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Price Transmission and Asymmetry in the Colorado Potato Supply Chain

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Abstract

We conduct a time-series analysis of Colorado, Idaho, and national potato markets to examine price transmission and asymmetry (relative likelihood and magnitude of upward versus downward price shocks). Prices are typically driven by supply-side shocks. Colorado potato producers' prices are influenced by Idaho and experience unfavorable asymmetry relative to downstream parties. We apply findings to the COVID-19 lockdown period as a case study to explore market behavior during that time. Identifying and noting potentially harmful price dynamics in commodity markets could help producers effectively respond to similar shocks in the future.

Keywords: commodity markets, Granger causality, local food, price asymmetry, price transmission, Russet potatoes, agri-supply chain, COVID-19

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Introduction

During March 2020, the global COVID-19 pandemic stymied economic activity in some sectors in the United States as state and local governments adopted shelter-in-place and stay-at-home orders in an attempt to slow the spread of the virus. As the American public faced the lockdown due to COVID-19 in March and April 2020, food retailers, such as Walmart, Target, and Kroger, saw major sales gains as consumers stocked up to prepare for extended stays at home and shifted their food expenditures toward food at home as opposed to food away from home (Redman, 2020a; Redman, 2020b; Redman, 2020c; U.S. Census Bureau, 2020). Specifically, grocery sales increased 28.5% from $56.5 billion in March 2019 to $72.6 billion in March 2020 (U.S. Census Bureau, 2020).

As consumers shopped for groceries with the goal of staying at home for long periods of time, they purchased food staples, cleaning supplies, and other household essentials (Parker-Pope, 2020). Potatoes were the highest-volume crop moved in refrigerated trucks during the March 1–May 31 COVID-19 lockdown period (USDA AMS, 2020b). Potatoes were a popular item in uncertain market conditions because they are seen as a shelf-stable pantry staple. A recent analysis of U.S. produce markets has shown that the volume of potatoes purchased by consumers in March 2020 was 41% higher than it was in March 2019 (Pieterse, 2020). Fresh potato sales increased 19.2% in dollars and 15% in volume in the third quarter of the marketing year 2020 (Potatoes USA, 2020b; Potatoes USA, 2020c).

With the retail sector performing so strongly, one might expect that sales and price gains might transmit back to the farmers that sell some of their product through these high-performing retail markets. However, historically, farmers have not reaped the full benefits of strong food demand. To explore that price transmission dynamic, we present a historical time-series analysis of farm gate, terminal market, and retail prices in potato commodity markets. Moreover, to explore whether Colorado farms were able to capture a share of the strong demand experienced in 2020, we compare potato price patterns during the pandemic to our historical analysis.

Our research questions are: What factors drive Colorado farmgate prices? What is the nature of price transmission and asymmetry experienced by Colorado potato farmers, particularly relative to Idaho? And, when demand for potatoes is strong at the retail level, as during the COVID-19 lockdown period, do farmers capture a proportional price gain? We explore the price transmission question by identifying Granger causality relationships at several key points in the potato supply chain using time-series datasets. When we refer to price asymmetry, we mean the speed with which prices return to "normal" pre-disruption levels if they are shocked by the market.

Background and Literature Review

We provide an overview of the study sector and region, Colorado potato production in a national context, supply chain margins, and market power before introducing our research methods.

Study Sector and Location

At the same time fresh potato markets saw increased activity during the COVID-19 lockdown period, markets focused on processed potatoes saw decreased sales as institutional purchasing (such as that by restaurants and schools) dropped drastically. The U.S. National Restaurant Association documented a 40% decrease in sales during the spring of 2020, compared to the same time period in 2019 (Jennings, 2020). Eighty-five percent of frozen potato sales typically go to the food service sector, and the remaining 15% to retail (Potatoes USA, 2020a). In comparison, 48% of fresh potato sales go to food service, and 52% go to retail. In 2020 some potatoes grown for processing were diverted to the fresh market. Increased demand and an influx of processing potatoes were competing pressures on fresh market potato prices. We chose to focus our analysis on the fresh potato market because it experienced consistently higher sales than the processed potato market and even absorbed some of the processed potato market for a short time.

Our focus on the fresh market sector led to our choice of study area. Colorado is second only to Idaho in terms of fresh table stock production (J. Ehrlich, personal communication). An active producer industry group in Colorado encouraged our examination of market power and price dynamics. Lessons learned about the relationship between Colorado and the fresh potato market's highest-volume contributor likely are generalizable to other states who have lower production volumes. If the market is structured such that when supply chain shocks like COVID-19 happen, some parties are more likely to experience better or worse outcomes on a consistent basis, that is important information. It could be used to inform policy mechanisms that would make food supply chains more resilient to shocks.

The San Luis Valley, a six-county region in southern Colorado, is a rural area whose economy is heavily reliant on agriculture. Crop production, chiefly potatoes, and adjacent activities are primary occupations (San Luis Valley Development Resources Group, 2008). Even before the COVID-19 pandemic, potato farmers in San Luis Valley provided anecdotal evidence of the prices they receive for their potatoes being influenced by price shocks emanating from Idaho potato markets, so we set out to investigate whether the econometric evidence aligns with their claim. In the late stages of our historical time series research, the COVID-19 pandemic started, providing an opportunity to see how the price dynamics we had detected econometrically played out during the early stages of the pandemic.

Potatoes: U.S. and Colorado Context

In the 2018 marketing year, the United States produced 45 billion pounds of potatoes at a total value of $3.75 billion on 1 million acres of cropland (National Potato Council, 2019; USDA NASS, 2019). In terms of U.S. production, Colorado ranked sixth for overall potato production and second for fresh or table stock production (see Table 1) (J. Ehrlich, personal communication) (National Potato Council 2019; USDA-NASS, 2019). Ninety-five percent of Colorado potatoes are shipped fresh (Ehrlich, Sullins, and Jablonski, 2020), and Colorado producers' focus on the fresh market makes them more attentive to perishability, fresh product demand and movements, and active distribution through a variety of market channels. Colorado sold 1.4 billion pounds of potatoes as

fresh table stock during the 2018 marketing year, which amounted to 13.5% of all table stock in the United States (USDA NASS, 2019; Colorado Potato Administrative Committee, 2020) .

A previous study found that while the U.S. potato market tends to behave efficiently in terms of price transmission overall, there is some room for improvement (Durborow et al., 2020). The Colorado Potato Administrative Committee (CPAC) is an industry group based in San Luis Valley, Colorado. Their annual report for the 2019 marketing year states, "Prices received by growers of potatoes are influenced by a competitive relationship with other growing areas, and to some extent, by U.S. economic trends. Current and potential supply levels, quality of supplies, time of harvest, consumer demand, and shipments of processed potatoes influence the price for fresh potatoes" (Colorado Potato Administrative Committee, 2020).

