**Supporting a vibrant organic sector: The state of applied economic research in the U.S.**

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**Abstract**

During the thirty years since the passage of the Organic Foods Production Act of 1990, the domestic organic sector has dramatically changed in size and scope. Yet organic products remain a small portion of the U.S. food system. As the industry continues to mature, new challenges face the organic sector. Supply issues, questions about the organic standards, integrity concerns, and growing interest in alternate labels have been growing in frequency. At this juncture in the development of the organic sector, increasing the amount of applied economic research addressing the needs of organic food and agriculture is critical to support the vibrancy of the sector. As a start, we assess the extant body of literature and the availability of data to conduct applied economic research.

**Keywords:** organic agriculture, applied economics, organic farming, economic sustainability, data

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**Introduction**

During the thirty years since the passage of the Organic Foods Production Act of 1990, the domestic organic sector has dramatically changed in size and scope. Retail sales of organic food approached $64 billion a year in 2023 (OTA, 2024). Organic foods are currently available in nearly every product category, from lettuce to milk to snack foods, and are widely available around the nation (Carlson et al., 2023). The expansion of organic foods was made possible by the entry of new certified organic firms that process and distribute organic products, increasing in number from 2,700 in 2004 to more than 10,000 in 2024 (Dimitri and Oberholtzer, 2008; USDA AMS, undated). Despite this dramatic growth at all levels of the organic food system, organic products remain a small portion of the food system and comprised 5.5 percent of overall food sales in 2021 and 3 percent of farm gate crop and livestock receipts in 2019 (USDA ERS, 2024; Carlson et al., 2023).

As the industry continues to mature, new challenges have caused stakeholders to vocalize concern, many of which are related to production costs and competitiveness of organic farms: imported grains that do not satisfy the organic standards are priced lower than domestic grains produced in adherence with the regulation. Protecting biodiversity on an organic farm may be more costly than disregarding the impact of farming production practices on biodiversity. Facing the possibility of drift, organic farmers need to decide whether to procure insurance for drift damage to crops (Mcleod, 2014). The cost differentials have serious implications for the economic viability of organic farms, which operate in financially competitive markets (Crowder and Reganold, 2015).

At this juncture, increasing the amount of applied economic research addressing the needs of organic food and agriculture is critical to support the vibrancy of the sector. Understanding the key economic problems faced by certified organic farmers and handlers, along with the decisions they need to make in the future, would allow researchers to target their resources to the most important questions. The first step in this process, presented in this document, is an assessment of the state of applied economic research regarding organic farming and marketing. We focus on organic farming and handling, and intentionally exclude the body of literature on consumers, including demographic studies, willingness to pay, and consumer demand.

**Review of data and literature related to economic sustainability of organic farms**

Most economic questions related to the organic sector are empirical, requiring data to be fully explored. Data scarcity has historically been a barrier to economic research on organic markets. For this reason, much of the early work (excluded from this review) covering the organic sector relied on piecemeal industry data, anecdotal evidence, and in some cases, primary data collected by researchers. Primary data collection remains an important source of evidence for researcher and is typically collected by individual research teams through surveys or interviews. Public data availability has considerably improved since 2008, when USDA conducted its first survey of organic producers as a follow on to the 2007 Census of Agriculture.

***Primary sources of data available for economic analysis of the U.S. organic farm sector***

At the time of this writing, in 2024, three sources of public data are available for analyzing the organic sector. All three are managed by different agencies in the US Department of Agriculture. First, the National Agricultural Statistical Service (NASS) has conducted follow-up surveys of organic farmers to the Agricultural Census in 2008, 2014, and 2019. In 2015, 2016, and 2021 surveys were conducted by NASS in cooperation with USDA’s Risk Management Agency (USDA NASS, undated). In this document, the six surveys are referred to as the “Organic Survey.” The data collected through the organic surveys includes farm numbers, acreage, and sales by crop and by state. For some years, surveys report additional information such as farm practices (for example, crop rotation or use of beneficial pests) and the use of farm programs such as crop insurance. Summary data are available online. Individual farm level data are not publicly available. Researchers can secure permission to access to the microdata in a NASS field office or other approved location (Pilgeram et al., 2020).

