

Food Safety and Industrial Engineering Methods

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ABSTRACT: The attention to food safety has increased over the past 15 to 20 years in many areas of the agricultural industry. However, there are significant areas of the food industry that have not been adequately prioritized in relation to food safety research. This study emphasizes one of those understudied areas: small-scale, low-income minority farming communities. An industrial engineering-based supply chain management approach is proposed as a method for addressing food safety concerns in this agricultural demographic.

The current article discusses an approach that centers around traceability technology as a means of providing heightened visibility and accountability within the food supply chains of farmers within this community. The persistent reality of food recalls is an unfortunate and frequently occurring circumstance in many categories of industry (example: technology, pharmaceutical, agriculture, etc.) of supply chain-based service and production industries. Consequently, the subsequent corollary of potentially critically damaging economic effects to businesses necessitates the need for better proactive and reactive approaches for preventing and reducing the effects of necessary recalls.

This is especially essential for farmers and the communities they serve. The economic effects are heightened for smaller enterprises such as small-scale, limited resource minority farmers. Many farmers and value-added producers have not been proactive in pursuing the use of newer technologies such as radio frequency identification technology (RFID) or other traceability technologies for several reasons: fear of the unknown, a lack of a realization of their importance to the life of their businesses, and a lack of money. The ultimate goal is to make local, national, and global food supplies more secure.

Keywords: Food Safety, RFID, Traceability Technology.

INTRODUCTION

Supply Chain Management techniques and tools (traceability technology) can be used for addressing food safety issues within the agricultural industry. According to [1] an article by Wowak, Craighead, and Ketchen (2016), there are three primary factors that hinder product traceability:

1. **Temporality:** time pressures that strain a firm's ability to track products. Perishability and problem discovery lag, the time it takes a company to actually discover an issue with a food product and how long it takes it to respond, are specific temporality elements impacting traceability.
2. **Supply chain permeation:** how the product flows through the supply chain. As a product is distributed through multiple supply chain products, it becomes more challenging to track and recall.
3. **Product information ambiguity:** a company's ability to trace a product is product information ambiguity, or product characteristics that "create vagueness or uncertainty about what to trace." This happens during product blending when a raw material is used to create a semi-finished or finished food product. "Product comingling" takes place when different products from various locations are packaged together or when production information has changed for some reason- product changes possession or crosses borders.

GROUPS THAT BENEFIT DIRECTLY

The primary groups in focus for the idea discussed in this article are: food consumers, direct food producers, and indirectly associated supply chain components connected with food production.

1) **Consumers of produce in any nation:** The general public of a nation, who are the largest consumers of domestically grown produce will be indirectly affected by successful results from this research project. Heightened sensitivity to the security of our nation and its citizens has been the cause of a greater focus on potential areas of security breaches in all parts of life. Possible threats to our domestic food supply are not only potential realities, but are actual experiences as is seen regularly by accidental contaminations of food or medicine requiring massive recalls of those items.

2) Small Scale Low Income Domestic Producers: Traceability technologies such as radio frequency identification (RFID) have great potential to be valuable tools in the efforts being made to make our domestic food supply more secure. Limited financial resources are a major constraint to the widespread use of these technologies. This constraint has a greater impact on low-income producers than it does on other producers.

3) Members of the Small Scale Low Income Domestic Producer Food Supply Chains: The same benefits from this research that apply to the farmer also apply to any members of that farmer’s food supply chain.

FOOD SAFETY CONCERNS

The specific food safety concern emphasized is the ability to provide accurate forwards and backwards tracking of food produced and distributed within the agricultural supply chains for various smaller operations across geographic, social, and ethnic demographics for the purpose of increasing food safety. Demonstration of this capability may allow for the use of certain methods to be utilized in these environments for minimizing the potential damage of food contamination (by any means whether deliberate or unintentional) and the corresponding recalls and other reactive measures that take place when recalls occur. In addition to this primary purpose, this approach can potentially provide a means to decrease the costs associated with recalls to the following:

