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Traceability in the US Food Supply: Dead End or Superhighway?

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Calls for mandatory food traceability are making news in policy discussions ranging over homeland security, country-of-origin labeling, Mad Cow disease, and genetically engineered foods. A frequent underlying assumption is that unlike Europe, the United States does not have food traceability. Here we argue that although the United States does not mandate system-wide traceability, firms have a number of motives for establishing traceability systems; as a result, private-sector traceability systems in the United States are extensive. The breadth, depth, and precision of private traceability systems vary depending on the attributes of interest and each firm's traceability costs and benefits. Mandatory traceability that fails to allow for variation across firms may impose unnecessary costs on firms already operating efficient traceability systems.

Why Firms Have Traceability Systems

Food suppliers have three motives for establishing product tracing systems: (a) to improve supply-side management; (b) to differentiate and market foods with subtle or undetectable quality attributes; and (c) to facilitate traceback for food safety and quality. Firms establish traceability systems to achieve one or more of these objectives. As a result, the private sector has a significant capacity for tracing.

Traceability for Supply-Side Management

Firms have a strong incentive to establish product-tracing systems to manage production flows and track retail activity. Traceability systems help firms reduce expensive overstocks, coordinate orders and shipments, and manage inventories. Electronic accounting systems for tracking inventory, purchases, production, and sales are an integral part of doing business in the United States.

In addition to private systems, US firms may also use an industry-standard coding system. The vast majority of packaged food products bear bar codes, as do a growing number of bulk foods, like bagged apples and oranges. Bar codes contain a series of numbers reflecting type of product and manufacturer (the UPC code) and a series of numbers assigned by the manufacturer to nonstandard production or distribution details. While bar codes were originally intended to facilitate tracking of retail sales and food consumption trends and patterns, the codes are now used to track numerous product attributes.

The success of the original UPC system has combined with technological advances and e-marketing to spur the development of integrated systems that code, track, and manage wholesale and retail transactions. In some cases, buyers manage these systems to monitor supply flow. For example, a few big retailers such as Walmart and Target have created proprietary supply-chain information systems that their suppliers must adopt. In other cases, firms establish systems to link suppliers and buyers. For example, UCCnet, which is a subsidiary of the Uniform Code Council, has developed an integrated system to standardize and automate information systems across a supply chain.

Sophisticated tracking systems are not confined to packaged products. The food industry has developed a number of complex coding systems to manage the flow of raw agricultural inputs and outputs. Vegetable and fruit farmers routinely tag their produce crates to record location and date of harvest. This information aids in inventory management at the packinghouse and in tracking shipments. Ranchers have been using electronic identification eartags and corresponding data collection cards to track information on an animal's lineage, vaccina-

tion records, and other health data. This allows for efficiency gains through sorting of individual cattle in feed yards, recording preconditioning and other health regimes, and facilitating disease surveillance and monitoring.

Traceability for Food Safety and Quality Control

Product tracing systems are essential for good safety and quality control systems. Traceability systems help firms isolate the source and extent of safety or quality control problems. The better and more precise the tracing system, the faster a producer can identify and resolve food safety or quality problems.

A firm's traceability system not only helps minimize potential damages for individual firms—it also helps minimize damages to the whole industry and to upstream and downstream industries. Contaminated meat sales and foodborne illness outbreaks damage the reputation and sales of the whole meat industry. Because of these spillovers, some product tracing systems are supported by industry groups or buyers. For example, the California cantaloupe industry has incorporated traceability requirements in their marketing in order to monitor food safety practices. Firms offering liability insurance may also require traceability systems to ensure that insured firms have minimized risks.

If the failure of a firm's quality control system results in sales of unsafe or defective products, a traceability system helps to track product distribution and reduce the size and cost of recall. Most if not all voluntary recalls listed on USDA's Food Safety and Inspection Service website refer consumers to coded information on products' packaging to identify the recalled items.

Traceability for product safety and quality is becoming a necessary part of doing business. Good product tracing systems help minimize the production and distribution of unsafe or poor quality products, thereby minimizing the potential for bad publicity, liability, and recalls.

