Journal of Agricultural and Applied Economics (2020), **52**, 222–239
doi:10.1017/aae.2019.44

CAMBRIDGE UNIVERSITY PRESS

RESEARCH ARTICLE

Online Sales: A Direct Marketing Opportunity for Rural Farms?

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Abstract
Online marketplaces could help direct-to-consumer (DTC) farms compete for customers making grocery purchases on the internet by reducing the search and transportation costs of in-person DTC transactions. While in-person DTC marketplaces have been conducive for metropolitan farms historically, we explore whether rural DTC farms, with distance-based challenges accessing customers, are more likely to have online platforms. We find that rural farms distant from metropolitan counties that are new to DTC marketing are 7% more likely to have online marketplaces than more experienced rural farms, while new metropolitan farms are less likely to have them.

Keywords: Direct sales; e-commerce; local food; online marketplaces

JEL Classifications: Q12; Q13; R12

1. Introduction

In an argument popularized in *The World is Flat*, decreasing communication costs have enabled firms to sell goods to consumers at increasingly greater geographic distances (Friedman, 2005). In this vein, technological advances within the past decade, such as greater internet availability in rural areas and improvements in online transaction software, could have helped farms sell agricultural products via the internet directly to consumers.

Online marketplaces can potentially reduce the transaction costs that consumers and farms experience when undertaking in-person direct-to-consumer (DTC) transactions at, for instance, on-farm stands and farmers markets. If online purchases of food are shipped by courier, transportation costs can decline since producers and consumers do not have to travel and coordinate schedules to undertake the transaction. So, online marketplaces can help DTC farms make sales that would otherwise be cost prohibitive. Online sales can also reduce the search costs of DTC transactions. This is because the internet allows customers to readily compare products and prices among DTC farms, along with food products from other online retailers. However, little is known about which farms sell products online despite the apparent value that e-commerce could have for DTC farms.

We use the U.S. Department of Agriculture's (USDA) 2015 Local Food Marketing Practices Survey (LFMPS) data to examine which DTC farms are selling products online. We estimate logit models in which we regress the probability that a DTC farm has an online marketplace on the rural-urban classification of its county, its experience level, the farmer's age, and other attributes. Previous research has modeled the attributes of farmers that use the internet (e.g., Briggeman and Whitacre, 2010). We extend this literature by providing one of the first national-level studies that

investigates which farms undertake e-commerce sales. The LFMPS provides data on online farm sales that was previously unavailable, and studies that have used LFMPS data thus far have not focused on online marketing (O'Hara and Lin, 2019; Plakias, Demko, and Katchova, 2019).

We focus on whether rural farms are more likely to undertake online sales. While rural farms may have comparative advantages to urban farms, like lower input costs, in-person DTC sales are more conducive for farms near cities (O'Hara and Lin, 2019). Since online marketplaces can reduce transportation costs, rural farms may be more likely to use them since they have fewer customers that are geographically close. In contrast, farms in metropolitan areas may be more likely to have online marketplaces if they have more in-person DTC marketing opportunities, and such transactions allow customers to become familiar with their farm and online platform.

We also examine whether the experience level of the farm influences online marketplace usage. More experienced farms could have greater brand awareness and more loyal customers than newer farms, which could increase the profile of their online marketplace. However, newer DTC farms may undertake online sales if they have more proficiency with the technology needed for online transactions or perceive new opportunities for accessing consumers that experienced farms are not pursuing. We further test whether the interaction terms between experience and the county's metropolitan status are significant. These interaction terms are important because the internet was less available in rural areas historically. In part because of policy efforts, in recent years internet availability in rural areas increased at a greater rate than in urban areas (Barnes and Coatney, 2015). So, more experienced rural DTC farms may not have developed a business model predicated on online sales if the internet was either not available or not widely used for food retail sales, while newer rural DTC farms may be better positioned to take advantage of the increased internet availability and the propensity of consumers to purchase food online.

Understanding which farms use online marketplaces can increase the effectiveness of local food policy support. For example, the Local Agriculture Market Program, an umbrella program established by the U.S. Congress in the 2018 Farm Bill, contains programs that could benefit from information about where food e-commerce platforms may be most effective. These programs include the Farmers Market Promotion Program, which offers technical assistance to practitioners to create new or expand existing DTC markets (including online platforms); and the Value-Added Producer Grant Program, which supports the development and marketing of processed agricultural products, including foods marketed as local.

2. Background

2.1. DTC agricultural production and online marketing

DTC agricultural sales traditionally occurred via farmers markets, on-farm stores, roadside stands, and community supported agriculture (CSA) programs. In 2017 for the first time, the Census of Agriculture's report form listed online marketplaces as a DTC market channel. Online sales accounted for 6% of aggregate DTC sales made by U.S. farms in 2015 (USDA NASS, 2016).

Fifty-four percent of DTC farms are in metropolitan counties (Table 1). O'Hara and Lin (2019) found that greater population levels within 50 miles of a local food farm increase the probability that it undertakes DTC sales and, conditional on entrance, their level of DTC sales. A challenge with establishing farmers markets in low population density areas is that vendors prefer attending fewer, but larger markets, to reduce their average marketing costs (Schmit and Gomez, 2011). Also, incomes may be higher in urban cities than in rural areas, and DTC production near cities is income elastic (O'Hara and Low, 2016). In addition to DTC sales, population density also facilitates direct sales of food by farms to retailers like supermarkets and restaurants (O'Hara and Lin, 2019).