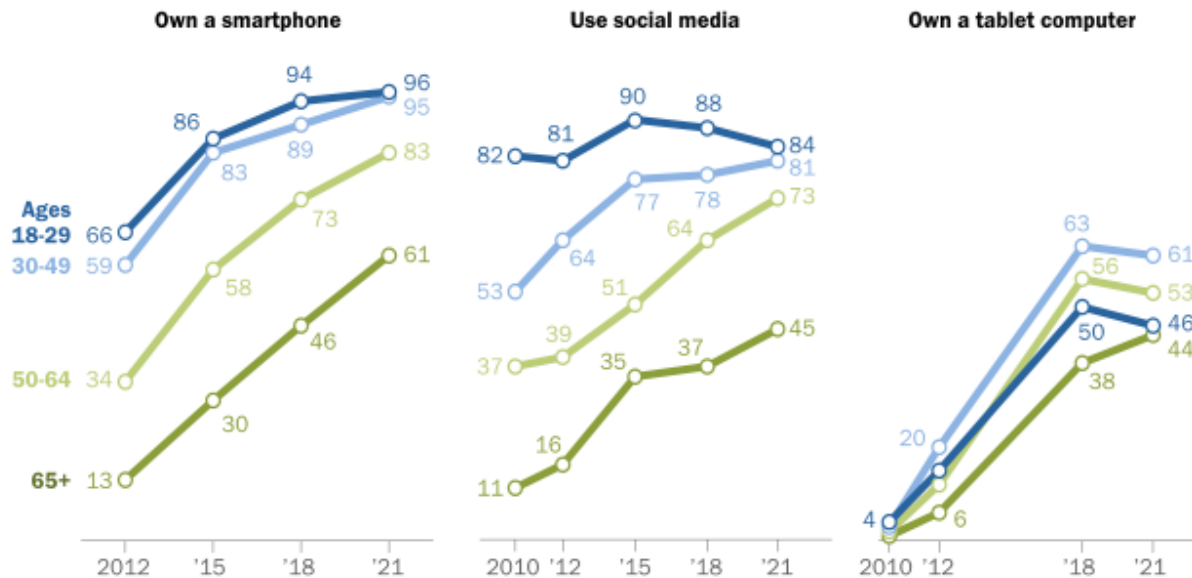
1. Direct consumers
2. Farmers
3. Communities serviced by these farmers

Openness to technology usage is often associated with younger-age demographics and tends to decrease in direct proportion to population age. A pew research study from 2021 illustrates this fact[2]. The summary graph below (Fig 1) from that study shows that while technology use among people sixty five years or older has increased, it still is not as high as that of younger demographics.

Figure 1: Smartphone Ownership And Social Media Use Among Older Adults Continue To Grow (Pew Research Center, Survey Of U.S. Adults Conducted Jan. 25 – Feb. 8, 2021; January 2022)

Smartphone ownership and social media use among older adults continue to grow

% of U.S. adults who say they ...

