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Do Farmers' Markets Boost Main Street? Direct-to-Consumer Agricultural Production Impacts on the Food Retail Sector

Jeffrey K. O'Hara[aΦ] and David Shideler[b]

[a]*Agricultural Marketing Specialist, U.S. Department of Agriculture, Agricultural Marketing Service, 1400 Independence Ave., SW Room 4509-S, Washington, DC 20250-0269*

[b]*Associate Professor and Extension Economist, Department of Agricultural Economics, Oklahoma State University, 323 Ag Hall, Stillwater, OK 74078*

Abstract

We estimate the county-level impacts of direct-to-consumer (DTC) agricultural production on two food and beverage retail subsectors in Arkansas, Louisiana, Oklahoma, and Texas using a first-difference model. We test for the endogeneity of DTC agricultural production by using a drought index and the lagged value of DTC production as instruments. We find that DTC agricultural production impacts the food services and drinking places subsector (which includes restaurants). This effect on food retail sales is positive in metropolitan counties and negative in nonmetropolitan counties. Our results inform planners about the complementarity between local agricultural production and food retail sectors.

Keywords: food retail, local foods, regional economic development

[Φ]Corresponding author: Tel: 202 756 2575
Email: jeffreyk.ohara@ams.usda.gov

Introduction

Given consumer interest in locally sourced foods, investigating whether local agricultural production can stimulate the downstream local "food economy" is a research priority. Vibrant food retail establishments can be an important source of revenue for communities, but previous research estimating the economic impacts of local agricultural production has focused on upstream effects, such as how local food markets provide jobs for farm laborers and/or revenue for input suppliers (e.g., Jablonski and Schmit, 2015). The impact of local agricultural production on the food retail sector has not been rigorously investigated in the literature.

In this study, we estimate the county-level impacts of direct-to-consumer (DTC) agricultural sales (defined as sales at on-farm stores, farmers' markets, and other direct marketing venues) on the economic performance of the food and beverage retail subsectors. Using data from 2007–2012 (the most recent time period for which county-level data on DTC production is available as of this writing), we focus on the U.S. Census Bureau West South Central (WSC) division—comprising Arkansas, Louisiana, Oklahoma, and Texas—a region in which sales to local retailers are a relatively important marketing opportunity for farmers. We examine the two most prominent food retail subsectors: food and beverage stores, which include grocery stores, and food services and drinking places, such as restaurants and cafeterias. In the WSC region, direct sales by farmers to retailers like supermarkets and restaurants accounted for 55% of local food sales in 2015, the highest percentage in the country (U.S. Department of Agriculture, 2016a).

Estimating a causal relationship between DTC production and food retail sales can be confounded by the potential for endogeneity from unobservable county-level attributes. This region and time period have attributes that make it possible to establish a causal link between DTC production and the food retail sector. Our identification strategy exploits the severe drought that impacted the WSC region between 2007 and 2012 as a natural experiment. The drought index that we create is a compelling instrument for our purposes for three reasons: i) there was variation in the severity of the drought within the WSC region; ii) the drought had a pronounced negative effect on agricultural production; and iii) we consider the drought to be exogenous with regard to unobserved factors that might influence food retail sales. We also use the lagged value of DTC agricultural production as an instrument. Lagged changes in the values of DTC production are correlated with current changes in the WSC division.

Enhancing local food systems has emerged as an economic development priority across the United States. For example, food policy councils have been formed across the country, in part to support this objective (Johns Hopkins Center for a Livable Future, 2018). Despite this interest, policy makers have little evidence to guide them in understanding the economic linkages between local agricultural production and food retail sectors. DTC production could support the food retail sector by increasing consumer interest, and subsequent expenditures, at food retail outlets. However, DTC markets could also compete with grocery stores and restaurants for consumer expenditures. A central contribution of our study is to provide greater insight into how incorporating local food production into food systems planning efforts would impact food retail businesses.

Background

DTC Production and Food Retail Linkages

Farmers sell agricultural products locally through various supply chains. DTC agricultural sales occur at farmers' markets, roadside stands, pick-your-own operations, community-supported agriculture (CSA) programs, and at other direct marketing outlets. DTC agricultural sales occur predominantly among small and medium-sized farms (Detre et al., 2011; Low and Vogel, 2011; Ahearn and Sterns, 2013). Local food sales can also occur when farmers sell products directly to anchor institutions, supermarkets, restaurants, or other intermediaries such as food hubs, which are distributors that aggregate and market locally branded food products. In 2015, local food sales from farms totaled $9 billion nationally (U.S. Department of Agriculture, 2016a).