DTC sales in the United States increased throughout the 1990s and 2000s in response to a greater consumer interest in purchasing local foods (O'Hara and Low, 2016). However, DTC sales

https://doi.org/10.1017/aae.2019.44 Published online by Cambridge University Press

Table 1. Descriptive statistics of DTC farms

Variable	Weighted Mean	Weighted Standard Deviation
Online marketplace	0.08	0.28
Female	0.64	0.48
Hispanic	0.04	0.20
Non-Hispanic white	0.89	0.31
Use internet to access resources	0.61	0.49
Ave. age	57	12
Square of ave. age	3,366	1,311
Metropolitan county	0.54	0.50
Non-metro adjacent county	0.31	0.46
Residential HSIC/total households (county)	0.75	0.13
Begin selling in DTC markets 2009 or later	0.35	0.48
Northeast	0.20	0.40
Midwest	0.31	0.46
South	0.28	0.45
Value-added production (binary)	0.66	0.48
Sell to retailers	0.14	0.35
Sell to intermediaries / institutions	0.12	0.32
Sell beef local	0.26	0.44
Sell vegetable local	0.35	0.48
Sell fruit local	0.28	0.45
Sell poultry local	0.27	0.44
Sell lamb local	0.11	0.31
Sell specialty animals local	0.09	0.29
Sell pork local	0.07	0.26
Sell dairy products local	0.04	0.19
Sell greenhouse local	0.06	0.24
Sell grains local	0.03	0.18
Percent bachelor's degree (county)	0.24	0.10
Per capita income / 10,000 (county)	4.24	0.99

Note: We calculated the statistics from 4,664 farms in LFMPS that participated in DTC markets.
We eliminated a select number of farms for which county-level internet statistics were not available.
Source: We use Census Bureau definitions from Tables 1, 2, and 3 when providing regional classifications.

have stagnated within the past decade (Low et al., 2015). The USDA NASS estimated that between 2015 and 2017, DTC sales declined by 10% from $3.1 billion (measured in 2017 USD) to $2.8 billion (USDA NASS, 2016, 2019).

Transaction costs incurred by producers and consumers are an impediment to in-person DTC agricultural venues. The marketing and distribution costs that farms incur for local sales can range between 13 and 62% of their revenue (King et al., 2010). Impediments that consumers experience with in-person DTC transactions include: operational hours of a neighborhood farmers' market

https://doi.org/10.1017/aae.2019.44 Published online by Cambridge University Press

may present scheduling conflicts or occur during inclement weather, local farms may be too far away for consumers to visit on a consistent basis, and CSA farms may deliver products that are incompatible with what consumers want or are able to prepare that week. Efforts to reduce the transaction costs for consumers can exacerbate the costs incurred by farmers, which, in turn, could have contributed to the recent plateau in DTC sales. For instance, more farmers markets within an area can, in some instances, fragment the customer base of existing ones (Lohr et al., 2011). If so, DTC farmers must attend more markets, and, thus, incur greater costs, to maintain their existing level of in-person sales.

A more fundamental challenge confronting DTC farms is that consumers now have more opportunities to make online grocery purchases (OneSpace, 2018), and, thus, can more readily buy local products without leaving their home. The percentage of groceries that consumers purchase online is increasing annually, and industry reports are predicting that this trend will continue (CNBC, 2017; OneSpace, 2018). Similarly, online businesses that deliver meal kits (e.g., Blue Apron) and imperfect fruits and vegetables (e.g., Imperfect Produce) are, at least anecdotally, adversely impacting CSA programs (Huntley, 2018; TNFE, 2018; Wolnik, 2019). Online delivery businesses compete with DTC agricultural producers since online produce buyers are younger, more educated, more likely to live in urban areas, and have greater local food expenditure levels than other market participants (Gumirakiza and VanZee, 2017).

E-commerce platforms could offer a way for DTC farms to compete for consumers that are increasing online grocery purchases. Online DTC sales can reduce the transportation costs of in-person DTC markets since, if the goods are shipped, neither producers nor consumers need to travel or coordinate schedules to fulfill the transaction. Since travel is not required, online sales are not geographically constrained. They can also reduce search costs for consumers. As an example, a consumer who wanted to subscribe to a CSA program while customizing their order could easily compare alternatives online.

At the same time, there are costs associated with online marketplaces. Customer acquisition costs may be higher since customers need to at least be aware of the website, and perhaps want detailed information about the farm. Consequently, some in-person interactions between farmers and consumers may be needed before online transactions occur. Lu and Reardon (2018) show that once consumers are familiar with a food product through tactile observation, they may be comfortable making subsequent online purchases.

2.2. Farm technology and internet use

The rural household broadband adoption rate changed from 46 to 62% between 2009 and 2013, which was higher than the corresponding increase of 67 to 70% in urban households (Barnes and Coatney, 2015). The percentage of farms with internet access increased from 57% in 2007 to 70% in 2012, and further increased to 75% in 2017 (USDA NASS, 2019; Whitacre, Mark, and Griffin, 2014). Broadband availability has increased farm sales and attracted new firms to rural areas (Kandilov et al., 2017; Kim and Orazem, 2017). However, despite improvements, high-speed internet deficiencies remain in rural areas (FCC, 2018). For instance, hosting an online marketplace requires high-speed internet access and not low-speed service. So, policymakers remain focused on expanding high-speed internet access in rural areas.

There is an extensive literature on agricultural technology adoption (e.g., Sunding and Zilberman, 2001). A farm's decision to sell products online is based, in part, on time-management factors. For instance, working off the farm is positively related to farm technology adoption and human capital levels (Fernandez-Cornejo et al., 2007). In reviewing the literature, Briggeman and Whitacre (2010) show that farm internet adoption can be associated with the farmer's age, education, farm size, regional location, whether they work off the farm, gender, and whether they have diversified operations. Internet access increases the probability that a farm makes DTC food sales (Low and

https://doi.org/10.1017/aae.2019.44 Published online by Cambridge University Press

Vogel, 2011; Park, Mishra, and Wozniak, 2014). Also, DTC farms with internet access have a greater level of sales (Detre et al., 2011; Low and Vogel, 2011; Uematsu and Mishra, 2011).

Agricultural Resource Management Survey (ARMS) data has been used extensively in the farm-level internet-use literature. The ARMS has focused on whether farms have the internet, but not on online marketing (Stenberg et al., 2009). The ARMS data in these studies are from the mid-2000s; subsequent versions of the ARMS have de-emphasized questions about internet use. However, there has been considerable innovation in ways that the internet could be valuable to farms since that period. DTC farms can use smartphones to process payments, use social media to advertise their products, or partner with software developers to create smartphone apps that allow customers to search for local farms. For instance, the "WhatsGood" app allows customers in the Northeast to order foods directly from local farmers and have it delivered to their home or workplace.