Traceability to Differentiate and Market Foods with Credence Attributes

Although the US food market successfully mass-produces homogenous commodities such as grains and meats, it also offers products tailored to the tastes and preferences of segments of the consumer population. Food producers differentiate products for micromarkets over such attributes as taste, texture, nutritional content, cultivation techniques, and origin. Consumers easily detect some quality innovations—green ketchup is hard to miss. However, other differences involve credence attributes—characteristics that consumers cannot discern even after consuming the product. Consumers cannot taste or otherwise distinguish between food products containing genetically engineered (GE) ingredients and those made with non-GE ingredients.

Credence attributes can be content or process attributes:

Content attributes affect the physical properties of a product, although they can be difficult for consumers to perceive. For example, consumers are unable to determine the amount of isoflavones in a glass of soymilk or the amount of calcium in a glass of enriched orange juice by drinking these beverages.

Process attributes do not affect final product content but refer to characteristics of the production process. Process attributes include country-of-origin, organic, free-range, dolphin-safe, shade-grown, earth-friendly, and fair trade. In general,

neither consumers nor specialized testing equipment can discern process attributes. No test conducted on a can of tuna, for example, could tell whether the tuna was caught using dolphin-safe technologies.

Traceability is an indispensable part of any market for process credence attributes—or content attributes that are difficult or costly to measure. The only way to verify the existence of these attributes is through a bookkeeping record that establishes their creation and preservation. For example, tuna caught with dolphin-safe nets can only be distinguished from tuna caught using other methods through the bookkeeping system that ties the dolphin-safe tuna to the observer on the boat from which the tuna was caught. Without traceability as evidence of value, no viable market could exist for dolphin-safe tuna, fair trade coffee, non-biotech corn oil, or any other process credence attribute.

Food producers have developed sophisticated systems for tracking and establishing value for credence attributes. For example, farmers have begun using Global Positioning Systems to create information to trace crops back to the precise location within a field to determine cultivation practices such as pesticide use. For ranchers, the chain of documentation generated by electronic eartags enables them to more easily sell their cattle at a price that reflects underlying quality.

Balancing Costs and Benefits in Private Traceability Systems

Private traceability systems are extensive, but what kind of traceability do they entail? Are they adequate for tracking production from farm to fork? From seed to finished product? The characteristics of a firm's traceability system depends on the firm's objectives and the costs and benefits of traceability. Firms balance costs and benefits to determine the breadth, depth, and precision of their individual traceability systems.

Breadth

Breadth is the amount of information the traceability system records. There is a lot to know about the food we eat, and firms must decide which information is of value. A recordkeeping system cataloging all of a food's attributes would be enormous and unnecessary. The beans for a cup of coffee could come from any number of countries, be grown with numerous pesticides or just a few, be grown on huge corporate organic farms or small family-run conventional farms, be harvested by children or by machines, be stored in hygienic or pest-infested facilities, or be decaffeinated using a chemical solvent or hot water. Even the most meticulous producer would not find it worthwhile to collect and maintain information on all coffee attributes.

Given the huge number of attributes that could describe any food product, full traceability is an unreachable goal. A traceability system that used DNA to track beef back to information on an animal's lineage, vaccination records, and feeding regime would be incomplete if pasturage hours or playtime were the attributes of interest. Only a handful of attributes—as determined by supply management requirements, consumer preferences, and food safety considerations—warrants the expense of traceability recordkeeping. Firms balance the costs and benefits of attribute information to determine the efficient breadth of the product tracing system.