Consumer interest in buying local foods can present a market opportunity for farmers and an economic development strategy for communities. Jablonski and Schmit (2015) found that local food farms have a greater dependence on labor and other local inputs relative to conventional farms. Other research studies (Hughes et al., 2008; Hughes and Isengildina-Massa, 2015; Jablonski, Schmit, and Kay, 2016; Rossi, Johnson, and Hendrickson, 2017; Watson et al., 2017) found that the localized economic impacts of local food sales can be higher than traditional food retail sales due to import substitution. Swenson (2010) estimated that fruit and vegetable agricultural production marketed locally would have a positive economic impact in the Upper Midwest if it displaced corn and soybean production.

Other studies have estimated linkages between local food production and other sectors in the economy. Brown et al. (2014) used U.S Census of Agriculture data to estimate the impacts of DTC agricultural production on aggregate agricultural production and, in turn, how agricultural production impacted aggregate economic activity. O'Hara and Benson (2018) found that dairy and DTC agricultural production had a positive impact on both local milk and local nonmilk purchases by school districts. Lev, Brewer, and Stephenson (2003) studied ten farmers' markets in Oregon and Idaho between 1998 and 2003. They found that, in some cases, the presence of a downtown farmers' market led to increased expenditures at neighboring businesses. There is, however, a dearth of studies that have empirically and systematically estimated whether DTC market outlets can influence food retail activity over a larger geographic region.

DTC agricultural production can increase food retail sales through supply-side mechanisms: DTC markets can provide a critical way for vendors to develop entrepreneurial skills and market their businesses (e.g., Feenstra et al., 2003; Morales, 2011; Lawson, Drake, and Fitzgerald, 2016; Horst, McClintock, and Hoey, 2017). Moreover, some farmers' markets serve as business incubators for new agricultural enterprises by providing shared facilities like kitchens or storage, retail space, or other forms of technical assistance (O'Hara and Coleman, 2017). This service enables some food retail businesses (e.g., a local baker) to coexist at farmers' markets alongside DTC farmers. Therefore, the existence of a farmers' market anchored by DTC farmers can help food retail vendors and businesses earn additional revenue and increase their visibility among community residents.

DTC markets can be amenable for beginning farmers since they have relatively low entry costs. Thus, marketing activity at DTC markets could provide a gateway for farmers and vendors to subsequently market products to local intermediaries in larger volumes. Examples include marketing higher-valued agricultural products (like vegetables) to restaurants or value-added products (like tomato sauce) to grocery stores or specialty food stores and selling directly to distributors that subsequently sell locally branded products to food retail establishments. Some farmers with local food sales use a variety of marketing channels, including both DTC and non-DTC outlets (Park, Mishra, and Wozniak, 2014; Low et al., 2015; U.S. Department of Agriculture, 2016a). In South Carolina, Hughes and Isengildina-Massa (2015) found that, among farmers with farmers' markets sales, 44% of their revenue came from farmers' markets, while the rest came from other market venues like restaurants and grocery stores.

On the demand side, DTC market venues can increase consumer awareness for local foods and contribute to increased demand for farm-to-table initiatives among restaurants and other retailers. For instance, product freshness and quality are important factors that influence local purchases by consumers (Low et al., 2015). Therefore, if a consumer becomes sensitized to these factors at a DTC market, the presence of local agricultural products on restaurant menus or on grocery store shelves might induce them to shop at food retail outlets that they might not otherwise patronize. In addition, they might spend more at food retail establishments. Increased expenditures may not come entirely from local residents; rather, some DTC markets could attract tourist expenditures from nonlocal residents at restaurants and other venues if local agricultural products are of high quality.

While the discussion thus far has emphasized the complementarity between DTC production and the food retail sector, these two market segments could also be substitutes. On the supply side, local producers may be reluctant to sell through non-DTC market channels if, for instance, higher prices at DTC markets crowd out the development of non-DTC local food market channels. On the demand side, more purchases at DTC agricultural markets could reduce expenditures at restaurants as consumers increase at-home food consumption at the expense of away-from-home consumption. Also, increased food purchases at DTC agricultural markets could result in consumers shopping for fewer products at grocery stores.

Trends in WSC Food Retail Subsectors

The WSC division experienced a 6% increase in real per capita income between 2007 and 2012, the largest among all U.S. Census Bureau divisions. We convert all monetary values into 2014 U.S. dollars using the Consumer Price Index (U.S. Department of Labor, 2015). Certain sectors that are exogenous to the food services sector contributed considerably to the region's growth. For instance, personal income from the mining, quarrying, and oil and gas extraction ($35 billion, or 52%); professional, scientific, and technical services ($9 billion, or 11%); finance and insurance ($8 billion, or 14%); and pipeline transportation sectors ($7 billion, or 114%) increased in the WSC division between 2007 and 2012 (U.S. Department of Commerce, 2015).