To summarize, earlier studies have investigated farm internet adoption. However, there is a dearth of research examining the characteristics of farms that market food online to consumers directly. We contribute to this literature by using a unique national-level dataset to examine which farms use online marketplaces for DTC food sales.

3. Data and methods

3.1. LFMPS

In 2016, for the first time, the USDA's National Agricultural Statistics Service (USDA NASS) administered the LFMPS (to collect 2015 data).[1] In contrast to the ARMS, which annually solicits information about farm production practices and profitability, the LFMPS is the first USDA dataset with detailed data about specific market channels used by "local" food farms. In the LFMPS, "local" food farms are those that make direct sales of food to consumers, retailers, institutions, and/or intermediaries that market locally-branded food products. The USDA NASS used the phrase "local" even though online sales are not geographically constrained, and could include transactions between farmers and consumers located anywhere in the country. In our article, for consistency we refer to LFMPS respondents as "local" food farms. The data do not allow for comparisons between local food and non-local food farms since farms not selling local food are not surveyed in the LFMPS.

The USDA NASS administered the LFMPS in all 50 states to 44,272 farms that might have sold food through local market channels. NASS identified the farms through their pre-existing sampling frame and the internet via "web scraping." The resulting cross-sectional dataset consists of 5,697 observations, which corresponds to a response rate of 13%. The USDA NASS obtained 42% of responses by mail, 39% by phone, 13% via face-to-face interviews, and 6% by web reporting. USDA NASS stratified the LFMPS sample by farm size, state, and marketing channels. Farms with greater sales levels had a greater probability of being sampled than smaller-sized farms. Since the resulting responses did not represent a random sample of local food farmers, the USDA NASS developed population weights to derive nationally representative totals from the data.

The LFMPS solicited sales data among various DTC channels, including online marketing, as well as the year that the farm commenced DTC marketing. The LFMPS defined an online marketplace as a "web-based platform designed for the selling of goods." Farms with online sales were further asked the percentage of online sales that were sold to consumers within either the same state or a 400-mile radius of the farm. The LFMPS also contained background questions about whether farmers used the internet to access resources in the following ways: purchase input supplies/equipment, access peer-learning resources, access business products/services, identify funding opportunities, and obtain price/market information.

[1]The USDA NASS is planning on administering a second LMFPS in 2021 to collect 2020 data.

https://doi.org/10.1017/aae.2019.44 Published online by Cambridge University Press

The LFMPS had binary questions about the agricultural commodities produced for local sale. Pertinent commodity classifications for DTC marketing included cattle/calves, vegetables/melons/potatoes, fruit/tree nuts/berries, poultry/eggs, and sheep/goats. The LFMPS did not ask which specific market channels the commodities are sold through or their respective sales levels. However, farms reported their aggregate sales level by market channels for unprocessed commodities and, for vertically integrated operations, value-added products. In the LFMPS, examples of value-added products included bottled milk, cheese, eggs in small cartons, meat, wine, and jam. Another distinguishing attribute of the LFMPS is that it was the first national-level survey by the USDA to collect sales data on value-added agricultural products.

3.2. Empirical model

We hypothesize that online marketplace use by a farm depends on its own characteristics and those of nearby customers. So, we test whether the probability that a DTC farm has an online marketplace that is influenced by the metropolitan classification of its county; socioeconomic attributes of its proximate customer base (i.e., income, education, and connectivity levels); and attributes of the farm operator, such as age and experience level.

We estimate a baseline regression with these variables that we refer to as Model 1. We then explore alternate specifications. In Model 2, we include interaction terms of the farm's experience level and its metropolitan county classification. In Model 3, we control for variables that capture characteristics of the farm that could be important, but could also be simultaneous. In Model 4, we estimate our model on a subset of the data.

More specifically, we estimate a logit regression specified in equation (1):

$$P(y = 1|\boldsymbol{x}) = \frac{\exp(\mathbf{x}\boldsymbol{\beta})}{1 + \exp(\mathbf{x}\boldsymbol{\beta})} \tag{1}$$

The binary dependent variable in equation (1), y, is equal to one if a farm with DTC sales operates an online marketplace and is equal to zero for DTC farms without online marketplaces. In equation (1), we denote the independent variables by $\boldsymbol{x}$ and their corresponding coefficients by $\boldsymbol{\beta}$. To correct for endogenous sampling, we estimate weighted regressions using population weights created by the USDA NASS.

In Model 1, we include two binary explanatory variables that control for whether the farm is in: (a) a metropolitan county, and (b) a non-metropolitan county that is adjacent to a metropolitan county (USDA ERS, 2016). The omitted variable, thus, is whether the farm is in a non-metropolitan non-adjacent county (15% of our sample). To improve the readability of this article, we refer to farms in non-metropolitan adjacent counties as "adjacent" farms and farms in non-metropolitan non-adjacent counties as "distant rural" farms. We include these variables because, as we described earlier, distant rural farms may be more likely to have an online marketplace to circumvent their greater transportation costs with accessing population centers. At the same time, metropolitan farms may be more likely to have online marketplaces if they have more in-person DTC marketing opportunities and can leverage in-person customer interactions to increase the visibility of their online platform.

We include an independent variable that represents the county-level ratio of residential high-speed internet connections (HSIC) to the total number of households (FCC, 2017a).[2] This variable is a proxy for local internet adoption. We include this variable because farms in counties with greater internet usage among potential local clients may be more likely to have an online marketplace. We assume that county-level internet subscribership is exogenous regarding the farm-level decision to have an online marketplace, given the relatively modest size of the local foods sector.

[2]The FCC form 477 data are the best available administrative data on high-speed internet access in the United States, although the data are self-reported by internet service providers and may overestimate availability (FCC, 2017b).

https://doi.org/10.1017/aae.2019.44 Published online by Cambridge University Press

We include two other county-level control variables that could be correlated with the propensity of customers to purchase foods online: per capita income and the percentage of the population with a bachelor's degree. Income could influence the propensity of customers to make online purchases, as higher-income customers may have greater opportunity costs of time associated with non-internet shopping. The percentage of the population with a bachelor's degree has been used as a control variable in other local food studies (e.g., Brown et al., 2014; O'Hara and Benson, 2019). In our context, education could be associated with internet shopping if those with greater levels of formal education have received greater training with using the internet.