Next, the Agricultural Resource Management Survey (ARMS) is conducted by USDA’s Economic Research Service (ERS) in tandem with NASS. The survey’s purpose is to illuminate production practices, production costs, resource use and farm financial well-being (USDA ERS, 2022). At times, the ARMS data include a representative sample of organic producers, and since 2005, ERS has periodically conducted ARMS surveys for organic dairy, apples, soybeans, wheat, and corn. This data can be used to assess cost of production, technical efficiency, organic farm practices, and market structure. Because the sampling methodology does not typically include an oversampling of organic producers, in most cases the ARMS data do not cover a sufficient number of organic producers.

Lastly, the Organic Integrity Database contains data on all operations, globally, that are certified as organic under the National Organic Standards (USDA AMS, 2018). The online dataset includes information on what kind of organic certificate the firm holds (crops, livestock, handling, wild crops), the commodities and services offered, the farm name, contact information, certifier name, country, and address of the operation (USDA AMS, 2023a). USDA accredited certifying agents report this data to the National Organic Program. More recently, the database was expanded to include trade partner modules that will allow international certifiers to report information about certified entities operating under equivalency agreements, starting with Canada with plans to expand to other countries (USDA AMS, 2023b). The administrative data included in the Organic Integrity Database is helpful when examining location and operation scope, but the publicly available data do not include sales or acreage.

***An overview of applied economic research on the organic sector***

We conducted a broad literature search on applied economic and related disciplines that examined topics related to organic farm economic sustainability. The search focused on research related to organic crop and livestock agriculture in the United States that was published between 2014 and 2023. Google scholar was used to identify relevant research, and we examined citations of papers to identify the full body of literature as applicable. Excluded were studies that focused on managing on-farm production issues, such as weed management and pest control, along with those examining aquaculture and hydroponic systems. Similarly, the vast literature on consumers of organic food, including willingness to pay studies, were excluded. We include a few papers from the small body of recent work on organic retail price premiums, which has implications for economic sustainability of organic farms.

The general topic areas identified in the applied economics and related literature are: spatial patterns in the organic sector; procurement, buyers and supply chain; transitioning to organic production; organic farm performance and technical efficiency; organic integrity; and risk management. Appendix A lists the key papers included in the literature review, the region studied, crops included, and data source.

***Topic 1: Spatial patterns in the organic sector***

One of the first papers to examine spatial distribution in the organic sector examined farm locations for presence of hotspots, and found evidence of hotspots of organic businesses in the West, and depending on how an organic operation is defined, in the Midwest and the Northeast (Marasteanu and Jaenicke, 2016a). Furthermore, there were differences between the geographic patterns of organic operations and nonorganic agricultural operations and general businesses. One implication of this work is that policies supporting organic production are more likely to have an impact in areas where organic agriculture is already present. A related paper by Marasteanu and Jaenicke (2016b) found that locations with organic certifying agents, both public and private, have a higher probability of being located in a hotspot. The third paper in this general area by Marasteanu and Jaenicke (2019) found that regions with an organic hotspot have a lower county-level poverty rate and a higher median household income.

Kuo and Peters (2017) examined the spatial distribution of organic farming, finding that organic agriculture is concentrated in the West, Northeast, Northern Great Lakes, and the Mountain West. They further identified spatial dependence in terms of the location of organic farms, and that regions with high levels of organic tend to have high levels of social capital as measured by the Penn State Social Capital Index (Kuo and Peters, 2017).

Herrera and Dimitri (2019) studied the geo-localization decisions of new organic dairy farm operations in the USA between 2002 and 2015. Network analysis was used to simulate spatial-temporal networks based on the location of existing and new organic dairy farming operations. The simulations were performed with different probabilities of connecting with existing or incoming organic farmer operations, to overcome the lack of data describing actual connections between farmers. New organic dairy operations were clustered around existing ones, reflecting the role of networks in the conversion into organic production.