Two 3-digit North American Industry Classification System (NAICS) subsectors encompass food retail sales. The food and beverage stores (FBS) subsector (NAICS code 445) represents sales from retail merchandise industries at fixed point-of-sale locations, including grocery stores;

specialty food stores; and beer, wine, and liquor stores. The food services and drinking places (FSDP) subsector (NAICS code 722) represents industries that prepare food and beverages for consumption and may also offer other service and entertainment options. Businesses in the FSDP subsector include full-service restaurants; limited-service eating places where customers pay before eating (e.g., cafeterias); special food services (e.g., food service contractors, caterers, and mobile food services); and drinking places where alcoholic beverages are served. We focus on the NAICS classifications at the 3-digit level because county-level data are reported less frequently for more granular classifications. Of the 470 counties in the WSC division, 260 reported sales in the FSDP and FBS subsectors in 2007, and 220 reported sales in these two subsectors in 2012.

While the value of sales in 2012 was similar in magnitude for the two subsectors in the WSC division, annual payroll in the FSDP subsector was 3.1 times larger than in the FBS in 2012, with 4.4 times as many employees (Table 1). The FSDP sector experienced greater growth than the FBS sector between 2007 and 2012, both in absolute and relative terms, across all four reported metrics. This is consistent with longer-term national trends, since away-from-home food expenditures in the United States increased from 26% of total food expenditures in 1970 to 44% in 2014 (U.S. Department of Agriculture, 2016b). Average pay in the two subsectors is fairly low, perhaps because not all jobs are full-time (Table 1). In 2012, the average annual salary was $20,343 in the FBS subsector and $14,359 in the FSDP subsector.

Table 1. Food Retail Sector Trends in the West South Central Division

	Value of Sales/Receipts (2014 $thousands)	**Establishments**	**Annual Payroll (2014 $thousands)**	**Employees**
Food and beverage stores subsector				
2007	$58,670,138	13,181	$5,421,942	268,256
2012	$66,765,019	13,258	$5,761,711	283,225
Absolute change	$8,094,881	77	$339,769	14,969
Percentage change	14%	1%	6%	6%
Food services and drinking places subsector				
2007	$54,141,129	56,837	$15,271,494	1,108,760
2012	$63,143,562	62,812	$17,756,025	1,236,563
Absolute change	$9,002,433	5,975	$2,484,531	127,803
Percentage change	17%	11%	16%	12%
Aggregated food retail subsectors				
2007	$112,811,267	70,018	$20,693,436	1,377,016
2012	$129,908,580	76,070	$23,517,736	1,519,788
Absolute change	$17,097,314	6,052	$2,824,300	142,772
Percentage change	15%	9%	14%	10%

Methods

First-Difference Model

We test the hypothesis that DTC agricultural production impacts food retail businesses. A challenge with estimating a causal impact of DTC production on the food retail sector is that factors that are unobserved or challenging to measure could be correlated with both variables. Also, the economic linkages between these two sectors could flow in the opposite direction if food retail businesses stimulate DTC production. Under these circumstances, the coefficient on DTC production would be biased.

We use two techniques in our empirical strategy to mitigate the possibility of a biased coefficient. First, we estimate first-difference regressions in which the variables represent the change in their values over time rather than their levels at a particular point in time. We do this because first-difference regressions eliminate the possibility of correlation between time-invariant unobserved effects and the regression's error term. Second, we test and control for time-varying sources of endogeneity through the use of two instruments that, we argue, are correlated with DTC production but are uncorrelated with the food retail sectors that we examine via other mechanisms.

We estimate a first-difference equation:

$$y_{it} - y_{it-1} = (x_{it} - x_{it-1})\alpha + \varepsilon_{it} - \varepsilon_{it-1}. \quad (1)$$

The dependent variable in equation (1) is represented by y_{it}, where subscripts i and t reflect the observation for a particular county in the WSC division and time period (t = 2012; t−1 = 2007), respectively. The independent variables are represented by x_{it}. We estimate parameter α in equation (1) using pooled ordinary least squares.

We use the value of sales, shipments, receipts, revenue, or business done[1] to represent the economic performance of the sectors we examine as the dependent variable. These data are reported in the Economic Census (U.S. Census Bureau, 2017). We estimate separate regressions for the FSDP and FBS subsectors since there could be differences in the magnitudes of the impacts that they experience from DTC agricultural production.