We control for the average age of operators on the farm and the square of average age. Previous studies have found that age has a quadratic impact on internet use (Mishra, Williams, and Detre, 2009; Briggeman and Whitacre, 2010). So, these findings suggest older farmers are less likely to use the internet, perhaps since they are less accustomed to this technology. Since making sales online is a way that farmers use the internet, we expect the effect of age on online marketing to be like its impact on internet use.

We also include a binary variable that is equal to one if the farm operation began selling in DTC markets in 2009 or later. Hereafter for brevity, we refer to such farms as "post-2009" farms and similarly refer to farms that began DTC marketing before 2009 as "pre-2009" farms. Some internet-use studies have used age and experience variables as proxies for each other (Mishra, Williams, and Detre, 2009). We distinguish between the influences of age and experience on online marketing since we control for both attributes. To do so, we model experience as a discrete variable since the positive correlation between the two variables may otherwise make interpreting their coefficients challenging. Thus, the age variable coefficients are conditional on whether their farm began DTC marketing prior to 2009 or not. Nonetheless, the age and experience variables are still correlated with each other.

We select 2009 as the threshold year for entering DTC marketing because it corresponds to the year in which the American Recovery and Reinvestment Act (ARRA) broadband internet resources were first deployed. The ARRA is relevant because it provided an unprecedented amount of money ($7.2 billion) for broadband grant programs (Barnes and Coatney, 2015). A positive coefficient on this variable could imply that post-2009 DTC farms are more likely to perceive online marketing as an effective way to reach consumers than pre-2009 DTC farms. This could occur if post-2009 farms have greater skill levels with online software and advertising techniques. In contrast, a negative coefficient could suggest that pre-2009 DTC farms are using online marketplaces as another market channel for pre-existing consumers. This latter explanation is plausible if pre-2009 farms have a loyal following among consumers or high brand awareness, and if post-2009 farms have challenges with advertising their online marketplace to consumers that are unfamiliar with their farm or products.

We include two race/ethnicity binary variables: farms with at least one Hispanic operator and farms with non-Hispanic white operators. Thus, we interpret these two race/ethnicity variables relative to farms that do not have a Hispanic operator but have at least one non-Hispanic non-white operator. We include race/ethnicity control variables because there could be language or cultural differences that influence the use of an online marketplace. We likewise test whether having a female operator influences online marketplace participation. Briggeman and Whitacre (2010) found that male farmers are more likely to use the internet. Also, O'Hara and Lin (2019) found that the gender and race/ethnicity of the farm operators influenced which local food market channels that the farm accessed.

Researchers have typically controlled for the farmer's education level in internet-use studies, since it is a proxy for human capital (Mishra, Williams, and Detre, 2009; Briggeman and Whitacre, 2010). The LFMPS does not contain questions about education. Instead, we include an independent variable that controls whether any farm operators have ever served on active duty in the U.S. Armed Forces, Reserves, or National Guard. This variable could be a proxy for human capital if veterans have received training on using the internet.

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We control for farm size using a variable representing the farm's total gross value of sales (GVS). The GVS code ranges between 1 for the smallest farms (i.e., those with sales less than $1,000) and 13 for the largest farms (i.e., those with sales greater than $5,000,000).[3] Larger farms are more capable of making non-DTC local sales (Low and Vogel, 2011). Since it is likely that there are technological synergies between making DTC sales online and non-DTC sales online, larger farms may thus be more likely to develop an online platform to enable non-DTC transactions. Finally, we include state fixed effects due to variation in state policies, consumer preferences, and infrastructure that could influence the decision of a farmer to have an online marketplace. State fixed effects have been used in other LFMPS studies (O'Hara and Lin, 2019).[4]

In Model 2 we add two interaction terms that we did not include in Model 1. The two interaction variables represent post-2009 farms in (a) metropolitan counties and (b) non-metropolitan adjacent counties. The inclusion of the two interaction terms changes the interpretation of three variables that we include in Model 1. In Model 1, the post-2009 variable represents all post-2009 farms, whereas in Model 2, the post-2009 variable represents post-2009 farms in distant rural counties. The metropolitan variable in Model 1 represents all metropolitan farms, whereas in Model 2, it reflects pre-2009 metropolitan farms, and likewise regarding the non-metropolitan adjacent variable. The interpretation of these five coefficients (the two new interaction terms and the three variables that represent experience and metropolitan county classifications that we include in Model 1) in Model 2 are relative to the omitted variable, which represents pre-2009 farms in distant rural counties.

In Model 3, we include a binary variable that is equal to one if a farmer uses the internet to access resources to assist them with their operation. We combine the responses to the various categories to create one composite internet-use variable because responses to these internet-use questions are positively correlated with each other. We classify farmers as using the internet to access resources if they provide an affirmative response to any of the LFMPS internet-use questions that we described previously. This variable could be interpreted as a proxy for the farm operator's computer skills and human capital, which, in turn, could influence their decision to sell products online. Also, in Model 3, we include a binary variable that is equal to one for farms that sell value-added products through DTC marketplaces. Value-added products could be more conducive to online marketing if they are less perishable, more durable to ship, or have packaging that allows farms to promote their mission and enterprise identity without direct customer contact.

We include these two variables as a robustness check against the possibility of omitted variable bias. Nonetheless, we separately present regression results for Model 3 because the value-added sales variable and internet-use variable are both potentially endogenous. For instance, the decision to market value-added products could be made simultaneously with the decision to sell products via an online marketplace. Or, a farmer could train on the internet for the purpose of developing an online marketplace.

In Model 4, we estimate the same specification from Model 2 on the subsample of DTC farms that produce value-added products. The purpose of Model 4 is to assess whether the spatial dimensions of online marketplace participation varies among value-added DTC farms without including a potentially endogenous variable in the regression.

We report the marginal effects since the parameter estimates from logit regressions are challenging to interpret. For the binary independent variables, the marginal effect represents the change in the predicted probability of having an online marketplace as the independent variable changes from zero to one. For the continuous independent variables, the marginal effect represents the instantaneous rate of change. In both instances, we evaluate the other independent variables at their mean values.