Table 1. Top 10 Potato Producing States

State	Total Production (100,000 lbs.)	% of Total Market Share	Price per 100 lbs. ($)	Value of Crop ($1,000)
Idaho	141,750	31.5%	6.85	960,199
Washington	100,800	22.4%	6.52	688,512
Wisconsin	27,135	6.0%	12.00	340,800
Oregon	27,000	6.0%	7.49	210,169
North Dakota	23,725	5.3%	9.70	226,592
Colorado	21,722	4.8%	9.69	210,486
Minnesota	18,705	4.2%	9.27	173,395
Michigan	18,240	4.1%	10.00	182,400
California	15,457	3.4%	14.50	224,497
Maine	15,035	3.3%	10.20	156,519

Note: Production volumes and prices are from the 2018 marketing year (National Potato Council, 2019; U.S. Department of Agriculture, Economic Research Service, 2019).

Idaho was the largest potato-producing state by volume in the 2018 crop year (see Table 1). Together, Idaho and Washington comprised more than 50% of the national market share by volume, much of which went to processed potato products. These states typically receive lower average prices for their potatoes, likely due to price differen ces between fresh table stock potatoes and potatoes destined for processing (National Potato Council, 2019). Idaho alone represented almost a third of the total U.S. potato market share by volume, while by comparison, Colorado's market share was 4.8%. Due to Idaho's large market share relative to other potato-producing states, of which Colorado is one example, we hypothesize that Idaho may have some influence over lower production volume states' fresh potato prices. Lessons learned about the relationship between Idaho's and Colorado's relative market and price dynamics can inform marketing strategy for other lower production volume states. We examined price data econometrically to identify evidence of price transmission patterns (one indicator of potential concentrated market structure) from other growing areas, particularly Idaho, due to its status as the industry leader in potato production.

In 2017, 69% of the potato acreage planted in the United States went into Russets, 21% into other white varieties, 7% into red and blue varieties, and 3% into yellow varieties (National Potato

Council, 2019). In Colorado, an even higher 80% of the acreage was planted in Russets, 10% in yellow varieties, 7% in red varieties, and 3% in other white varieties. Russets also constitute the largest category in terms of volume (66%) of all potatoes sold (Karst, 2018). As Russets are the dominant variety in terms of acres planted and volume sold, we focus our analysis on that variety to capture market dynamics at play in this predominant product category. A general survey of supply chain literature provides helpful context before we revisit our sector and region of interest.

Farmer Share of the Food Dollar

As supply chain efficiency and delivery of more differentiated products to consumers have increased, the distribution of revenues along longer, more complex agri-supply chains has changed (Van der Spiegel, 2004; Van der Vorst, 2005). Every dollar spent by consumers at the retail level must be divided amongst all the parties that contributed to the production, processing, distribution, and retailing of the final product (Cucagna and Goldsmith, 2018). As a result, in 2018, only 7.7% of every dollar spent by consumers on food made its way back along the supply chain to the farmer who grew the raw product, down from 21% in 2000 and 40% in 1952 (Coltrain, Barton, and Boland, 2000; USDA ERS, 2020).

The various supply chain parties who capture food revenues generally include agricultural producers, storage facilities, processors, shippers or distributors, retailers, restaurants, and consumers, all of whom may or may not have aligned values, missions, and governance with one another (Cucagna and Goldsmith, 2018). Some businesses achieve economies of scale and cost savings through vertical integration, which combines several supply chain links into a single enterprise (Sexton, 2000; Saitone and Sexton, 2017). Happe et al. (2008) and LeRoux et al. (2010) found that many possible strategies to improve producer outcomes, specifically revenues, must address how to change the roles, transparency, and competitive market behaviors along the supply chain. Therefore, it is imperative to consider the entire supply chain, even when the outcome of interest is concentrated in one stage (e.g., producers). Price transmission, asymmetry, market power, and other factors that reflect dynamics amongst actors at various stages of the supply chain are important determinants for farmer outcomes, and more broadly, for rural economic development (Rogers and Sexton, 1994; Happe et al., 2008; LeRoux et al., 2010; Saitone and Sexton, 2017; Willingham and Green, 2019; Sexton 2000).

Market Power and Price Setting at the Farm Gate

Consolidation of supply chains over the past several decades has contributed to increased efficiency in the distribution of agricultural goods around the country (Rogers and Sexton, 1994; Azzam and Schroeter, Jr., 1995; Morrison Paul, 2001; Hausman and Leibtag, 2007; Saitone and Sexton, 2017; Willingham and Green, 2019). Commonly, that focus on efficiency unintentionally resulted in the concentration of buying power into fewer agribusinesses. Some have argued consolidation had negative impacts on family farms or independent farms without sufficient negotiating leverage to challenge the requirements of corporate buyers, manufacturers, processors, and distributors (Rogers and Sexton, 1994; Willingham and Green, 2019, Sexton, 2000; Sexton, 2013). Saitone, Sexton, and Sumner (2015) and Saitone and Sexton (2017) found that concentrated

market power among agricultural buyers was associated with a decrease in farmer market access and opportunities to fully realize any gains from investments in quality improvement measures or increased consumer demand. Instead, downstream supply chain actors captured a disproportionate share of gains from these changes. Moreover, McBride and Key (2003) point out that costs to farmers associated with participating in more efficient, high-volume supply chain pathways may outweigh potential gains due to costly contracting requirements and other transaction costs. As one example, the United States Department of Agriculture Economic Research Service (USDA ERS) reported concerns on the part of fresh produce shippers that retailers had used their consolidated market power to demand more than their fair share of the retail dollar in the form of fees and special services (Calvin et al., 2001). The literature suggests that increased efficiency and commoditization of agricultural supply chains, frequently accompanied by oligopsony relationships, may be associated with less bargaining power for producers in the marketing of their products.

Data and Empirical Methods

We explored key dynamics among supply chain stage (shipping point price, terminal market price, and retail price) and geographic markets by performing Granger causality and dynamic Houck price asymmetry tests. In this section, we introduce the data used in our analysis, report exploratory and fundamental analytical approaches, and finish by outlining the Granger causality and dynamic Houck hypothesis tests.

We tested non-organic Russet potatoes in 50-lb. cartons (size 70) and 10 5-lb. bags (film bag, mesh film bag, mesh bag, and sacks). Analyzing price transmission and price asymmetry patterns required a compilation of time-series price data for several points along the supply chain, and in our case, multiple states, since we were interested in potential price transmission from Idaho products to Colorado products. We used publicly accessible U.S. Department of Agriculture Agricultural Marketing Service (USDA AMS) data on three price points along the supply chain: shipping point price (a proxy for farm gate price), terminal market price (a proxy for wholesale price), and retail price (see Figure 1) (USDA AMS, 2019). We examined the supply chain dynamics for Colorado and Idaho potatoes—Idaho being Colorado's primary fresh market competitor—in order to draw inferences about potential price transmission and source of price shocks.