Our main independent variable of interest is DTC agricultural sales. County-level DTC agricultural sales data are publically reported in the Census of Agriculture every 5 years. Data from 2012, the most recent year for which Census of Agriculture data are available and

[1] The U.S. Census Bureau specifies that this category includes "sales of merchandise for cash or credit at retail and wholesale by establishments primarily engaged in retail trade; amounts received from customers for layaway purchases; receipts from rental of vehicles, equipment, instruments, tools, etc.; receipts for delivery, installation, maintenance, repair, alteration, storage, and other services; the total value of service contracts; gasoline, liquor, tobacco, and other excise taxes that are paid by the manufacturer or wholesaler and passed on to the retailer; and shipping and handling receipts."

applicable to this study, represent unprocessed agricultural products sold directly by producers to individuals for human consumption at DTC market outlets (U.S. Department of Agriculture, 2014). Products can include fresh fruit, fresh vegetables, eggs, chickens, turkey, cattle, or lamb. Sales of nonedible products, commodities that are not produced on the vendor's farm, and processed products like cheese, sausage, and cider are excluded from the definition.[2]

We include control variables to account for changes in county-level socioeconomic characteristics. We control for changes in total population since greater population density will increase the level of economic activity at food retail establishments. We also test whether our results are sensitive to changes in the age profile of the population. This is important since the proportion of food expenditures for at-home consumption (relative to away-from-home consumption) increases as people age (Foster, 2015). We control for these changes by including variables that represent the percentage of residents between the ages of 25 and 44, the percentage of residents between the ages of 45 and 64, and the percentage of residents aged 65 or older (U.S. Census Bureau, 2017). The omitted variable corresponds to the percentage of residents under the age of 25.

We control for changes in aggregate per capita income (U.S. Department of Commerce, 2015) since households can reduce away-from-home food expenditures during macroeconomic contractions (e.g., Todd and Morrison, 2014). Income can also be correlated with the consumption of DTC agricultural products (O'Hara and Low, 2016). We use aggregate per capita income as a control variable because food retail is ubiquitous relative to more geographically concentrated sectors (e.g., manufacturing or natural resource production). This implies that income changes from more delineated subsectors would result in having fewer observations. It is possible that there are feedback mechanisms between the food retail subsectors and aggregate income levels, which could imply that income is endogenous. However, we assume per capita income is exogenous since the increase in income in the WSC division during the 2007–2012 period was attributable, to a considerable extent, to factors exogenous to the food services sector, such as increased oil and gas production. Simultaneity is not plausible with regard to this sector since, for example, oil wells are not developed in areas with bustling food retail sectors.

We control for the state in which the county is located and use rural–urban continuum codes (U.S. Department of Agriculture, 2013) to control for its metropolitan designation. These indicator variables capture whether there are changes over time that are specific to a particular state or attributable to the metropolitan status of a county. We control for metropolitan and nonmetropolitan counties because consumer preferences may have changed differently between 2007 and 2012 in metropolitan areas relative to nonmetropolitan areas. If so, such shifts could impact the relationship between DTC production and food retail sales. We also estimate separate specifications in which we include the interaction between DTC sales and metropolitan counties

[2] Other local food data sources exist, including a recent USDA survey that solicits information about various local food distribution channels used by farmers (U.S. Department of Agriculture, 2016a). However, we use the Agricultural Census data since these represent a cross-sectional sample of farms and cannot be used for panel data applications. There are also insufficient observations in the sample to link to food retail subsector data for a county-level study.

as a control variable. DTC markets can be more feasible to establish in areas with larger populations, since vendors prefer selling at a smaller number of larger markets (e.g., Schmit and Gomez, 2011). Thus, it might be easier for a farmer selling at a farmers' market to identify food retailers who will then market their products in more densely populated regions.

County-level DTC sales data represent the county where the agricultural operation is located. The production county may not always correspond to the county where a direct marketing transaction occurs, although in many cases it does, since U.S. Department of Agriculture (2016a) data show that 61% of agricultural operations selling at farmers' markets traveled less than 20 miles to reach their highest grossing market and 82% traveled less than 40 miles. Regardless, we also estimate a regression in which we include DTC agricultural sales in neighboring counties as an independent variable as a sensitivity test to evaluate whether there are spatial implications to the relationship between DTC production in nearby counties and the food retail sector.

We report elasticities for the statistically significant variables to facilitate interpreting the results. We calculate the percentage increase in the independent variables as a 1-unit increase in their average county-level values in 2007. We calculate the percentage change in food retail subsector sales for a particular independent variable using the corresponding parameter estimate from the regression and the average county-level sales value in 2007 for the food retail subsector of interest.

Endogeneity Test

Even though we control for both unobserved time-invariant factors and exogenous socioeconomic changes, there could be other unobserved factors correlated with changes in DTC sales and food retail sales. For example, residents in some counties may have developed a "foodie" culture over time that resulted in increased expenditures at both DTC agricultural markets and food retail establishments. Alternatively, some counties may have undertaken economic development initiatives to revitalize both sectors simultaneously. For example, planners or economic development officials may seek to draw shoppers to a business district by promoting both a farmers' market and local restaurants.