[3]The minimum values for the 13 GVS categories in the survey are, respectively, $1; $1,000; $2,500; $5,000; $10,000; $25,000; $50,000; $100,000; $250,000; $500,000; $1,000,000; $2,500,000; and $5,000,000.

[4]The regression results are similar when we use regional fixed effects with definitions established by either the Census Bureau or the USDA NASS (2016) instead of state fixed effects.

https://doi.org/10.1017/aae.2019.44 Published online by Cambridge University Press

4. Results

4.1. Descriptive statistics

The descriptive statistics of online marketplace usage are insightful since the LFMPS represents the first time the USDA has collected data on this subject. Eight percent of DTC farms have an online marketplace (Table 1).[5] More than 60% of DTC farms use the internet to access resources (i.e., purchase inputs, peer-learning, access business products or services, find funding opportunities, or obtain price/market information). Thirty-five percent of farms began DTC sales in 2009 or later, while 85% are in metropolitan or non-metropolitan adjacent counties.

We compare the means of pertinent variables between DTC farms with and without online marketplaces in Table 2. Aggregate DTC sales for farms with online marketplaces, on average, are four times greater ($79,928) relative to other DTC farms ($21,157). Online sales average $18,287 for DTC farms participating in this marketing channel. On average, 72% of online sales are to customers less than 400 miles away or within the same state. Farms with online marketplaces have higher DTC value-added sales ($62,059, representing 78% of their DTC sales) relative to DTC farms without online marketplaces ($7,801, representing 37% of their DTC sales) on both a proportional and absolute basis.

For farms with online marketplaces, 71% of DTC sales occur without the farm operator leaving the farm (i.e., either via an on-farm stand or online marketplace). This percentage is 42% for farms without online marketplaces. DTC farms with online marketplaces are more likely to sell directly to retailers and intermediaries/institutions compared to DTC farms without online marketplaces (Table 2). These statistics are consistent with a scenario in which there are technological synergies between making DTC sales online and non-DTC sales online. If so, the economics of having an online marketplace may be more conducive for larger farms making both DTC and non-DTC sales.

Generally, DTC marketing is conducive for vegetable producers (Plakias, Demko, and Katchova, 2019). However, DTC farms with online marketplaces are less likely to produce vegetables than DTC farms without them (Table 2). Collectively, these statistics indicate there could be limitations to online marketing for products that are more perishable and less durable, like salad greens. In contrast, once the tactile observation of a reasonably consistent product has occurred at an in-person DTC marketplace, consumers may feel more comfortable ordering the product online during subsequent purchases (Lu and Reardon, 2018).

In Table 3, for the subset of DTC farms with online marketplaces, we present pairwise correlations among the pertinent variables. Correlations allow us to discern how the profile of farms with online marketplaces varies regionally and by the metropolitan classification of their county. The level of online sales is uncorrelated with the metropolitan county classification of DTC farms, although a farm's rural-urban continuum classification influences the distance the food travels. Specifically, a greater proportion of sales from metropolitan farms with online marketplaces are marketed locally (i.e., within the same state or 400 miles) relative to non-metropolitan farms. This result indicates accessing non-local customers is important for non-metropolitan farms, as their proximate customer base may be smaller than that of metropolitan farms.

In general, metropolitan farms with online marketplaces are more likely to produce fruit and vegetables (Table 3). This is consistent with other evidence that metropolitan farms generally produce higher-valued agricultural products like vegetables (Castle, Wu, and Weber, 2011). Fruits and vegetables have also historically been among the prominent commodities marketed locally

[5]The USDA NASS did not approve the disclosure of descriptive statistics for the farm size and veteran status variables. For the entire LFMPS sample, 14% of local food farmers are veterans (USDA NASS, 2016). Also, operations with direct food sales of $500,000 or more accounted for 2% of direct marketing operations and 45% of income (USDA NASS, 2016). The percentage of local food farm operators that are female is 38%, farm as a primary occupation is 41%, are younger than 35 years old is 9%, and have fewer than ten years of experience is 23%. For all U.S. farm operators, these percentages are 31%, 44%, 8%, and 22%, respectively (USDA NASS, 2016).

https://doi.org/10.1017/aae.2019.44 Published online by Cambridge University Press

Table 2. Characteristics of DTC farms conditional on online marketplace

Variable (Weighted Number)	DTC without Online Marketplaces (103,051)	DTC with Online Marketplaces (9,290)
DTC sales***	$21,157	$79,928
	($82,475)	($231,392)
DTC commodity sales***	$13,356	$17,869
	($67,533)	($104,572)
DTC value-added sales***	$7,801	$62,059
	($41,656)	($188,581)
On-farm stand sales***	$8,833	$38,231
	($45,365)	($161,106)
Online sales	N.A.	$18,287
		($70,572)
Other DTC sales***	$12,324	$23,410
	($59,080)	($70,514)
Proportion online sales “local”	N.A.	0.72
		(0.40)
Proportion metro***	0.55	0.49
	(0.50)	(0.50)
Proportion non-metro adjacent***	0.31	0.33
	(0.46)	(0.47)
Average began 2009 or later***	0.35	0.43
	(0.48)	(0.50)
Northeast***	0.20	0.23
	(0.40)	(0.42)
Midwest***	0.32	0.22
	(0.47)	(0.42)
South***	0.27	0.35
	(0.45)	(0.48)
Sell to retailers***	0.12	0.33
	(0.33)	(0.47)
Sell to intermediaries/institutions***	0.11	0.19
	(0.32)	(0.39)
Sell beef local***	0.27	0.20
	(0.44)	(0.40)
Sell vegetables local***	0.36	0.23
	(0.48)	(0.42)
Sell fruit local	0.28	0.28
	(0.45)	(0.45)

(*Continued*)

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Table 2. (*Continued*)

Variable (Weighted Number)	DTC without Online Marketplaces (103,051)	DTC with Online Marketplaces (9,290)
Sell poultry local***	0.27	0.29
	(0.44)	(0.46)
Sell lamb local***	0.10	0.20
	(0.30)	(0.40)

Weighted Mean (Weighted Std. Dev.) *** Mean difference between the two groups is statistically significant at 0.01 level.