***Topic 2: Organic buyers, organic producers, and thin markets***

Relationships among firms along the organic supply chain are an integral part of the process that transforms organic farm commodities into organic food products. In a well-functioning supply chain, organic handlers or buyers, in their role as intermediaries, transmit information about consumer preferences back to the farm level. As the intermediary segment of the supply chain has become more concentrated over time, concern has grown about the existence of imperfect competition and potential for paying farmers low prices (Sexton, 2012). The literature on market structure in agriculture, vertical coordination, and contract typically ponders whether agricultural markets exhibit increased efficiency by reducing transaction costs or increased market power (MacDonald et al., 2004). In the organic sector, large processors expanded their organic portfolios by purchasing existing organic brands, and in 2020, the 30 largest food processors in North America had purchased organic brands that were previously independent (Howard, 2020). The control of organic food products, now in the hands of large processors, raises questions about whether imperfect competition exists in the organic sector, and the potential price impacts on organic farmers.

The organic market, despite tremendous growth, remains relatively small in comparison to the agricultural sector. Thus, buyers may incur high transaction costs when seeking certified organic inputs, and farmers may similarly struggle to find buyers for their organic farm production. Organic markets are frequently described as ‘thin markets,’ and are characterized by a small number of buyers and sellers with a limited number of observable transactions. The lack of transparency about prices in thin markets implies that buyers may be able to pay farmers prices below the competitive market price (Raszap Skorbiansky and Adjemian, 2021).

Thin market problems for organic or other niche markets can be ameliorated under certain conditions. One, a clear link between commodity prices and organic prices measured as stability of the organic premium, even when few organic transactions are observed, means that negative consequences are unlikely to occur (Raszap Skorbiansky and Adjemian, 2021). Using price data for 2011-2020, Raszap Skorbiansky and Adjemian (2021) found evidence of stability in organic premiums for organic corn and soybeans. They further suggest that, since organic corn and soybean prices are not readily available, analysts could instead rely on conventional prices when forecasting organic prices.

Another scenario that points to reduced concern about negative consequences for farmers when markets are thin is the existence of long-term relationships that both meet buyer procurement needs and provide organic farmers with financial stability (Hadachek et al., 2022). Until approximately 2015, organic dairy farmers and processors developed effective long-term relationships likely mitigating the impacts of thin markets, but entry of new processors and dairies into the organic sector introduced instability into the relationships (Hadacheck et al., 2022; Dimitri and Nehring, 2022). Vertical integration dominates the organic beef cattle sector, and the sector lacks processing capacity, suggesting that concerns about thin markets are warranted since these conditions limit expansion of organic cattle production (Hadacheck et al., 2022).

***Topic 3: Supply chain relationships***

Baron and Dimitri (2019) found that three key concepts characterize the relationships between handlers and their suppliers: closeness, support, and commitment. The buyer-seller relationships followed a spectrum of intensity, where the least engaged handlers provided little support and commitment and the most engaged handlers provided support and commitment through a long-term relationship or contract. In related work, Dimitri and Baron (2020) found that organic handlers provide different types of support to their suppliers, most often focused on reducing technical barriers to organic farming, assisting with transition, and providing advice on the organic standards and organic farming practices.

Domestic production of organic grain was historically slow to respond to growing market demands, even with increased profit potential made possible by organic price premiums (Greene et al., 2017). A major barrier to entry in the organic grain market for producers is the inability to locate buyers (Torres et al., 2020). Lack of clarity about what buyers seek from their farmer suppliers may be an obstacle to growth at the farm level. Important differences existed between groups of organic buyers in terms of values and commitments to building relationships, where one group preferred contracts while another preferred relationships and flexibility (Torres et al., 2020).

***Topic 4: Transitioning to or giving up organic production***

According to USDA estimates, certified organic farm acreage tripled between 2000 and 2019 (Carlson et al., 2023). Growth in organic field crop and oilseed production, particularly for feed, has historically lagged overall organic farm growth. Researchers often point to the profit potential of organic grain and oilseeds, and question why domestic grain and oilseed producers seem unwilling to adopt organic systems, particularly given the needs of the growing organic dairy, eggs, and meat sectors. Many researchers have pointed out that transition rates should be higher than what is observed (see for example Delbridge et al., 2017; McBride and Greene, 2015). The observation led to a large body of research that examines the barriers to transition and support systems for transitioning producers.