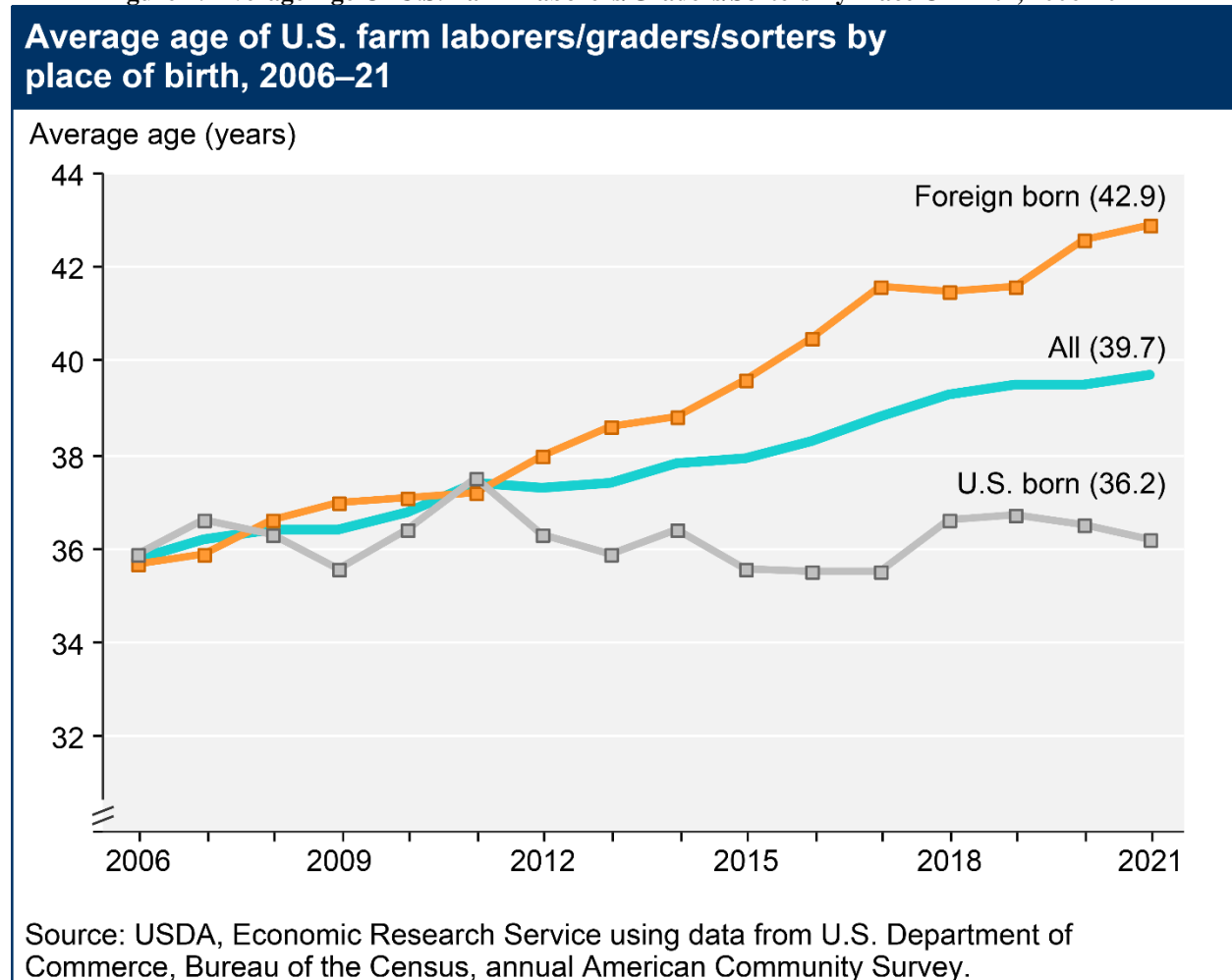


Note: Respondents who did not give an answer are not shown.
 Source: Survey of U.S. adults conducted Jan. 25-Feb. 8, 2021.

PEW RESEARCH CENTER

Recent census reports have shown that the age of the population of agricultural workers is increasingly high [3]. Fig 2 shows that from 2006 - 2021 the overall average age of workers on farms in the United States has increased.

Figure 2: Average Age Of U.S. Farm Laborers/Graders/Sorters By Place Of Birth, 2006-2021



The increasing societal trend towards dependence on technology is ubiquitous. As people age, they may tend to be less likely to either 1) desire to use newer technology or 2) be able to effectively use new technology. Unfortunately, many younger people are not necessarily looking to pursue careers in agriculture. However, due to industry demands, educational emphases, and governmental focus, many younger people are seeking to pursue careers in engineering. It is possible that utilizing an engineering-based approach for addressing food safety issues could be a means of creating interest in agricultural industry problem-solving for this demographic. This is even more important for largely rural regions of the world.

The focused target demographic for application of this idea is small-scaled, limited resource, minority farmers in the United States. However, the magnitude and scope of the research extends across the globe. Other research has shown that, one of the hindrances to considering using traceability technology for farmers in this demographic was the ability of the food supplier to cover the costs of purchasing and using the technology. One possible solution to this is to transfer the costs of using traceability to the consumer. Sun, Wang, and Zhang (2017) stated the following:

From practice, we can observe two key features of the sustainable food traceability problem: (i) Food safety events may increase costs; thus, increased costs may come from product recall, a penalty, etc.; (ii) Consumers may be willing to pay for traceability. A couple of studies have shown that consumers are improving their awareness of

traceability and subsequently, their willingness to pay (WTP) for traceable food products. A segment of the population (e.g., with a higher family income, better education), which we refer to as traceability consciousness consumers, are willing to pay a premium for a traceable product. Therefore, the sourcing strategy of the buyer can be associated with its marketing strategy, as selecting a traceable supplier can reduce its costs, whilst allowing the firm to extract additional profit from the traceability consciousness segment (p. 2).

Similar activities could potentially be used to 1) assess the awareness of the communities of the farmers in the research demographic in relation to their food safety consciousness and 2) raise the proportion of traceability conscious food buyers in these communities. One related focus area is food safety threats in the form of contamination within a farming food supply chain. In [5] a book published in 2017, John Ryan stated that, "...it should surprise you to know that there are no established sanitation, traceability, or temperature control food safety standards that perishable food carriers must comply with during the transportation process...This lack of standards means that anything goes as long as the food gets through the supply chain..." (p.xiii) There are two types of contamination: 1) intentional and 2) unintentional. Intentional contamination occurs when food is tainted deliberately by either an individual, a small group, or a national or pseudo national organization. Unintentional contamination occurs when pollution is caused by bacteria, viruses, or decomposition that is not attributable to the malicious actions and intent of a person or group of people.