We use the severe drought that impacted the WSC division between 2007 and 2012 as an instrument to test for endogeneity. Since measuring drought conditions is inherently challenging, we represent drought conditions by using the U.S. Drought Monitor index (U.S. Drought Monitor, 2015). These county-level data are reported weekly and show the percentage of a county that is in various stages of drought. There are six classifications: "nothing" (i.e., neither in a drought nor considered a drought watch area), "abnormally dry," and four drought categories that range from "moderate drought" to "exceptional drought." We classify these categories on a sequential scale of 1 for "nothing" to 6 for "exceptional drought." We subsequently create a single index number for each week of 2007 and 2012 in each county by multiplying these index values by the corresponding percentage of the county in that stage of drought. We then average the weekly conditions to obtain an annual composite index for each county. This variable's resulting parameter estimate in our first-stage regression is an estimate of how changes in drought conditions affected DTC sales between 2007 and 2012.

The drought index is a useful instrument for several reasons. First, there is exogenous variation in drought severity across the WSC. Second, the drought had a negative impact on conventional agriculture in the region (Ziolkowska, 2016). While the adverse drought impacts on agricultural commodity sectors received considerable attention, given their prominence in the region, we also hypothesize that the drought would have had similarly negative impacts on DTC agricultural production.

A third reason we use the drought index is that we assume it to be exogenous with regard to unobserved factors that may influence expenditures at food and beverage retail establishments. This exclusion restriction implies that the only impact drought would have on food retail establishments would be its impact on DTC agricultural production. A possible way by which the exclusion restriction could be violated is if non-DTC farmers were unable to supply products to restaurants and grocery stores within their county. However, we do not view this as a concern because the prominent crops produced in the WSC division (like cotton and grains) are not directly consumed by humans.[3] Also, since non-DTC livestock production is marketed at the regional or national scale, we assume that such impacts would not be specific to the county in which the livestock production occurred.

We also use the 5-year lag of changes in DTC agricultural sales as an instrument. These changes are not a source of simultaneity with the dependent variable, by construction, since the changes in their values occurred in previous time periods. Although lags of longer duration are preferable relative to lags of shorter duration, we utilize a 5-year lag based on feedback about recent regional trends that we received at a listening session with 40 county-based agricultural educators (OCES, 2016).[4] The agricultural educators emphasized that some experienced local food farmers had retired in recent years and not been replaced. This implies that, at markets with fewer farmers selling locally, this could have a proportionally large negative impact on market activity. They also indicated that, while there has been an influx of prospective farmers undertaking local food marketing, particularly among retirees or those pursuing a second career, after several years these new farmers discontinued and ended up renting out their land.

We perform Hausman tests to estimate whether DTC agricultural sales are endogenous. Specifically, we first regress DTC agricultural sales on the instruments and the other explanatory variables. We then use the residuals from this regression as an independent variable in a second-stage regression in which the sales level of the respective food retail subsector is regressed on this residual term and the other independent variables. DTC agricultural sales is an endogenous

[3] We do not report results when including control variables for field crops like grains/oilseeds, hay, or cotton production because these data are not reported for all counties. Thus, including these controls restricts the number of observations used in the regressions even further.

[4] Agricultural educators in the region are tasked with providing technical assistance and resources to farmers and ranchers. This implies awareness of agricultural trends in their counties, including the emergence (or lack thereof) of small farms and ranches selling DTC. Additionally, agricultural educators in some instances manage their local farmers' market, so they know which farmers were selling at the market as well as the market's overall activity.

variable if the residuals coefficient in the second-stage regression is statistically significant (Wooldridge, 2002).

Descriptive Statistics

Table 2 presents descriptive statistics. DTC sales and FBS and FSDP sales are reported for 195 and 221 counties in the WSC division for 2007 and 2012. The descriptive statistics are highly similar between the two observations that are included in the two regressions. County-level sales in the two subsectors increased, on average, by similar levels—approximately $33 million.

County-level DTC agricultural sales decreased by approximately $70,000 on average between 2007 and 2012. The U.S. Drought Monitor index increased by 1.4 and 1.6, on average, in the FBS and FSDP subsectors. Texas counties accounted for between 50% and 57% of the sample, while the rest of the sample was nearly equally distributed across the remaining three states. On average, 40%–42% of counties were metropolitan. Population increased on average by approximately 11,000 residents per county. There were modest increases in the average percentage of residents in older age cohorts.

Table 2. Descriptive Statistics (difference between 2007 and 2012)

	Food and Beverage Stores (*N* = 195)		**Food Services and Drinking Places (*N* = 221)**	
Variable	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Total sales/receipts ($thousands)	$32,655	$137,858	$33,305	$114,768
DTC sales 2007–2012 ($thousands)	−$69	$163	−$73	$178
Metropolitan county	0.42	0.49	0.40	0.49
Oklahoma	0.18	0.38	0.15	0.36
Arkansas	0.17	0.38	0.16	0.37
Louisiana	0.15	0.36	0.12	0.33
Population	11,177	39,685	10,662	36,968
Per capita income	$3,036	$3,384	$3,846	$4,869
% residents age 25–44	−0.01	0.02	−0.01	0.02
% residents age 45–64	0.02	0.01	0.02	0.01
% residents age ≥ 65	0.01	0.01	0.01	0.01
DTC neighboring counties ($thousands)	−$61	$55	−$60	$53
DTC × metro ($thousands)	−$25	$142	−$25	$143
Drought index	1.43	0.85	1.60	0.87
DTC sales 2002–2007 ($thousands)[a]	$75	$244	$83	$254

Notes: [a] There were 188 observations for 2002 DTC sales and 210 observations for 2007 DTC sales.