Three categories of barriers to organic transition that have been observed are: management, policy, and cultural (Delbridge et al., 2017). Management includes mastering the certification process, developing an Organic Systems Plan, maintaining records, and learning how to farm organically. Producers also need to develop new marketing networks by locating certified organic handler buyers, which are relatively few in number. Federal crop insurance may not provide organic farmers with adequate risk management support, especially (but not only) during the transition period. Cultural norms may prevent some producers from undertaking the organic transition (Delbridge et al., 2017). In general, simulations indicate that the transition to organic farming systems is a better option when revenues from nonorganic production are low, and that organic systems are a better option for small-scale operations (Delbridge and King, 2016).

The decision to transition to organic production has been studied more closely by focusing on farmers in specific regions. For instance, limited resource producers located in the Delmarva Peninsula were too busy to transition to organic, in addition to believing that the three years needed to complete the transition was too long (Marsh et al., 2017). Small-scale producers located in the South were more likely to transition to organic when they had access to a farmers market to sell their production. Older farmers, those with larger farms, and those concerned about finding reliable buyers for organic farm products were less likely to transition (Liu et al., 2019). Farmers in Iowa lacked markets for transitional grains, small grains, and hay, and indicated that technical support with organic certification was needed (Han et al., 2022; Han and Grudens-Schuck, 2022). Indiana farmers, who often both rented and owned land, were reluctant to invest in the conversion of farmland to organic on the rental land (Bruce et al., 2022).

Private sector support of farms by certified organic handlers through the three-year transition period is often promoted as an effective method for increasing the supply of organic farm products, particularly for grains and feed. Handlers offering support to farmers were most likely to provide advice on the organic standards and organic farming practices. Manufacturers were less likely to provide transition support, largely because they typically do not interact with farmers, and small handlers were also less likely to support the transition. Handlers purchasing organic dairy were the most likely to assist farmers with the transition to organic (Dimitri and Baron, 2020).

Farmers enrolled in conservation programs, such as EQIP, may be more interested in converting their operations to organic. Yet not all transitioning farmers who were also enrolled in the EQIP conservation program chose to get certified (Stephenson et al., 2022). Critical aspects supporting successful conversion were availability of labor, organic inputs, and organic processing facilities (Stephenson et al., 2022). Factors inhibiting the transition included prices received for farm products during the transition period and the record keeping required for organic operations (Stephenson et al., 2022).

Direct markets, once an important outlet for organic producers, currently capture a smaller share of the organic market, declining from 10% of the organic market in 2006 to 6% in 2020 (Carlson et al., 2023). The question regarding market channel choice and organic certification is the focus of several publications. Fruit and vegetable producers who operated small or medium sized organic farms were likely to forgo certification unless they sold into the wholesale market (Torres et al., 2017). Certified organic farmers were less likely to use direct markets, although fruit and vegetable producers were likely to be both certified organic and direct marketers (Chen et al., 2020).

Similarly, farmers may also decide to give up their certification, referred to as ‘decertification’ in the literature. In one study, farmers located in the Midwest were more likely to decertify (Torres and Marshall, 2018). Women farmers, as well as farmers who had strong connections with other organic farmers were less likely to decertify (Torres and Marshall, 2018). Considering entry and exit of organic farms in Washington State during the years 1998 to 2019, the highest rate of exit occurs within the first two years after obtaining certification (Brady et al., 2023), suggesting that beginning organic farmers may need extra support for success. Medium and large-scale operations were most sensitive to market conditions, with exits increasing as the organic price premium declined, while farms that had been organic for a relatively long period of time were less responsive to changes in the price premium (Brady et al., 2023).

***Topic 5: Farm performance, profitability and technical efficiency***

Researchers have been keenly interested in understanding the economic performance of organic farms, particularly in comparison to nonorganic farms. Questions of profitability and farm performance are intertwined with other farm decisions, such as whether to adopt organic farming systems or relinquish certification.

Using total value of farm sales and net cash farm income as two distinct measures of farm financial performance, smaller organic farms exhibited higher financial performance from crop diversity while larger farms benefited from specialization (Khanal et al., 2018). Smaller crop and grain organic farms had higher net cash farm income, and small and medium sized farms located in the West similarly exhibited higher net cash farm income (Khanal et al., 2018). Land rental rates for certified organic farmland were an estimated 26% higher than for similar nonorganic farms (Fuller et al., 2021).