Figure 1. Simplified Potato Supply Chain Identifying Available Data Points

Shipping point and terminal market data were available from January 1998 to May 2019, and retail data were available from October 2007 to May 2019. USDA AMS collects data weekly, and to

minimize the potential bias from missing data points, we aggregated the data to a monthly average of the available weekly prices. The final aggregated data had no more than four missing monthly observations out of the 257 expected observations per variable (see Table 2). We adjusted prices for inflation using the Consumer Price Index (CPI) and converted nominal prices to real prices on a per pound basis. We confirmed the accuracy of post-conversion AMS prices by comparing them to National Agricultural Statistics Service data. Summary statistics for the final set of variables are available below (see Table 2).

Table 2. Summary Statistics of Price Variables ($/lb.)

Variable	Observations	Mean	St. Dev.	Min.	Max.
Colorado shipping point price for 50-lb. cartons	253	$0.118	$0.038	$0.048	$0.257
Colorado shipping point price for 5-lb. bags	253	$0.080	$0.022	$0.044	$0.160
Terminal market price for 50-lb. cartons	257	$0.358	$0.087	$0.197	$0.697
Terminal market price for 5-lb. bags	255	$0.281	$0.052	$0.184	$0.470
National retail price	140	$0.524	$0.056	$0.413	$0.696
South central retail price	140	$0.448	$0.073	$0.307	$0.705
Idaho shipping point price for 50-lb. cartons	257	$0.128	$0.045	$0.051	$0.272
Idaho shipping point price for 5-lb. bags	257	$0.072	$0.021	$0.040	$0.161

Note: All price data are compiled using the USDA-AMS Custom Price Report Function (U.S. Department of Agriculture, Agricultural Marketing Service, 2019).

Mean Price Comparison

We performed preliminary *t*-tests on select pairs of shipping point prices of interest to see if they were significantly different, and additional analyses were warranted: Colorado and Idaho prices for 50-lb. cartons, Colorado and Idaho prices for 5-lb. bags, and Colorado prices for 50-lb. cartons and 5-lb. bags. In each case, the null hypothesis was that the means of the two price series being compared were equal. Statistically significant differences between Idaho and Colorado shipping point prices justified additional time-series analysis on prices to better understand dynamics across markets. We compared prices for different package sizes from Colorado, as well as Idaho and Colorado prices for different package sizes. *T*-test results are summarized below in Table 3. Colorado shipping point prices for 50-lb. and 5-lb. bags were statistically significantly different at

the 1% level. Colorado and Idaho prices for both 50-lb. bags and 5-lb. bags were also significantly different at the 1% level.

Table 3. *T*-Test Results for Different Package Sizes and for Idaho Versus Colorado Shipping Point Prices

Variables	*T*-statistic	*P*-value	Mean Difference
Colorado shipping point price for 50-lb. cartons > Colorado shipping point price for 5-lb. bags	13.50	< 0.01	0.04
Colorado shipping point price for 50-lb. cartons < Idaho shipping point price for 50-lb. cartons	-2.70	0.01	-0.01
Colorado shipping point price for 5-lb. bags > Idaho shipping point price for 5-lb. bags	4.09	< 0.01	0.01

Note: All price data are compiled using the USDA-AMS Custom Price Report function (U.S. Department of Agriculture, Agricultural Marketing Service, 2019).

Fundamental Analysis

Once data were cleaned and adjusted for inflation, we conducted fundamental time-series analyses on each price series to test for stationarity and appropriate lag length. The empirical tests we performed relied on the principle of stationarity in the data, meaning the mean and variance of the data were constant over time (Gujarati and Porter, 2009). In other words, we performed tests to assure the data did not exhibit any trends over time that made behavior of prices fundamentally different at different points in time. We used an Augmented Dickey-Fuller Test with trend and intercept terms to test for stationarity in all eight price series (Gujarati and Porter, 2009). The null hypothesis of the Augmented Dickey-Fuller Test was that a unit root was present in a time series, meaning the data were not stationary.

We chose to address potential lag specification issues by determining appropriate lag length using the ad hoc sequential estimation or "testing up" method described by Gujarati and Porter (2009). Determining appropriate lag length was important because in the distributed lag model that we employed, omitting a lag that had a statistically significant effect would subject the model to omitted variable bias, invalidating the results of hypothesis testing (Gujarati and Porter, 2009). Once we included the appropriate number of lags, identified as two lags for all price series, we could reject the null hypothesis of the Augmented Dickey-Fuller test, indicating stationarity for all price series of interest.

Our process to assure the stationarity requirement within our empirical methods of choice allowed us to deflate prices using the CPI. Without adjusting the price series for inflation, the mean price would likely change over time. There is some debate in the literature about the best approach because deflating prices can change the properties of a time series relative to its nominal counterpart (Peterson and Tomek, 2000). However, some previous studies that used a Granger causality framework deflated the commodity prices used in their analyses (Bradshaw and Orden, 1990; Myint and Bauer, 2010). We felt that the benefits of performing our analysis on a stable series of prices over time outweighed the potential complications of deflation.

Granger Causality

The next step was to perform a Granger causality test among all links of the supply chain (Equations 1-2). The Granger causality test consisted of two "opposite" regressions, F-tests on the variables of interest in each regression, and a subsequent comparison of the resulting *p*-values. For example, if we wanted to examine the relationship between two prices series, price series X and price series Y, we would run the following regressions if the appropriate lag number were 2:

$$y_t = \alpha + \beta_1 x_{t-1} + \beta_2 x_{t-2} + \beta_3 y_{t-1} + \beta_4 y_{t-2} + e \quad (1)$$

$$x_t = \gamma + \delta_1 y_{t-1} + \delta_2 y_{t-2} + \delta_3 x_{t-1} + \delta_4 x_{t-2} + e \quad (2)$$

Note that the contemporaneous independent variable of interest was excluded. The three possible outcomes of the Granger causality test were unidirectional causality, bidirectional causality, or independence. If the *p*-value of one F-test was statistically significant and the other one was not, we concluded unidirectional causality, meaning one variable Granger-caused the other at the 5% significance level. If the *p*-values of both F-tests were statistically significant, we concluded bidirectional causality, meaning both variables Granger-caused each other at the 5% significance level. If the *p*-values of neither F-test were significant, we concluded independence, meaning that statistical tests did not detect a significant Granger-causal relationship at the 5% level.