Results

Endogeneity Tests

We present the first-stage regression results in Table 3. The FBS specifications use fewer observations than the corresponding regressions for the FSDP subsector since the FBS subsector data are not reported in as many counties. The 5-year lag of DTC agricultural sales is negative and statistically significant ($p < 0.01$). The negative coefficient suggests that greater decreases in DTC agricultural production occurred between 2007 and 2012 in counties that experienced greater increases in DTC agricultural production between 2002 and 2007 after controlling for the drought and other socioeconomic changes. As we elaborate later, this negative coefficient is consistent with the declining trends in DTC production perceived by agricultural educators (OCES, 2016).

Table 3. Instrumental Variable Diagnostic Checks

	Food and Beverage Stores Sales ($thousands)	**Food Services and Drinking Places Sales ($thousands)**
First-stage regression results		
Drought index coefficient	−9.01	0.02
DTC sales 02–07 coefficient ($thousands)	−0.55***	−0.58***
N	188	210
F-statistic	32.64***	40.41***
Instrumental variable test statistics		
Hausman exogeneity test first-stage residual *p*-value	0.64	0.02
Second-stage observations	188	210
Overidentifying restrictions χ^2 test statistic	0.02	0.08

Notes: Coefficients for other independent variables not reported for brevity. Triple asterisks (***) indicate significance at the 1% level.

The drought index has a negative and statistically significant impact on DTC agricultural sales when it is the only instrument included in the regression. However, we do not report these regression results in Table 3 because the *F*-statistics from the first-stage regressions are less than 10 in magnitude. The drought index is not statistically significant in the first-stage regression when we also include the 5-year lag of DTC agricultural sales as an instrument. The magnitudes of the *F*-statistic in the first-stage regression are 32.6 and 40.4 for the FBS and FSDP subsector, respectively, when both the 5-year lag of DTC agricultural sales and the drought index are included as instruments.

The Hausman tests indicate that DTC agricultural sales are exogenous when FBS sales is the independent variable but endogenous with regard to FSDP subsector sales. We further see that

the overidentification test statistic is statistically insignificant in both FSDP and FBS specifications. This latter result provides justification for the use of both instruments.

First-Difference Regression Results

We present first-difference (FD) regression results in Table 4.[5] Sales from the FBS and FSDP subsectors are the dependent variables in specifications 1–3 and 4–6, respectively.

Population has a positive and statistically significant impact ($p < 0.01$) on both food retail subsectors in each of the specifications that we estimate. The coefficient magnitudes imply that a 1-person increase in population leads to an approximately $3,400 increase in county-level FBS sales and an approximately $3,000 increase in county-level FSDP sales. These parameter estimates imply that both food retail subsectors are elastic with respect to population changes. The elasticity values for population in specifications 1 and 4 are 1.91 and 1.89, respectively.

Per capita income does not impact sales in the FBS subsector; however, per capita income has a positive impact on sales at FSDP establishments ($p < 0.05$). The coefficient's magnitude implies that a $1 increase in county-level per capita income increases county-level sales at FSDP establishments between $560 and $730. Although the per capita income coefficients in specifications 4 through 6 are statistically significant, they are inelastic. For instance, the coefficient magnitude in specification 4 corresponds to an elasticity of 0.13.

The percentage of residents between the ages of 25 and 44 has a positive effect on both food retail subsectors. However, the impact that this percentage has on FBS subsector sales is more pronounced than in the FSDP subsector. The parameter coefficients imply that the FBS and FSDP subsectors have elasticities of 0.83 (specification 1) and 0.28 (specification 4), respectively. The other two age cohort percentage parameter estimates are statistically insignificant in all of the reported specifications.

DTC agricultural sales does not have a statistically significant impact on the FBS subsector. In specification 4, we find that a county-level $1,000 increase in DTC agricultural sales increases the county-level FSDP sales by $31,870 ($p < 0.05$). However, this corresponds to a modest elasticity value of 0.04. A $1,000 increase in DTC sales is a relatively large change compared to the implied change in FSDP sales.