Integrated organic livestock and corn operations in Ohio, of which two-thirds relied on horses rather than tractors, earned positive returns to labor and management in 2017 (Brock et al., 2021). Drawing conclusions about long term viability in this research is not possible since the positive returns might have been a function of high market prices for organic corn in 2017, which declined by one-quarter in 2020 (Brock et al., 2021).

***Topic 6: Studies of the economic condition of organic dairies***

Dairy farms, particularly small and medium operations, often opt to transition to organic production to increase profitability, and in some cases to remain in dairy production (Walsh et al., 2020). Thus, the profitability and technical efficiency of organic dairy operations has been the focus of multiple studies.

Small scale organic dairy is an important part of Vermont’s agricultural landscape, albeit market stresses over the past decades have resulted in a reduction in the number of farms. In 2017, there were approximately 40 thousand dairies remaining in the state. Walsh et al. (2020) used an unbalanced panel of organic dairies for 2006-2016 and found that farm management practices that increase milk per cow results in higher return on assets. Other factors that increased return on assets were increased cow numbers and reduced feed costs resulting from growing and storing hay on farm.

Nehring et al. (2021) estimated technical efficiency and returns to scale for organic dairies, finding that returns to scale increased as farm size rose, with higher productivity of inputs as farms became larger. Farm return on assets similarly increased with the number of cows. The authors found that organic dairies were more profitable than similarly sized nonorganic farms. A related study finds that, at the national level, the profitability of organic dairies remained relatively stable at three points in time: 2005, 2010, and 2016 (Dimitri and Nehring, 2022). Looking at profitability across regions and by farm size revealed that the profitability of large-scale organic dairies in the West substantially increased in 2016 (Dimitri and Nehring, 2022).

Related to viability is the concept of social, economic, and ecological resilience, critical for dairies which face price volatility and frequently changing market conditions. New England dairies coped with market shocks by diversifying, which includes producing organic milk, creating value added products, raising other farm products, and land management practices (Snorek et al., 2023). A value-added strategy, organic and grassfed milk, is a high growth market segment, and in 2021 industry data reported the retail category had a three year annual compound growth of 27% (Maugeri, 2021). Estimates suggest that the number of organic grass-fed dairies increased approximately 400% between 2016 and 2019 (Niles et al., 2019). Because of the reliance on pasture, grass-fed organic cows tend to produce less milk than organic grain fed cows. Higher milk production on grass fed organic operations was associated with herds consisting of Holstein cows, farmers with higher levels of knowledge regarding reproduction and milk (based on 13 factors), and greater frequency and depth of dairy information sources (Snider et al., 2021).

***Topic 7: The organic price premium***

Often higher profitability for organic farms is dependent on farmers receiving a premium for their organic farm products. For many products, it is reasonable to assume that the farm level premium is related to the premium paid at the consumer level. Historically, the organic price premium at the retail level has varied by product (Carlson and Jaenicke, 2016). That said, consumers posited that price, and perceptions that organic food is expensive, were among their main obstacles to buying organic food (Aschemann‐Witzel and Zielke, 2017).

The baseline knowledge of price premiums has gaps, largely because estimating price premiums is time consuming, data intensive, and has many technical issues. Furthermore, organic price premiums are dynamic because they respond to market conditions. A handful of studies have examined retail level price premiums, with research relying on supermarket scanner data or household purchase data. Estimates of the organic retail price premium over a six year period for organic canned soups were 40 percent; coffee, 50 percent; milk, 70 percent and bagged carrots, 30 percent (Jaenicke and Carlson, 2015). The organic premiums remained high throughout the 28 quarters in the six year time period (Jaenicke and Carlson, 2015). Further, growth in the size of the organic market was related to larger premiums, while growth in the nonorganic market was related to smaller premiums (Jaenicke and Carlson, 2015).