Depth

The depth of a traceability system is how far back or forward the system tracks. Most businesses have one-up, one-back traceability. Firms must know who their suppliers are if they pay their bills and they must know who their buyers are if they cash their checks. Most businesses in the United States, and certainly all large businesses, maintain electronic bookkeeping systems to track their accounts. The bulk of the US food supply system is therefore

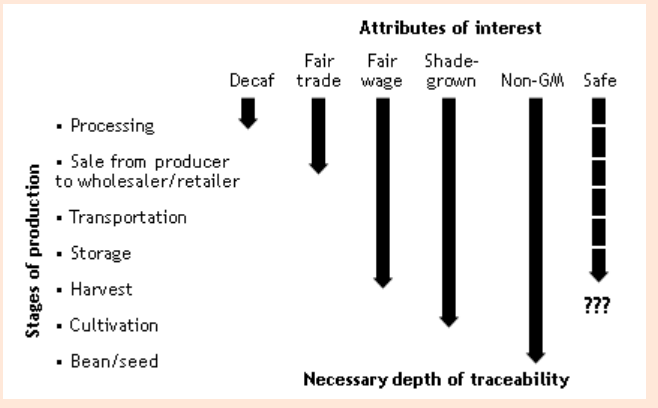

Figure 1. The depth of a traceability system (for coffee) depends on the attributes of interest.

monitored with electronic one-up, one-back traceability systems.

Whether product tracing goes beyond buyers and sellers depends on the objective of the system—and the attributes of interest to the producer or consumer. A traceability system for decaffeinated coffee would only extend back to the processing stage (Figure 1). A traceability system for fair trade coffee would only extend to information on price and terms of trade between coffee growers and processors. A traceability system for fair wage would extend to harvest; for shade grown, to cultivation; and for non-GE, to bean or seed. For food safety, depth of the traceability system depends on where hazards and remedies can enter the food production chain.

Precision

Precision reflects the degree of assurance with which the tracing system can pinpoint a particular food product's movement. A precise traceability system would trace an apple to its orchard with high assurance, while a less precise system would only trace a crate of apples to two or three orchards with lower assurance.

The first decision a firm makes with respect to precision involves the acceptable error rate. In a shipment of white corn, how many yellow kernels are acceptable? In a shipment of non-GE soybeans, how many GE beans are acceptable? Error-rate specifications (driven by quality requirements) will determine the strictness of the segregation system with which the traceability system is paired. Low tolerances for yellow kernels in a shipment of white corn or for GE content in a shipment of non-GE soybeans will require strict segregation systems and accurate bookkeeping systems.

The second decision a firm makes with respect to precision is regarding the unit of analysis—container, truck, crate, day of production, or shift? Firms must determine the most efficient tracking unit for their objectives. Firms that choose a large unit (such as feedlot or grain silo) for tracking purposes will have poor precision in isolating safety or quality problems. A smaller unit of analysis (such as individual cow or crate) will allow greater precision.

Precision in traceability—as reflected in the accuracy of the segregation system and the size of unit of analysis—is more valuable the higher the likelihood and cost of safety or quality breaches. If the likelihood and cost of recall were high, a manufacturer would quickly see the benefit in accurately reducing the size of the standard recall lot. However, precision comes at a cost. In particular, the error tolerance rate strongly affects the costs of segregation and traceability. The benefits of strict identity preservation and product tracing will outweigh the costs for some firms but not for others. The accuracy of the traceability system and level of segregation will vary widely depending on the motivations driving their development.

Firms are Building a Traceability Superhighway

Technological advances are pushing improvements in supply-side management and quality control systems throughout the US food system. Electronic accounting and traceability systems are standardizing information on product attributes and synchronizing product tracking across the food system. Firms balance traceability costs and benefits so that the breadth, depth, and precision of private systems reflect technological limits and consumer preferences. In some cases, however, firms may not supply the socially optimal amount of traceability, as when private and social traceability costs and benefits differ. In these cases, mandatory traceability may be a policy option.

Paradoxically, the widespread voluntary adoption of traceability in the United States may increase firms' cost of compliance with mandatory traceability systems. Efficient traceability by firms results in systems with differing levels of breath, depth, and precision. Because government requirements rarely allow for variation in process and outcome, firms may be required to make changes to their traceability systems that do not improve efficiency. Mandatory traceability that allows for variation or targets specific traceability gaps could be more efficient than system-wide requirements.

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