(Low and Vogel, 2011; Low et al., 2015). In contrast, non-metropolitan online marketplace farms are more likely to produce poultry and lamb (Table 3).

A greater percentage of DTC farms with online marketplaces are in the South rather than in the Midwest, and vice versa for those without online marketplaces (Table 2). Farms with online marketplaces in the West tend to be in metropolitan counties and have relatively high online sales levels, and vice versa for the South (Table 3). DTC farms with online marketplaces have more experience in the Northeast and West, which is where DTC production has historically been pronounced (Low and Vogel, 2011; Low et al., 2015). Less experienced DTC farms with online marketplaces tend to be in the South and Midwest. Farms with online marketplaces tend to produce fruit in the West, poultry and lamb in the South, and vegetables and beef in the Midwest.

4.2. Empirical results

Post-2009 DTC farms are 3% more likely to have an online marketplace in Model 1 (Table 4).[6] This coefficient suggests that new DTC farms are more likely to perceive online marketing as an opportunity to compete for new customers than more experienced DTC farms, perhaps because they have a competitive advantage with using online marketing technology. The metropolitan and adjacent variables have statistically insignificant coefficients in Model 1.

Relative to farms with non-Hispanic non-white operators, farms that are operated by either Hispanics or non-Hispanic whites have a greater probability of having an online marketplace. The marginal effects corresponding to these parameter estimates in Model 1 are 8 and 6%, respectively. DTC farms with at least one female operator are 3% more likely to have an online marketplace than farms with exclusively male operators, and DTC farms with veteran operators are 2% more likely than those with non-veterans. The two age terms are both statistically significant, and they show that the probability of having an online marketplace is increasing at a decreasing rate as farm operators age. Larger farms are also more likely to have an online marketplace.

The coefficients on the two interaction terms that we include in Model 2 (that we do not include in Model 1) are both statistically significant at the 0.05 level. The coefficients imply that relative to pre-2009 distant rural farms, post-2009 metropolitan farms and post-2009 adjacent farms are 5 and 7% less likely to have an online marketplace, respectively. Post-2009 distant rural farms are 7% more likely to have an online marketplace than pre-2009 distant rural farms. There is no statistically significant difference in having an online marketplace between pre-2009 metropolitan and adjacent farms with pre-2009 distant rural farms. The other independent variables have the same interpretation between Models 1 and 2, and the corresponding parameter estimates are similar between the two models.

[6]The results are similar when we estimate the regression with a probit or linear probability model (LPM) instead of a logit model. For instance, the LPM coefficient for farmers that began DTC marketing in 2009 or later, is statistically significant with a value of 0.04, which is like the logit model marginal effect of 0.03. The main distinction between the LPM with logit or probit models is that, in the former case the marginal effects are constant, whereas in the latter cases, they are diminishing.

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Table 3. Weighted pairwise correlations among DTC farms with online marketplaces

Variable	DTC online sales	Northeast	South	Midwest	West	Perc. online sales shipped locally	Metro	Non-metro adjacent	Non-metro non-adjacent	Average began 2009 or later	Beef	Vegetable	Fruit	Poultry	Lamb
DTC online sales	1.00														
Northeast	−0.01	1.00													
South	−0.09**	−0.41***	1.00												
Midwest	−0.03	−0.30***	−0.39***	1.00											
West	0.15***	−0.27***	−0.36***	−0.26***	1.00										
Perc. online sales shipped Locally	−0.09**	0.04	−0.07*	0.07	−0.03	1.00									
Metro	0.07	0.02	−0.12***	−0.04	0.16***	0.24***	1.00								
Non-metro adjacent	−0.06	0.10**	0.09**	−0.01	−0.21***	−0.20***	−0.70***	1.00							
Non-metro non-adjacent	−0.01	−0.15***	0.04	0.06	0.05	−0.06	−0.45***	−0.32***	1.00						
Average began 2009 or later	−0.09**	−0.18***	0.16***	0.08*	−0.09**	0.16***	−0.05	−0.09**	0.18***	1.00					
Beef	0.07	−0.10**	−0.09**	0.14***	0.07	0.24***	0.07	−0.05	−0.03	−0.04	1.00				
Vegetable	−0.07	−0.03	−0.15***	0.21***	−0.01	0.14***	0.09**	0.05	−0.18***	0.04	−0.18***	1.00			
Fruit	0.14***	−0.11***	−0.10**	0.01	0.23***	−0.11**	0.20***	−0.22***	0.01	−0.01	−0.24***	0.16***	1.00		
Poultry	−0.07*	−0.16***	0.33***	0.01	−0.23***	−0.02	−0.32***	0.25***	0.12***	0.06	−0.03	0.07	−0.26***	1.00	
Lamb	−0.03	−0.02	0.12***	0.01	−0.14***	0.21***	−0.33***	0.17***	0.22***	0.24***	−0.01	−0.01	−0.29***	0.36***	1.00

Note: Local shipment is defined as when products are shipped within either the same state or 400 miles of where they are produced.
*** Statistically significant at the 0.01 level. ** Statistically significant at the 0.05 level. * Statistically significant at the 0.1 level.

In Model 3, DTC farms with value-added production are 3% more likely to have an online marketplace than those without value-added production. This result reinforces our hypothesis that value-added agricultural products are conducive for online transactions. Farms that use the internet to access resources are 6% more likely to have an online marketplace, which is also consistent with our expectations. In Model 3, pre-2009 adjacent farms are 3% more likely to use online marketplaces relative to pre-2009 distant rural farms. Otherwise, the coefficient signs on the other independent variables are unchanged between Models 2 and 3 with smaller coefficient magnitudes in Model 3. The smaller coefficients could be attributable to the correlation that these independent variables have with value-added production and using the internet to access resources.

The pseudo R-squared of the regression increases from 0.18 in Model 2 to 0.24 in Model 3 when we include these two new terms (i.e., value-added production and use of the internet to access resources). This improvement in the goodness-of-fit of the model suggests that farm- or operator-specific characteristics can be important in predicting whether the farm has an online marketplace. If the LFMPS contained other questions relative to human capital or more detailed information on the foods that farms are producing, then perhaps the goodness-of-fit would further increase.