A cyclical pattern to the organic retail premiums of organic milk, eggs, and yogurt was identified, with the organic milk premium growing over time (Badruddoza et al., 2022). The retail price premium for organic yogurt and organic eggs initially increased and then declined (Badruddoza et al., 2022). The authors speculated about how supply and demand are affecting the organic premium and consumer behavior, and posit that, at current levels, the higher price of organic prevents more consumers from buying organic products. Expansion of organic into supercenters and private label products will place a downward pressure on organic premiums (Badruddoza et al., 2022).

***Topic 8: Risk management***

Farming is inherently risky, with USDA identifying 5 categories of risk: production, pricing, financial, institutional, and human (USDA ERS, 2023b). The bulk of the research examining agricultural risk considers on-farm production risk, which was the sole focus of approximately two-thirds of the publications identified in a review paper (Komarek et al., 2020). Research on risk management by organic farmers is not extensive, with just a handful of peer reviewed articles examining the topic and all focusing on crop insurance. One report by a nonprofit mentioned that some producers, especially those who raise specialty crops, manage market risk by creating a CSA, or by marketing to multiple outlets (Snyder et al., 2022).

A key policy tool for risk management is crop insurance, which manages risks created by yield or price variability (although a few policies address quality). Decisions to purchase insurance are part of a broader set of farmer actions. For example, lenders may require producers to have crop insurance in order to secure financing, and some federal programs require crop insurance for farmers participating in their programs (Raszap Skorbiansky et al., 2022). Perhaps, then, it is not unexpected that highly leveraged producers are more likely to purchase crop insurance (DeLay et al., 2022).

Farmers without an organic production history for their crop, such as those who are newly certified, are required to use a transitional yield (t-yield) for their crops when purchasing insurance. In 2014, the Risk Management Agency (RMA) implemented an organic specific t-yield for new organic farmers. A simulation of a panel that included field level yield data for 37 organic farms (24 corn, 15 soybean) in Minnesota revealed that the shift to organic specific t-yields on these farms reduced the losses so significantly that they were equivalent to those earned by their nonorganic peers (Delbridge and King, 2019). One consequence of the organic specific t-yield, however, is that farmers who believe the assigned t-yields are too low will forgo crop insurance (Delbridge and King, 2019). The use of the organic t-yields may be a barrier to organic insurance adoption by beginning farmers, or even a barrier to transition for producers seeking risk management during the transition. This may be especially problematic for the organic sector since, in 2021, 54% of organic farmers were farming organically for less than 10 years and thus considered beginning farmers (USDA NASS, 2022).

Organic operations that are more diverse (as measured by the number of commodities grown), are less likely to use crop insurance (Belasco and Fuller, 2022). Similarly, farmers with more years of experience in the organic sector are less likely to adopt crop insurance, while organic farms with higher gross sales are more likely to adopt crop insurance (Belasco and Fuller, 2022). In contrast, conflicting research using different data finds that relatively more diverse organic farms are more likely to adopt crop insurance, but Belasco and Fuller (2022) argue this may result from the ARMS data, which includes farms with relatively low levels of crop diversity. The ARMS data also suggest that the higher the share of farmland that is organic, the lower the likelihood of purchasing crop insurance. Network effects may be present, as well, given that the more organic farms in a county, the higher the likelihood of buying crop insurance. Relatedly, Morris et al. (2019) find a relationship between peer use of crop insurance and producer interest in crop insurance.

Qualitative data suggests that organic farmers who do not buy crop insurance believe their farms are too diversified or too small to make insurance worthwhile (Belasco and Fuller, 2022). Other research suggests that organic producers believe that crop insurance and other USDA programs benefit large scale operations, and that completing the paperwork tracking yields for each crop is prohibitive (Raszap Skorbiansky et al., 2022). The same study found that specialty crop producers prefer to manage risk through their production practices, rather than purchasing crop insurance (Raszap Skorbiansky et al., 2022).

***Topic 9: Risks related to organic integrity***

One of the primary reasons for creating the federal organic certification program in the U.S. was to give consumers confidence in the integrity of organic food. The USDA logo meant that food was raised, processed, and distributed according to rigorous standards. However, several high visibility cases of organic fraud, specifically regarding grain, have pointed to vulnerabilities in the system (Parker, 2021; Real Organic Project, undated). The Strengthening Organic Enforcement Rule is intended to strengthen enforcement, and was implemented in 2023.