The impact of DTC sales on the FSDP subsector varies depending on the metropolitan status of the county. In specification 5, the interaction term of DTC sales and metropolitan counties is positive and statistically significant ($p < 0.01$). The impact of a $1,000 increase in DTC sales

[5] We also estimate a Seemingly Unrelated Regression (SUR) as a robustness check. There are only 136 observations in the SUR since the greater number of variables decreases the number of counties that do not have missing values for at least one variable. The SUR results are similar to the FD regression results. Specifically, population has a positive and statistically significant impact on both subsectors, with similar coefficient magnitudes to the FD regressions. DTC sales are statistically insignificant with regard to the FBS subsector, while positive and significant with regard to the FSDP subsector.

Table 4. First-Difference Regression Results

Dependent Variable	Food and Beverage Stores Sales ($thousands)			Food Services and Drinking Places Sales ($thousands)		
Specification No.	**1**	**2**	**3**	**4**	**5**	**6**
DTC sales 2007–2012	24.38	−2.25	27.16	31.87**	−9.67**	33.61**
	(22.81)	(9.29)	(23.41)	(14.87)	(4.55)	(15.48)
Metropolitan county	−5,998	−3,430	−6,683	−406	5,256	−601
	(6,599)	(6,591)	(6,829)	(5,294)	(4,942)	(5,303)
Oklahoma	−837	−1,775	−2,305	3,848	3,233	2,786
	(3,915)	(3,899)	(3,600)	(3,007)	(3,078)	(3,008)
Arkansas	12,159**	11,797*	12,563**	5,683**	7,016**	5,564**
	(6,092)	(6,092)	(6,241)	(2,781)	(2,891)	(2,815)
Louisiana	1,507	456	2,399	9,871	7,825	10,285
	(5,849)	(5,803)	(6,271)	(6,071)	(5,831)	(6,245)
Population	3.37***	3.36***	3.35***	3.01***	3.00***	3.00***
	(0.35)	(0.34)	(0.34)	(0.27)	(0.26)	(0.27)
Per capita income	−0.03	−0.20	−0.19	0.73***	0.56**	0.69***
	(0.51)	(0.51)	(0.52)	(0.26)	(0.24)	(0.25)
% residents age 25–44	432,024*	445,459**	405,785**	209,850*	242,089**	189,305*
	(182,702)	(181,214)	(167,343)	(114,240)	(121,348)	(104,553)
% residents age 45–64	19,349	153	−37,041	57,683	−11,161	−1,959
	(152,001)	(151,306)	(172,792)	(80,439)	(79,732)	(126,500)
% residents age ≥ 65	227,361	211,450	134,896	−25,364	−72,081	−71,280
	(160,080)	(161,682)	(166,215)	(101,621)	(97,741)	(94,289)
DTC × metro		38.11			69.68***	
		(31.76)			(21.97)	
DTC neighboring counties			−53.81			−36.52
			(52.84)			(43.18)
R^2	0.92	0.92	0.92	0.94	0.94	0.94
F-statistic	225.38***	204.93***	204.93***	328.22***	310.31***	298.26***
N	195	195	195	221	221	221

Notes: Numbers in parentheses are robust standard errors. Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level, respectively.

results in a FSDP subsector increase of approximately $70,000, more than twice the size of the coefficient magnitude on DTC sales in specification 4. Thus, the impact of DTC agricultural production on the FSDP subsector is more pronounced in metropolitan counties. When the interaction term is included in specification 5, the coefficient on DTC sales is negative and statistically significant ($p < 0.05$). DTC agricultural sales in neighboring counties do not impact either of the food retail subsectors (specifications 3 and 6).

Instrumental Variable Regression Results

The instrumental variable (IV) regression results in Table 5 are similar to the FD regression results in Table 4. In particular, population has the same coefficient magnitudes in Table 5 as in specifications 1 and 4 in Table 4. Likewise, per capita income has a positive impact on the FSDP subsector but a statistically insignificant impact on FBS subsector sales. The percentage of residents between the ages of 25 and 44 is statistically insignificant in the IV regression with regard to the FSDP subsector. While this contrasts with the FD regression results, the parameter estimate in the FSDP IV regression is close in magnitude to the FD regression coefficient reported in specification 4.

Table 5. Instrumental Variable Regression Results

Dependent Variable	Food and Beverage Store Sales ($thousands)	Food Services and Drinking Places Sales ($thousands)
DTC sales	18.87	48.60***
	(28.38)	(18.38)
Metropolitan county	−9,267	−791
	(6,311)	(5,361)
Oklahoma	−936	4,129
	(3,964)	(3,249)
Arkansas	6,302	4,818*
	(4,010)	(2,927)
Louisiana	2,549	9,971
	(6,248)	(6,421)
Population	3.37***	3.01***
	(0.35)	(0.26)
Per capita income	0.02	0.82***
	(0.50)	(0.28)
% residents age 25–44	396,900**	208,885
	(181,796)	(137,274)
% residents age 45–64	15,998	87,625
	(165,539)	(90,468)
% residents age ≥ 65	252,898	−10,567
	(163,110)	(115,910)
F-statistic	325.76***	412.34***
N	188	210

Notes: Numbers in parentheses are robust standard errors. Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level, respectively. *F*-statistics are calculated for the joint significance of the socioeconomic variables.