Model 4 includes only the subsample of DTC farms that produce value-added products (e.g., bottled milk, wine, cheese, and meat), but is otherwise identical to Model 2 (which includes all DTC farms). Of this subset, pre-2009 adjacent DTC farms are 6% more likely to market products online relative to pre-2009 distant rural farms. The results from Model 4 are otherwise like the results from Model 2, suggesting fundamental similarities between all DTC farms and value-added farms with respect to online marketing. The marginal effect for post-2009 distant rural farms is 0.10 among those with value-added production, which is greater than the corresponding marginal effect in Model 2 of 0.07. Thus, developing an online marketplace may be particularly critical for new DTC farms in rural areas that are marketing value-added products.

5. Discussion

Post-2009 DTC farms are more likely to have an online marketplace than pre-2009 farms (Model 1 in Table 4). This may be because pre-2009 DTC farms already have established marketing channels and perceive less of a need to promote an online marketplace.

Among all DTC farms, the metropolitan county classification does not influence the probability that a farm has an online marketplace (Model 1 in Table 4). More specifically, the proportion of DTC farms with online marketplaces differs only modestly among metropolitan, adjacent, and distant rural farms in the descriptive statistics (7, 9, and 10%, respectively, Tables 1 and 2). The lack of a significant difference across the rural-urban continuum codes could be because (a) the use of online marketplaces by DTC farmers is in a relatively nascent stage and (b) for pre-2009 farms, which comprise 65% of our sample, there is no statistically significant difference in the probability that metropolitan or adjacent farms had online marketplaces relative to distant rural farms (Model 2 in Table 4).

Post-2009 DTC farms in distant rural counties, however, are more likely to have developed an online marketplace than pre-2009 distant rural farms (Model 2 in Table 4). Conversely, post-2009 metropolitan farms and post-2009 adjacent farms are less likely. So, if these trends persist, the proportion of distant rural farms with online marketplaces may increase relative to the proportion of metropolitan or adjacent farms. This phenomenon could be occurring if the decision of post-2009 distant rural farms to enter DTC marketing is premised on online marketing, since this coincides with a period in which broadband availability increased at a greater rate in rural areas than in urban areas (Barnes and Coatney, 2015). In particular, the propensity of rural consumers to use the internet could have increased at a greater rate than did the propensity of urban

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Table 4. Weighted logit regression results with corresponding marginal effects

Model Number	1		2		3		4	
	DTC Farms		DTC Farms		DTC Farms		Value Added DTC Farms	
Sample	Parameter Estimates	Marg. Eff. (at means)	Parameter Estimates	Marg. Eff. (at'means)	Parameter Estimates	Marg. Eff. (at'means)	Parameter Estimates	Marg. Eff. (at'means)
Female	0.74***	0.03***	0.71***	0.03***	0.43**	0.014**	0.57**	0.03**
	(0.22)	(0.01)	(0.21)	(0.01)	(0.20)	(0.007)	(0.23)	(0.01)
Hispanic	1.78***	0.08***	1.87***	0.08***	1.77***	0.06***	1.82***	0.09***
	(0.52)	(0.02)	(0.53)	(0.02)	(0.51)	(0.02)	(0.64)	(0.03)
Non-Hispanic white	1.43***	0.06***	1.51***	0.06***	1.28***	0.04***	1.15**	0.06**
	(0.43)	(0.02)	(0.45)	(0.02)	(0.44)	(0.02)	(0.55)	(0.03)
Veteran	0.47*	0.02*	0.42	0.02	0.32	0.01	0.28	0.01
	(0.28)	(0.01)	(0.27)	(0.01)	(0.27)	(0.01)	(0.32)	(0.02)
Ave. age	0.20***	0.009***	0.20***	0.009***	0.16**	0.005**	0.19**	0.010**
	(0.07)	(0.003)	(0.07)	(0.003)	(0.07)	(0.002)	(0.09)	(0.005)
Square of ave. age	−0.0019***	−0.00008***	−0.0019***	−0.00008***	−0.0015**	−0.00005**	−0.002**	−0.00009**
	(0.0007)	(0.00003)	(0.0007)	(0.00003)	(0.0006)	(0.00002)	(0.001)	(0.00004)
Begin in DTC markets 2009 or later	0.58**	0.03**	1.71***	0.07***	1.66***	0.05***	2.01***	0.10***
	(0.24)	(0.01)	(0.48)	(0.02)	(0.49)	(0.02)	(0.55)	(0.03)
Metropolitan county	−0.33	−0.01	0.19	0.008	0.39	0.01	0.52	0.03
	(0.33)	(0.01)	(0.32)	(0.014)	(0.37)	(0.01)	(0.44)	(0.02)
Non-metro adjacent county	−0.02	−0.001	0.67	0.03	0.90**	0.03**	1.15**	0.06**
	(0.39)	(0.017)	(0.43)	(0.02)	(0.44)	(0.01)	(0.52)	(0.03)
Resid. HSC/total households (county)	0.58	0.03	0.53	0.02	0.37	0.01	0.47	0.02
	(0.91)	(0.04)	(0.92)	(0.04)	(0.92)	(0.03)	(1.26)	(0.06)

(*Continued*)

Table 4. (*Continued*)