Price Asymmetry

We used the dynamic Houck Method as presented by Capps Jr. and Sherwell (2005) to examine the data for price asymmetry (Equation 3). We tested several pairs of variables for price "stickiness," or rigidity, using the directionality established by the Granger causality test, with a particular focus on whether that rigidity varied for positive and negative shocks: Colorado shipping point and terminal market prices, Colorado terminal market and national retail prices, Colorado shipping point and national retail prices, and Idaho shipping point and Colorado shipping point prices. All relationships were tested for both 50-lb. cartons and 5-lb. bags.

$$\Delta P_{rt} = \alpha_0 + \sum_{i=0}^{M_1} \alpha_{1i} \Delta P^{+}_{ft-i} + \sum_{i=0}^{M_2} \alpha_{2i} \Delta P^{-}_{ft-i} + v_t \text{, where:} \quad (3)$$

ΔP_{rt}=First-differenced retail prices

$\sum_{i=0}^{M_1} \alpha_{1i} \Delta P^{+}_{ft-i}$= Sum of positive lagged first-differenced farmgate price variables

$\sum_{i=0}^{M_2} \alpha_{2i} \Delta P^{-}_{ft-i}$ =Sum of negative lagged first-differenced farmgate price variables

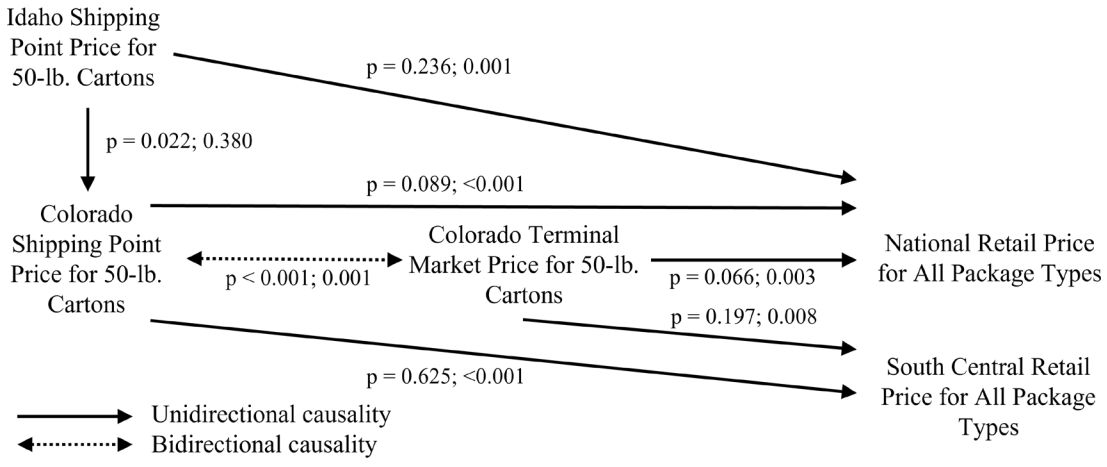
$$H_0: \sum_{i=0}^{M_1} \alpha_{1i} \Delta P^{+}_{ft-i} = \sum_{i=0}^{M_2} \alpha_{2i} \Delta P^{-}_{ft-i}$$

The price asymmetry test informed us about the speed with which prices returned to "normal" pre-shock levels after they are shocked by the market. If certain parts of the supply chain took longer to return to "normalcy," those prices were considered "sticky" or asymmetric.

Price asymmetry is an important characteristic, and we can consider two situations when price stickiness would be detrimental to Colorado producers. First, if prices are asymmetric between Idaho and Colorado producers, and if the market experiences a downturn and prices are low, the Colorado producers' prices may be depressed for longer than would be the case under more sensitive markets. Second, if the market experiences higher-than-average prices driven by a demand shift, lack of price transmission due to price asymmetry means that producers may not be able to capture gains from strong markets as quickly (or at all) as other parts of the supply chain. In short, the market dynamics of the supply chain could hinder the financial performance and viability of producers. It is the second situation that COVID-19 potato markets gave us the opportunity to examine.

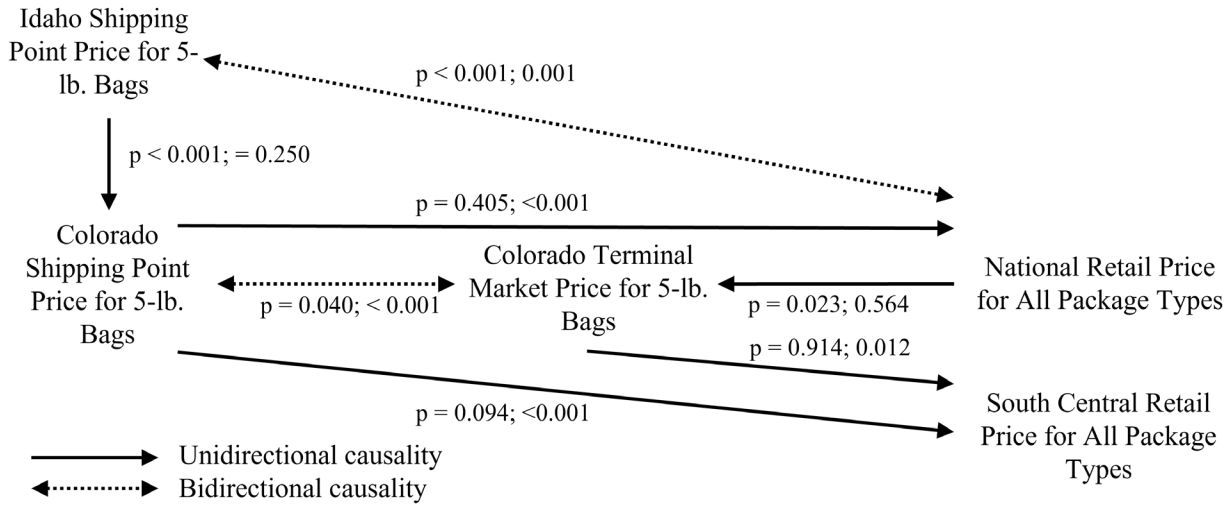
Results

We present the results of the Granger causality test for the 50-lb. carton and 5-lb. bag prices through a visualization of relationships (see Figures 2-3). Note that, in general, the direction of price causality flowed "downstream" from points of production in the supply chain to points closer to final consumption. A key result was that, for both package sizes, Idaho farmgate prices Granger-caused Colorado farmgate prices, as well as national retail prices. In the case of 5-lb. bags, the Idaho-national retail Granger causality result was bi-directional (see Figure 3). Econometric results support anecdotal evidence from Colorado potato farmers that Idaho may have catalyzed price shocks (which may have allowed them to exert some market influence) for fresh potatoes, perhaps because that state produced such a high volume and production share of U.S. potatoes.



Note: *P*-values are provided for F-tests performed on each pair of prices. *P*-values are listed for the F-test on the regression with the "upstream" contemporaneous price variable first as the dependent variable and then as the explanatory variable. Shipping point prices are "upstream" of terminal market prices, which are "upstream" of retail prices. In the case of Idaho versus Colorado prices, *p*-values are listed for the F-test on the regression with the contemporaneous Colorado price variable first as the dependent variable and then as the explanatory variable.