DTC sales has a positive and statistically significant impact on the FSDP subsector. The IV coefficient's magnitude implies that a $1,000 increase in county-level DTC agricultural sales increases FSDP sales by approximately $48,600. Thus, the magnitude of the DTC sales parameter estimate in the IV regression is greater than the corresponding coefficient in the FD regression.

Discussion

We find that the drought had a detrimental impact on DTC agricultural production, which is consistent with the adverse impacts that conventional agricultural sectors similarly experienced. We attribute the negative coefficient on the 5-year lag of DTC agricultural sales in the first-stage regression to supply-side constraints that adversely impacted DTC market performance in the region, as reported by agricultural educators (OCES, 2016).

The positive coefficient on population with respect to both dependent variables is consistent with the expected sign. While both food retail subsectors are highly elastic with regard to population changes, they experience different outcomes from changes in other socioeconomic variables. For example, if an expenditure at an FSDP establishment represents more of a luxury purchase than one at an FBS establishment, then per capita income impacts sales in the FSDP subsector but not necessarily the FBS subsector. The positive impact that the percentage of the population between the ages of 25 and 44 has on both food retail subsectors could be due to people in this age cohort consuming food in greater quantities than do other age cohorts. However, the relatively smaller impact that this percentage has on the FSDP subsector could be because other socioeconomic factors, such as income changes, have a relatively greater influence on these expenditures.

Our finding that DTC production is exogenous with regard to the FBS subsector but endogenous with regard to the FSDP subsector could be due to the different ways in which people shop at the stores. A demand-side explanation for this finding is if FBS expenditures at grocery stores are more for staple foods and less influenced by whether such products are local. In contrast, expenditures at restaurants may be more influenced by quality attributes of the food product. A supply-side explanation for this finding is that grocery store supply chains may be more consolidated and challenging for DTC farmers to access, whereas selling products directly to a restaurant may be more straightforward. Regardless, so as to not overstate this finding, we emphasize that the magnitude of the impact on restaurant sales from changes in DTC sales is modest, corresponding to an elasticity of 0.04.

We find that DTC production and the FSDP subsector were complements in metropolitan areas and substitutes in nonmetropolitan areas. It may be more efficient for food retail businesses to sell at direct markets in metropolitan areas if the greater population density reduces their per unit direct marketing transaction costs by a relatively greater amount (e.g., Schmit and Gomez, 2011). Also, direct marketing farmers may be able to more easily connect with food retail businesses that will market their products where population density is greater. If such opportunities are not as easy to establish in nonmetropolitan areas, then DTC markets could compete with food retail businesses for customer purchases. Alternatively, residents of nonmetropolitan areas may patronize food businesses in metropolitan areas, where it could be easier to promote locally sourced products.

Conclusion

In the United States, two food consumption trends have emerged in recent decades: i) an increasing proportion of away-from-home food expenditures and ii) greater consumer awareness and interest in buying source-identified local foods. While numerous mechanisms provide plausible explanations as to why DTC agricultural production could bolster food retail sectors, the complementarity of these sectors has not been extensively researched. Such research is valuable given the headwinds confronting the retail sector in general and the food retail sector in particular. For instance, traditional food retailers have confronted challenges from the increasing consolidation of the sector, such as an increasing market share of supercenters, as well as from an increased share of sales occurring online (Daniels, 2017; U.S. Department of Agriculture, 2018).

Our results suggest that policy makers and economic development officials can view supporting DTC production as reinforcing the FSDP subsector in metropolitan counties. Practically, our results suggest that planners should engage local agricultural producers and food retail enterprises collectively in planning efforts in such areas. We also found that DTC markets can be a substitute for restaurants in nonmetropolitan counties. Thus, planners in nonmetropolitan counties should be aware of the trade-offs between these sectors when developing long-term economic development programs. We did not find that DTC production impacts the performance of the FBS subsector, which similarly informs planners that enhancing DTC markets has neither positive nor negative impacts on grocery stores and supermarkets.

In recent years, researchers have surveyed farmers (U.S. Department of Agriculture, 2016a), distributors/food hubs (Hardy et al., 2016), and institutional sectors such as schools (O'Hara and Benson, 2018) in an effort to understand opportunities, supply chain logistics, and market size in buying local foods. While our findings provide evidence of a relationship between DTC production and food retail businesses at the county level, there have been few studies examining food retail business practices pertaining to local food sourcing. Future research could involve surveying food retail enterprises to identify trends and patterns in both sourcing local food products and marketing at DTC outlets.

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