Model Number	1		2		3		4	
	DTC Farms		DTC Farms		DTC Farms		Value Added DTC Farms	
Sample	Parameter Estimates	Marg. Eff. (at means)	Parameter Estimates	Marg. Eff. (at'means)	Parameter Estimates	Marg. Eff. (at'means)	Parameter Estimates	Marg. Eff. (at'means)
Total farm size	0.28***	0.012***	0.28***	0.012***	0.28***	0.009***	0.32***	0.016***
	(0.04)	(0.002)	(0.04)	(0.002)	(0.04)	(0.001)	(0.05)	(0.003)
Percent bachelor's degree (county)	−0.64	−0.03	−0.34	−0.01	−0.45	−0.01	−0.17	−0.01
	(1.98)	(0.09)	(1.95)	(0.08)	(1.83)	(0.06)	(2.27)	(0.12)
Per capita income/10,000 (county)	−0.04	−0.002	−0.06	0.002	−0.02	−0.0005	−0.08	−0.004
	(0.17)	(0.008)	(0.16)	(0.007)	(0.15)	(0.0046)	(0.18)	(0.009)
Metro × sell in 2009 or later			−1.20**	−0.05**	−1.26**	−0.04**	−1.70***	−0.09***
			(0.54)	(0.02)	(0.55)	(0.02)	(0.63)	(0.03)
Non-metro adj. × sell in 2009 or later			−1.60**	−0.07**	−1.70**	−0.05**	−2.07***	−0.11***
			(0.68)	(0.03)	(0.69)	(0.02)	(0.78)	(0.04)
Use internet to access resources					1.80***	0.06***		
					(0.37)	(0.01)		
Value-added production (binary)					0.85***	0.03***		
					(0.25)	(0.01)		
Constant and State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,664		4,664		4,664		2,750	
Wald chi-square statistic	317.26***		329.25***		383.87***		264.77***	
Log pseudolikelihood	−26,588		−26,361		−24,317		−19,065	
Pseudo R-squared	0.17		0.18		0.24		0.22	

Parameter estimate (robust standard error).
*** Statistically significant at the 0.01 level. ** Statistically significant at the 0.05 level. * Statistically significant at the 0.1 level.

consumers since 2009 due to this increased availability. In contrast, post-2009 metropolitan and adjacent farms could have made an entrance decision premised on undertaking in-person DTC transactions, since by 2009 the developments of farmers markets and other non-online DTC marketplaces, was relatively mature in urban areas (Lohr et al., 2011; O'Hara and Low, 2016).

Likewise, among pre-2009 DTC farms with value-added production (e.g., bottled milk, wine, cheese, and meat), those adjacent to metropolitan counties were more likely to have an online marketplace than distant rural farms. If distant rural value-added farms had less internet availability than adjacent farms prior to 2009, they may have developed a business model that was not predicated on online sales.

DTC farms with female operators are more likely to have an online marketplace, *ceteris paribus*. This result is consistent with previous research that found women may be more likely to undertake new labor market activities (Lin, 2011), but it contrasts with the finding that male operators are more likely to adopt the internet (Briggeman and Whitacre, 2010). Farms with Hispanic operators and with exclusively non-Hispanic white operators are more likely to use online marketplaces when compared to farms with non-Hispanic non-white operators. This result is conditional on county-level socioeconomic characteristics and holds when controlling for ways that farmers use the internet to access resources (Model 3 in Table 4), the latter of which is a proxy for human capital levels. These results could occur if African American operators sell local foods to a clientele that are less likely to purchase foods online due to cultural differences or if there are socioeconomic differences in their clientele that are not captured by county-level control variables. In general, these findings reinforce other evidence that an improved understanding of cultural aspects that influence the use of local food market channels is needed if policies are intended to advance equity objectives (O'Hara and Lin, 2019).

The quadratic impact of age on developing an online marketplace is consistent with other studies that found farm internet use is increasing at a decreasing rate as farm operators age (Mishra, Williams, and Detre, 2009; Briggeman and Whitacre, 2010). While younger farmers may be comfortable with technology, they may have other competing demands on their time, like younger children or educational opportunities, that prevent them from devoting the time to developing an online marketplace as a supplementary income stream. As farmers incrementally age, they may have more time and resources to develop an online marketplace until they reach a threshold age. The probability of having an online marketplace declines beyond this threshold age as, perhaps, their proclivity for using the internet declines.

6. Conclusions

Metropolitan farms have exploited traditional DTC marketing outlets due to the relatively low transportation costs of accessing many proximate customers (Castle, Wu, and Weber, 2011; O'Hara and Lin, 2019). However, the use of online marketplaces by farmers has not been extensively researched. In this study, we examine a specific marketing mechanism by which the internet may have offered a comparative advantage to rural farmers. We provide new evidence that online marketplaces may be strategically important for rural farms that are new to DTC marketing and lack cost-effective access to densely populated urban DTC marketplaces.

Our data do not allow us to establish a direct linkage between broadband expansion policies and online marketplace use by DTC farms. We do not know when the internet became available to respondent farms due to the large aerial scale of the Federal Communications Commission (FCC) data, and the LFMPS did not ask DTC farms the year they adopted an online marketplace. Also, other pertinent conditions besides broadband availability have changed over time, such as improvements in online transaction technology. Nonetheless, broadband policies have improved rural internet availability, which is a precondition for developing an online marketplace. So, a potential barrier to having an online marketplace was being partially addressed by rural development policy

https://doi.org/10.1017/aae.2019.44 Published online by Cambridge University Press

aimed at increasing high-speed internet availability, reliability, affordability, and adoption in rural America. While broadband policies could have assisted DTC farms with online marketing, panel data would be valuable in refining the linkage between changes in broadband access and the decision of a DTC farm to develop an online marketplace.

While our research focuses on how online marketing can impact producers, consumer impacts could be further investigated. One drawback of online purchases is that consumers do not experience the in-person interactions that are important in traditional DTC marketplaces (Hunt, 2007). However, consumers may benefit from online marketplaces because online purchases may take less time to execute than purchases at traditional DTC marketplaces. For instance, consumers with scheduling constraints that prevent them from attending a weekly farmers' market could still make food purchases directly from farmers by doing so online. Further, the availability of online products could result in increased competition and, consequently, lower prices and different products.

Acknowledgements. The authors appreciate helpful comments from participants at the 2018 National Direct Agricultural Marketing Summit and Southern Regional Science Association annual meeting. The authors thank the USDA's National Agricultural Statistics Service for providing access to the data and clearing the results.

Financial disclosure. This research received no specific grant from any funding agency, commercial, or non-for-profit sectors.

Conflicts of interest. None.

Disclaimer. The findings and conclusions in this article are those of the authors and should not be construed to represent any official USDA or U.S. Government determination or policy, nor be attributed to the University of Missouri.

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Cite this article: O'Hara JK and Low SA (2020). Online Sales: A Direct Marketing Opportunity for Rural Farms? *Journal of Agricultural and Applied Economics* **52**, 222–239. https://doi.org/10.1017/aae.2019.44