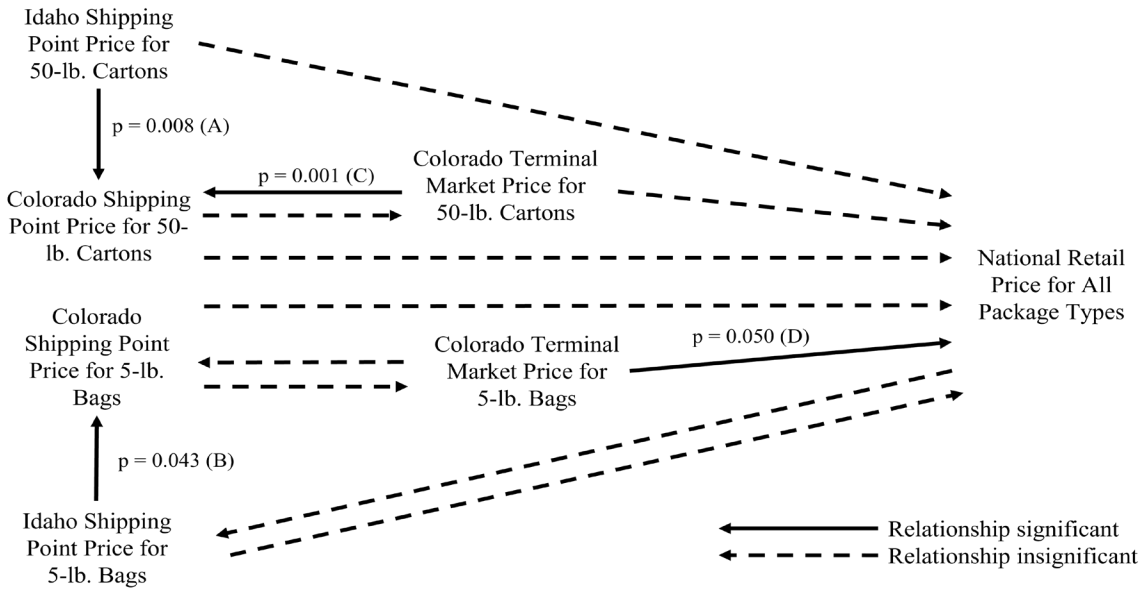
Figure 2. Granger Causality Results for 50-lb. Cartons



Note*: P*-values are provided for F-tests performed on each pair of prices. *P*-values are listed for the F-test on the regression with the "upstream" contemporaneous price variable first as the dependent variable and then as the explanatory variable. Shipping point prices are "upstream" of terminal market prices, which are "upstream" of retail prices. In the case of Idaho versus Colorado prices, *p*-values are listed for the F-test on the regression with the contemporaneous Colorado price variable first as the dependent variable and then as the explanatory variable.

Figure 3. Granger Causality Results for 5-lb. Bags

The results of the price asymmetry test indicated that there was price asymmetry between Idaho and Colorado farmgate prices at the 5% level for 5-lb. bags and at the 1% level for 50-lb. cartons (see Figure 4). There was also asymmetry at the 1% level between the Colorado shipping and terminal markets for 50-lb. cartons and asymmetry at the 5% level between Colorado terminal markets for 5-lb. bags and national retail prices. In short, there is evidence to suggest that high-volume production actors (Idaho) and "downstream" supply chain actors (proxied by terminal and retail markets) may be the source of price shocks and affect the speed of price transmissions, motivating a closer look at these dynamics.



Notes: Statistically significant (5% level) asymmetric price relationships are represented by solid lines and labeled with capital letters, and *p*-values are provided. Statistically insignificant asymmetric price relationships are represented by dotted lines. Full regression results for statistically significant asymmetric price relationships are available in Table 4.

Figure 4. Summary of Results of Price Asymmetry Tests

Table 4. Price Asymmetry Regression Results for Colorado Shipping Point Prices (50-lb. Cartons)

Independent Variable	**Coefficient (Std. Err.)**	**T-statistic**	***P*-value**
Positive Once-lagged First-differenced Idaho Shipping Point Price for 50-lb. Cartons	0.194 (0.010)	1.94	0.053
Positive Twice-lagged First-differenced Idaho Shipping Point Price for 50-lb. Cartons	-0.267 (0.112)	-2.39	0.018
Negative Once-lagged First-differenced Idaho Shipping Point Price for 50-lb. Cartons	0.343 (0.079)	4.35	< 0.001
Negative Twice-lagged First-differenced Idaho Shipping Point Price for 50-lb. Cartons	0.069 (0.078)	0.89	0.374
Constant	0.005 (0.002)	2.31	0.021

Note: Regressed on Idaho Shipping Point Prices for 50-lb. Cartons (relationship (A) from Figure 3). F-statistic = 4.13, *P*-value = 0.043.

Table 5. Price Asymmetry Regression Results for Colorado Shipping Point Prices (5-lb. Bags)

	Coefficient (Std. Err.)	**T-statistic**	***p*-value**
Positive once-lagged first-differenced Idaho	0.394	5.18	< 0.001
Shipping point price for 5-lb. bags	(0.076)		
Positive twice-lagged first-differenced Idaho	-0.448	-5.64	< 0.001
Shipping point price for 5-lb. Bags	(0.080)		
Negative once-lagged first-differenced Idaho	0.165	2.00	0.047
Shipping point price for 5-lb. bags	(0.083)		
Negative twice-lagged first-differenced Idaho	0.075	0.97	0.331
Shipping point price for 5-lb. bags	(0.077)		
Constant	0.001	1.64	0.101
	(0.001)		

Note: Regressed on Idaho Shipping Point Prices for 5-lb. Bags (relationship (B) from Figure 3). F-statistic = 7.11, *P*-value = 0.008.

Table 6. Price Asymmetry Results for Colorado Shipping Point Prices (50-lb. Cartons)

Independent Variable	**Coefficient (Std. Err.)**	**T-statistic**	***P*-value**
Positive once-lagged first-differenced Colorado	<0.001	0.01	0.996
Terminal market price for 50-lb. cartons	(0.056)		
Positive twice-lagged first-differenced	-0.179	-2.75	0.006
Colorado terminal market price for 50-lb. cartons	(0.065)		
Negative once-lagged first-differenced	0.154	3.08	0.002
Colorado terminal market price for 50-lb. cartons	(0.050)		
Negative twice-lagged first-differenced	0.004	0.08	0.933
Colorado terminal market price for 50-lb. Cartons	(0.050)		
Constant	0.005	2.62	0.009
	(0.002)		

Note: Regressed on Colorado Terminal Market Prices for 50-lb. Cartons (relationship (C) from Figure 3). F-statistic = 11.16, *P*-value = 0.001.