The ability to pass off nonorganic food as organic results from asymmetric information, resulting from the inability to directly observe the quality ‘organic.” Thus, a producer has private knowledge of how the food was produced and the buyer is not able to detect whether this is true. Organic certification is a mechanism by which a seller can signal to the buyer that the product is organic. But the process contains incentives for sellers to misrepresent their products, in hopes of gaining a higher price without incurring the higher costs (Giannakas and Yiannaka, 2023). A potential problem with certification is caused by low inspection standards and the fact that the time of both the inspection and audit are known in advance, so any evidence of noncompliance can be hidden (Giannakas and Yiannaka, 2023).

The risk of fraud increases as the size and complexity of the organic market grows (Ferreira et al., 2021). Factors that increase the likelihood of fraud are high organic premiums and supply shortages (Ferreira et al., 2021). A food fraud vulnerability tool designed by SSAFE is available for use by businesses to assess their supply chains. Researchers used this tool to assess the systems for organic bananas, eggs, olive oil, pork and milk, finding higher perceived vulnerability for organic pork and olive oil (Huisman and van Ruth, 2023). Some point to the effectiveness of private public partnerships intended to reduce fraud in the organic sector, along with the need to collect more data and implement stronger surveillance methods (Manning and Kowalska, 2021).

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**Appendix A. Papers cited in the literature review**

The following table shows the papers included, the region, crops analyzed and data sources.

|  |  |  |  |
| --- | --- | --- | --- |
| **Citation** | **Region** | **Crop coverage** | **Source of data used** |
| Baron and Dimitri, 2019; Dimitri and Baron, 2020 | National | General organic | Interview and survey data |
| Belasco and Fuller, 2022 | National  | Crop insurance | Survey and ARMS |
| Brady, M.P., Granatstein, D. and Kirby, E., 2023 | Washington State | General organic | Administrative data from Washington state organic certifier |
| Brock et al, 2021 | Eastern corn belt | Corn | Survey data  |
| Bruce et al., 2022 | Indiana | Grain | Interview and survey data |
| Delbridge and King, 2019 | Minnesota | Corn and soy | Survey data  |
| Dimitri and Nehring, 2022 | National | Dairy | ARMS and USDA Organic Survey |
| Fuller et al., 2021 | National | General organic | ARMS |
| Hadachek et al., 2023 | National | Grain and feed | Interview |
| Han et al., 2022; Han and Grudens-Schuck, 2022 | Iowa | Corn | Survey |
| Herrera and Dimitri, 2019 | National | Dairy | Organic Integrity Database |
| Kuo and Peters, 2017 | National | General organic | Census of Agriculture[[1]](#footnote-1) |
| Khanal et al., 2018 | National | General organic | ARMS |
| Lui et al., 2019 | South | General organic | Survey |
| Marasteanu and Jaenicke, 2019; Marasteanu and Jaenicke, 2016a; Marasteanu and Jaenicke, 2016b | National | General organic | Organic Integrity Database |
| Morris et al., 2019 | National | Crop insurance | Survey and interviews |
| Nehring et al., 2021 | National | Dairy | ARMS |
| Raszap Skorbiansky and Adjemian, 2021 | National | Corn and soybeans | USDA National Organic Report (prices, AMS) |
| Snider et al., 2021 | National | Dairy | Survey |
| Snorek et al., 2023 | New England | Dairy | Interview |
| Torres et al., 2020 | Midwest | Grain | Interview and survey |
| Torres and Marshall, 2018 | 16 states | Fruit and vegetable | Interview and survey |
| Torres et al., 2017 | 16 states | Fruit and vegetable | Interview and survey  |
| Walsh et al., 2020 | Vermont | Dairy | Survey  |

1. The authors use county level data from the 2007 and 2012 Census of Agriculture, which reports the number of organic and farms in the organic transition. They use organic farm share of farms in the county in 2012 and the difference in the number of organic farms between 2007 and 2012. The amount of data on organic farms in the 2007 and 2012 Census is limited to the number of organic farms, sales, number of farms in transition to organic, gender, off-farm work, whether farmers live on the operation, age, and years on present farm (Table 54, Census of Agriculture 2012). [↑](#footnote-ref-1)