average kill	14,084	14,644	18,624	18,264	21,559	22,597	27,920	32,520	28,661
top 4 plants	95%	97%	98%	98%	99%	99%	95%	95%	95%
CANADA									
year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
# of plants	40	38	33	31	29	26	29	28	31
average kill	78,283	88,289	98,039	103,633	112,524	116,663	124,632	129,352	105,972
top 4 plants	75%	78%	86%	89%	89%	89%	88%	91%	89%

Source: AAFC 2007 (Table 24)

Table 16 Cattle Slaughter by Province.

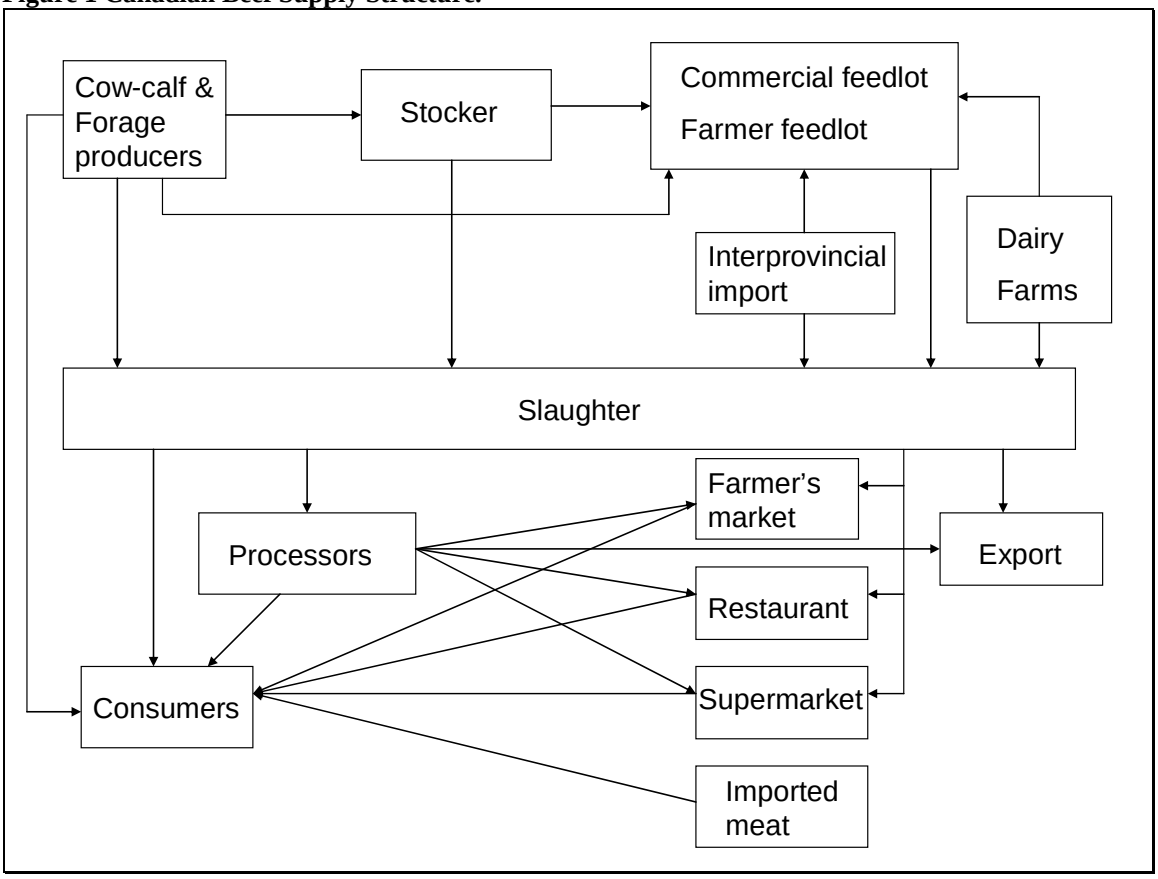
PROVINCE	***Net Trade*** *(2006)*	***Supply*** *(2006)*	***Slaughter*** *(2006)*	***slaughter/week*** *(2006)*	***capacity/week****	***capacity****
British Columbia	-187,100	261,600	74,500	1,433	1,125	58,500
Alberta	995,200	1,043,100	2,038,300	39,198	60,195	3,130,140
Saskatchewan	-663,600	1,070,600	407,000	7,827	9,200	478,400
Manitoba	-356,700	420,100	63,400	1,219	128	6,656
Ontario	265,900	495,200	761,100	14,637	13,000	676,000
Quebec	81,800	463,900	545,700	10,494	10,745	558,740
Prince Edward Is.	1,200	25,200	26,400	508	500	26,000
CANADA	0	3,962,300	3,962,300	76,198	94,893	4,934,436

* in federal establishments

Sources: Canadian Premium Meats Inc. 2006, Steckle 2004 (Table 2.2), Les Viande de la Petite Nation 2007, MacLachlan et al. 2006, Rude et al. 2007, Statistics Canada 2007, and Sunterra Meats Innisfail 2007. Note: numbers may be estimated based on other factors.

APPENDIX 7. CANADIAN CATTLE/BEEF SECTOR

Figure 1 Canadian Beef Supply Structure.



Adapted from: Golan *et al.* 2004