Table 7. Price Asymmetry Regression Results for National Retail Prices

Independent Variable	Coefficient (Std. Err.)	T-statistic	*P*-value
Positive once-lagged first-differenced Colorado	-0.070	-0.41	0.685
Terminal market price for 5-lb. bags	(0.173)		
Positive twice-lagged first-differenced	-0.310	-1.77	0.079
Colorado terminal market price for 5-lb. bags	(0.175)		
Negative once-lagged first-differenced	0.183	1.03	0.305
Colorado terminal market price for 5-lb. bags	(0.178)		
Negative twice-lagged first-differenced	0.085	0.49	0.623
Colorado terminal market price for 5-lb. Bags	(0.173)		
Constant	0.005	1.32	0.188
	(0.004)		

Note: Regressed on Colorado terminal market prices for 5-lb. bags (relationship (D) from Figure 3). F-statistic = 3.92, *P*-value = 0.050.

The price asymmetry tests allowed us to understand the nature of price shocks by comparing the magnitude, speed (comparing different lag lengths), and direction of positive and negative price changes at various points in the supply chain (see Tables 4-7). Past work by Capps Jr. and Sherwell (2005) used such results to explore the "balance" between positive and negative adjustments and infer what that meant for the behavior of various supply chain actors, but focusing more on the cumulative effect (see Figure 3) tells a more complete story than any one of the coefficients for a particular market pair-lag length response.

We observed that positive price changes in Idaho shipping point prices were associated with positive effects on Colorado shipping point prices at one lag and negative effects on Colorado shipping point prices at two lags, suggesting a potential correction to an overresponse as time goes on (see Tables 4-7). Negative price changes for 50-lb. cartons at the Idaho shipping point had a highly statistically significant effect on Colorado shipping point prices (see Table 5), so in that part of the commodity potato market, negative price changes at the shipping point in Idaho had a rapid and cumulatively stronger effect on the Colorado shipping point prices.

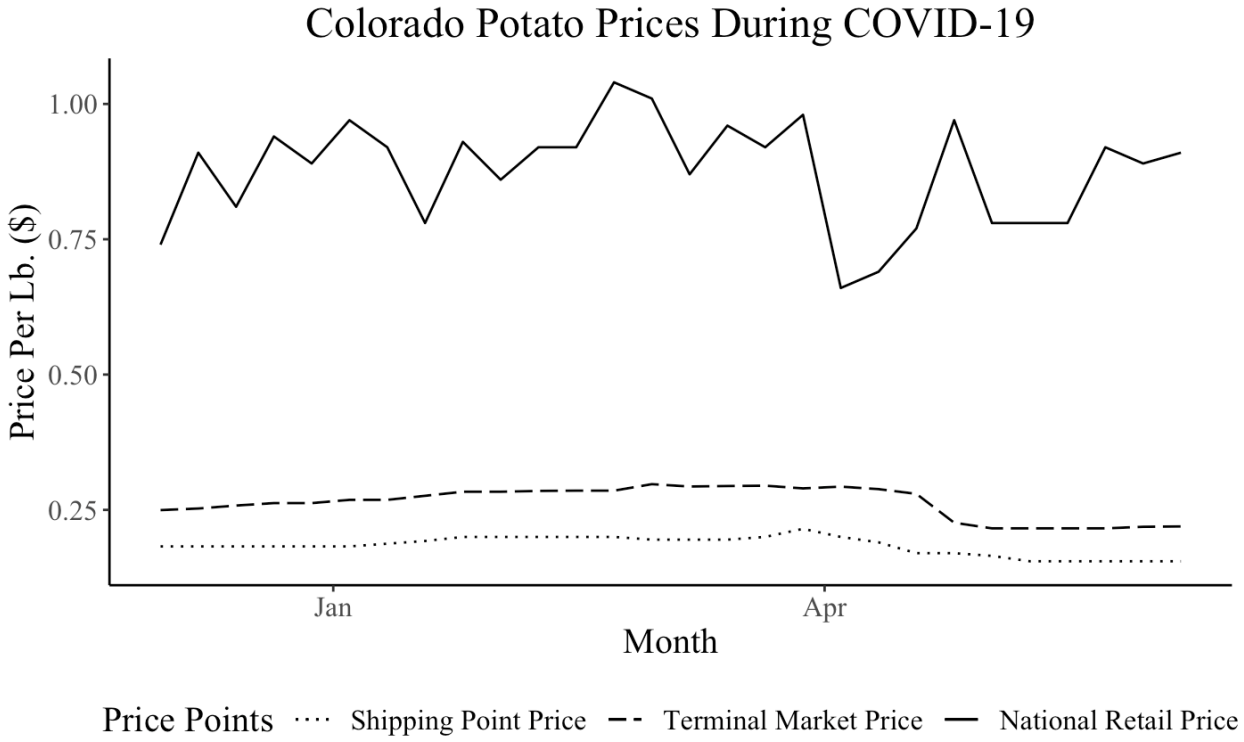
In addition to geographic effects, we also noted asymmetric transmission across different stages of the supply chain. Notably, we observed that prices transmitted between Colorado shipping point and terminal market prices indicated different speed in price response, as the negative terminal market price shifts had a statistically significant effect when lagged one period, while positive terminal market price shocks took two periods to transmit to shipping points (see Table 6). We interpreted this to mean that negative price changes traveled more quickly than positive price changes from "downstream" terminal market supply chain points back up the supply chain to producers.

Potato Prices during COVID-19

Turning our attention to recent events, the Colorado potato market amidst COVID-19 food supply chain market dynamics is a timely case to explore some of the implications of the price dynamics

faced by farmers. If we take a closer look at the COVID-19 lockdown event period of March–May 2020, we see a more nuanced story than is reflected in the strong annual retail gains. We chose to examine nominal prices during this relatively short event period and relied on the assumption that inflationary pressures would not affect the key takeaways in a 7-month snapshot as much as they would over a 20-year period.

Retail prices for potatoes dropped drastically in late March 2020, and subsequently recovered throughout the month of April (see Figure 4). During that same time period, prices at the farmgate briefly and mildly improved and then steadily decreased with no price recovery in line with retail prices (USDA AMS, 2020a). The lag in price transmission and slow regression back to "normal" price levels at the farmgate, once other links of the supply chain had returned to "normal" price levels, was a recent example of price asymmetry. It is difficult to tell to what extent fresh market prices were driven by an oversupply due to diversion from processed potato markets versus structural dynamics of the fresh market itself. And contracts with buyers may have locked in prices for a period of a few months and created rigidity in pricing during an otherwise dynamic period of price fluctuation. But the story of uneven price gains along the supply chain aligns with the historical Granger causality and price asymmetry analyses presented above. The spring 2020 situation of strong demand and prices at the retail level failing to transmit back along the supply chain to the farmer is neither unique nor surprising. Price dynamics were likely due, in part, to the smaller scale and negotiating power of Colorado farms compared to Idaho growers and distributors.