[6] Feltes, Ariseto-Bragotto and Block (2017) stated that, "due to public health concerns and economic losses caused by food-borne diseases, as well as by the presence of contaminants, there has been a recent global effort from food suppliers, industries, and governments to assure the quality and safety of food"(p. 14). Addressing contamination in any supply chain requires the knowledge of product handling (point of contact) within the supply chain itself. This requires being able to trace the product as it travels through different points in the supply chain.

[7] An article on the "Science Daily" website that cited results from a study performed at the University of Notre Dame (June 22, 2016) discussed the difficulty of tracing certain products, particularly products that move quickly through an organization's supply chain. A researcher, who is an expert in the field of supply chain management and traceability, stated the following:

Wowak says traceability should be managed differently depending on the product's perishability. "Our research reveals a downside to supply chain initiatives that stress pushing products to market too quickly. Thus, firms should consider adopting different traceability requirements for fast-flowing products," she says. "Federal regulations mandate that firms have traceability one step up and down the chain. However, this may not be sufficient for perishable products that flow quickly, such as fresh strawberries or dairy products (p. 1).

[8] Wowak and Boone (2015) stated, "Although the literature on product recalls is informative, our understanding of these events is still in its infancy" (p.54). In this same article, the authors highlighted the impact of food recalls on businesses when the authors stated, "In a recent survey, 81 percent of participating firms deemed the financial risk of recalls as "significant" to "catastrophic". However, the financial repercussions of product recalled, pale in comparison with the life-threatening risk tainted or defective products pose to consumers" (p.54).

[1] Wowak, Craighead, and Ketchen (2016) in discussing the current conditions of traceability technology usage stated, "Many other organizations also struggle with establishing and maintaining traceability. Within the U. S. food industry, for example, government investigators were only able to trace five of 40 products throughout the entire supply chain. Additionally, nearly 60% of facilities did not maintain accurate records about their suppliers, recipients, and transportation providers (p. 132).

[9] Liang, Cao, Fan, Zhu, and Dai (2015) discussed the potential benefits of traceability technology within food supply chains and some areas of weakness currently existing in this area of study:

Traceability can be useful for optimizing production planning and scheduling, and for improving company coordination in supply chain. In addition, traceability can also be used as part of a competitive strategy. However, food traceability is lacking because of the traceability information related to food products and production processes is often lost within companies, as well as between companies in supply chain, thus more detailed studies of each step in the supply chain are needed to better document each process (p. 1).

Whenever food (produce or meat) is recalled, it is necessary to try to determine the source of the product. A normal cause for recalling food is the report of an illness directly related to the consumption of a particular food product.

The illness is commonly caused by contamination of the food by some known or unknown pathogen. [10] Carlisle Technology presents the number of food recalls by the United States Department of Agriculture each year between 2010 and 2022.

TABLE 1: Number Of Food Recalls Per Year In The United States From 2010 – 2022 (Carlisle Technology, 2022)

Year	Number of Food Recalls
2022	69
2021	63
2020	50
2019	131
2018	133
2017	145
2016	138
2015	157
2014	102
2013	89
2012	88
2011	109
2010	75

The activities that have been discussed also address the problem of food supply chain management and security by means of industrial engineering-based technology. Discussions and meetings are needed to assess the current condition of farming operations and food supply chains for small scale and limited resource farmers in relation to the increasing focus on food security and various other domestic and global security related issues. An absence of awareness and/or utilization about traceability technology potential usefulness among limited resource farmers may be present. This creates a prevailing concern about the following:

1. Small scale and limited resource farmer viability and growth as we move deeper into the Twenty-First Century.
2. Small scale and limited resource farmer certifications (such as Good Agricultural Practices) [G.A.P.] certification.
3. Quality and security of food provided to consumers of small scale and limited resource farmers.
4. The capability to identify areas of contamination of food for this demographic.
5. The training of a workforce that is knowledgeable about these types of issues and equipped to be able to adequately address them.

CONCLUSION

Sustainable food safety in many societies cannot be achieved without prioritizing an increasing of the level of food safety within low-income minority farming operations and their associated communities. One way this can be achieved is by means of industrial engineering. A potential means for achieving this goal is to determine the potential effectiveness of using a technology-based method that is uncommon in this agricultural demographic by implementing and testing an existing traceability technology within actual farming supply chains in the geographic and demographic research test area. Doing this may also be a tool for improved awareness of food safety issues and potential solutions to those issues within this community. One means could be through interaction with the primary

food producers and suppliers for this geographic and demographic population. The amount of study that has focused on this agricultural demographic is minimal.

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