Note*:* Data were compiled using the U.. Department of Agriculture's Custom Price Report tool (U.S. Department of Agriculture, Agricultural Marketing Service 2020a).

Figure 5. Farmgate, Terminal Market, and Retail Prices for Potatoes December 2019–June 2020

The fact that farmers do not appear to capture more revenues when prices strengthen "downstream" in the supply chain indicates that there may be imperfect information flows or competitive conditions in the potato supply chain that make it challenging for producers to capture a higher price in conjunction with their retailer counterparts, particularly if they are not in the industry's highest-volume growing region. It seems that in commodity supply chains, the gains farmers receive when prices are higher than usual are disproportionate to the losses they suffer when prices are unexpectedly low, indicating that they pay for taking the risks inherent in production agriculture but less frequently see the benefits. In short, market or policy interventions may be justified in cases of price asymmetry, and events related to COVID-19 draw attention to where supply chains exhibit such shortcomings.

Conclusions

The goal of this analysis was to examine the dynamics of market price transmission, differential influence among supply chain actors, and price response asymmetry patterns across Colorado and national potato supply chains. Through Granger causality and dynamic Houck price asymmetry tests, we found evidence that commodity potato supply chains in Colorado experience imperfect price transmission and price asymmetry, which may represent higher downside price risk for producers and thwart opportunities for them to capture favorable price movements that occur "downstream" in the supply chain. Our analysis contributes evidence of a specific mechanism (i.e., price transmission along supply chains) that policy makers can target to improve economic outcomes in agriculturally focused communities, as higher or more stable prices would likely improve the resilience of those foodsheds. While many studies have focused on the concentration of market power becoming more prevalent among buyers of agricultural products, our contribution indicates there may also be evidence of concentrated market power across crop production actors within the supply chain, especially when one growing region dominates others in terms of volume produced. Vertical integration between buyers and those larger regions may also play a role here, but such exploration is left to future research.

Potential policy interventions to improve price transmission include expanded contracts with retailers to reduce downside price risk, increased participation in local markets and shortened supply chains, and government-funded efforts to strengthen communication between producers and institutional buyers who want to build marketing relationships in Colorado, such as public schools and buying agents in public buying entities. Potato producers in lower production volume states other than Colorado and producers of other crops located outside the highest-volume production region may also consider implementing these strategies.

The trends during COVID-19 align with findings from historical data analysis and demonstrate the potential role of alternative marketing channels, such as local food markets, as a market intervention to capture the benefits of strong consumer markets. Such marketing opportunities can move a limited volume of products, but they represent an opportunity to rebalance or partially address power dynamics if they are identified in commodity market pricing behavior. Shortening supply chains may also improve producers' chances of capturing higher prices for investments in quality, such as breeding improvements, equipment upgrades, and production practices. Expanded

contracts with retailers may be able to provide some price stability as producers experiment with other marketing channels.

Efforts to increase institutional buying are underway not only with potato producers, but with farmers in other key Colorado commodity sectors, such as peaches, wheat, and beef (Jablonski et al., 2019). The Denver Food Vision, adopted by the City of Denver in October 2017, includes a 2030 "Winnable Goal" that 25% of all food purchased by public institutions in Denver will come from Colorado (Hancock, 2017). Local and state policies, such as the Denver Food Vision, that prioritize shortened and localized supply chains in institutional food procurement policies may allow producers to capture more of the proportion of the food dollar that they added value to by investing in quality improvements. Scaling up to the national level, the Good Food Purchasing Program (GFPP) is a nationwide certification program that aims to reorient agri-supply chains toward local and regional purchasing behavior (Center for Good Food Purchasing, 2020). It aims to harness collective purchasing power and leverage it to make food and agriculture practices along the supply chain more ethical, including fairer prices for producers in the local markets (Center for Good Food Purchasing, 2020).

After the supply chain disruptions of COVID-19, many states and food sectors are considering policies to support a more resilient food system, with both an eye toward securing a food supply for their region and to support the economic viability of their producers and food enterprises. Without downplaying the benefits of staying connected to national and global markets, state and local policy leaders and economic development stakeholders are exploring innovative ways to connect agricultural producers, value-added food enterprises, and household and institutional buyers, including new procurement programs such as the GFPP.

Oregon farmer Cory Carman summarized the benefits of local food supply chains during the pandemic, saying, "Everything that made us a little less efficient, a little less competitive before is making us more resilient, more secure, and more responsive now." (Curry, 2020). In other words, there are notable tradeoffs between highly efficient commodity agri-supply chains and shorter supply chains that support farmer viability, a more favorable risk exposure, and connections to broader local economic development goals in agriculturally dependent regions.

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Regional Patterns of Outsourcing in Higher Education Foodservice: Implications for Conscious Consumption

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Abstract

Outsourcing has long been the dominant trend in higher education foodservice. However, in an era of heightened interest in local food provision and regional food economies, little is known about regional patterns in outsourcing. Using foodservice provider and location data from 1,399 institutions across the United States, we analyze and map the distribution of foodservice providers. Additionally, we compare provider structures to regional variability in direct and intermediated sales of local foods. We find distinct regional variability in outsourcing practices, including increased use of self-op and fresh-prep providers in regions with existing regional food infrastructure.

Keywords: outsourcing, foodservice, foodservice provider

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Introduction

Our understanding of the food system as a complex set of relationships that impact production capacity, sustainability, resilience, and human health has matured over the past 20 years (Eakin et al., 2017). The current system is characterized by consolidation and an input/output approach (Lobao and Meyer, 2002) that has maximized the total volume of production, increased caloric output, and diminished global hunger (Tilman et al., 2002). However, increased consolidation and the enhanced use of agricultural inputs have resulted in profound negative impacts to agricultural communities (Lobao and Stofferan, 2008), growing concerns related to malnutrition, the equitable distribution of foods, and the negative environmental impacts of production (Moragues-Faus et al., 2017). The primary alternative to the current system has, for many years, been embodied by the *local food movement*. Conceptually, local foods prioritize the decentralization of agricultural production and distribution while infusing individual relationships and equitable exchange back into the system (Lyson and Guptill, 2004). Despite years of growth in direct-to-consumer sales (Low et al., 2015), an awareness has emerged that to reshape the industrial food system, small farms and local food infrastructure are insufficient (Clancy and Ruhf, 2010). A growing emphasis on "agriculture of the middle" (large independent family farms) (Kirschenmann et al., 2008) and regional (multistate) distribution networks has moved to the forefront of research (Clancy and Ruhf, 2010; Stevenson et al., 2011; Mount, 2012).

Investigation of regional food economies and midscale agriculture has increased interest in the role of intermediated markets. Intermediated markets are defined as local and regional sales that pass through an aggregator, restaurant, grocer, or institution before reaching the consumer (Low and Vogel, 2011). Amongst intermediated markets, institutional buyers (e.g., hospitals, K-12 schools, and higher education), with their multimillion-dollar food budgets and thousands (or millions) of meals served per year, are thought to serve as a lynchpin in regional food economies (Thottathil, 2019). Institutional buyers may provide stability that allows producers to grow into new markets (Friedmann, 2007; Mount, 2012). While a focus on institutional purchasing and the scaling of production reaches back nearly 15 years, there is still a great deal unknown about the actors that occupy the institutional foodservice space.

The college and university foodservice sector, with its approximately $18 billion annual budget (MAFSI, 2017), could be a valuable institutional contributor to regional food systems. Minimal research has focused on foodservice structures within higher education. This work contributes to a developing narrative regarding the role foodservice providers (often third parties contracted by the university) play in higher education food purchasing (Glickman et al., 2007; Barlett, 2017; FINE, 2017; Santo and Fitch, 2018; Henshaw, 2019). The current study explores the composition of the college and university foodservice management landscape. We ask: What percentage of all foodservice at residential colleges and universities is outsourced? Do patterns of geographic variability exist in foodservice outsourcing? And do those patterns provide insight into the potential for local and regional food purchasing at these institutions?

Literature Review

Regional Food Systems and Values-based Food Chains

Even as demand has increased in the local food economy, there is growing awareness that growth in very small farms and direct-marketing opportunities are not addressing a clear gap in the production system (Clancy and Ruhf, 2010; Stevenson et al., 2011). Bifurcated control of distribution channels between small-scale direct-to-consumer sales and highly consolidated "broadline" distributors (e.g., Sysco and US Foods) (Howard, 2016) has only further exacerbated a "hollowing out" of the middle of U.S. agriculture that has been present for decades (Buttel and LaRamee, 1987; Stevenson et al., 2011). A number of "alternative" institutions have emerged to fill the gap left by consolidation. Collectively, this refocusing has become known as "agriculture of the middle" (AOTM) (Kirschenmann et al., 2008; Stevenson et al., 2011). Much of the focus of AOTM research is directed at the need for properly scaled processing and distribution channels that will provide midsized farms a competitive marketplace and allow small farms to scale up production to meet market demands (Mount, 2012; Clark and Inwood, 2016).

Two strategies of growing interest and importance for creating mid-scale infrastructure are food hubs and values-based food chains. Food hubs serve as aggregators and "supply chain managers" of "source identified products from local and regional producers" (Berti and Mulligan, 2016, p. 22). Food hubs allow smaller producers with sub-wholesale quantities of product to access wholesale markets, while not losing their individual identities and direct market premiums (Barham et al,. 2012). Food hubs are embedded in a values-based food chain (Stevenson and Pirog, 2008), which bridge the gap between direct, source-identified and conventional, anonymous marketing channels (Bloom and Hinrichs, 2010). They take advantage of conventional logistics and distribution systems while maintaining a set of core operating values and product identities from farm to market (Bloom and Hinrichs, 2010; Diamond and Barham, 2012). Key to the functioning of a values-based food chain is the securing of buyers who share the system's values or benefit from the differentiated products available in a values-based marketplace (Diamond and Barham, 2012; Thottathil, 2018). These buyers may take a variety of forms, including restaurants that prioritize local ingredients, small "mom-and-pop" retailers with consumers that value source-identified local products, or institutions that identify as "conscious" consumers in an attempt to benefit their local communities (Bloom and Hinrichs, 2010; Thottathil, 2018).

Institutional Buyers as Conscious Consumers

The vast majority of institutional buyers utilize conventional purchasing or "broadline" supply chains to ensure consistent and inexpensive products (Stahlbrand, 2017; Goger, 2018). However, there are a subset of institutions including hospitals, K-12 school systems, and colleges and universities that may act as "values-based" or "conscious" consumers. (Izumi, Wright, and Hamm, 2010; Conner et al., 2014; Thottathil, 2018). These institutions see value in the provision of "better" quality food, as it provides health or other benefits to their users. Conscious institutions may be more willing to engage in practices that benefit local and regional sourcing. They may be less cost dependent (or averse) and willing to undertake more complicated sourcing practices in order to

obtain better-quality products, overcoming a primary impediment to greater local food inclusion (Feenstra, 2011; Hardesty et al., 2014; Stahlbrand, 2017). Motivation for local food purchasing in the higher education sector is tied to benefits including improving connections to the local community, deeper connections with campus sustainability, improving the public image of the institution, and benefits to the local economy (Ng, Bednar, and Longely, 2010). There is currently no national summary of local food purchasing in higher education; however, a 2017 Farm to Institution New England (FINE) report provides insight into the purchasing habits of more than 100 colleges and universities in a six-state region. Amongst the participating institutions, 95% reported purchasing local foods with an average of 21% of their annual food budget dedicated to local food purchasing (FINE, 2017).

It is still an open question as to whether institutional purchasing has transformative capacity (Thottathil, 2018). One of the primary challenges associated with understanding institutions as transformative agents is the consumer orientation of the institutions themselves (Allen and Guthman, 2006; Barlett, 2017). Institutions are fundamentally constrained by the demands of their users. Additionally, the relationship between the institution and the market is often buffered by an intermediary food-service provider (Goger, 2018). Regardless of the interest or intent of the institution itself, the contractual relationship between the institution and foodservice provider will greatly inform purchasing decisions (Klein, 2015; Fitch and Santo, 2016; Barlett, 2017). It is of concern that the separation of the end consumer from the decision process in the institutional environment inhibits change or undercuts the fundamental change capacity of local foods (Delind, 2011; Mount, 2012; Nost, 2014). Other critiques state that any process that resides with an institution can be undone by that same institution, which begs the question of durability of institutional markets (Mount, 2012).

Foodservice Outsourcing in Higher Education

Outsourcing of non-primary functions (maintenance, foodservice, transportation) in higher education is a well-documented trend. Starting in the 1990s, institutions began to seek cost savings and upfront investment from outside providers of needed support services (LeBruto and Farsad, 1993; Gupta, Herath, and Mikouiza, 2005; Glickman et al., 2007; Wekolu, 2017). Despite recent commentary on a push to break from corporate foodservice (Anderson, 2021), the overwhelming trend in outsourcing has continued or even accelerated over the past 30 years. Documented estimates of total foodservice outsourcing in higher education have risen from 24% in 1997 (King, 1997) to 50% in 2005 (Gupta, 2005). The market is dominated by the "Big 3" corporations, Sodexo, Aramark, and Compass Group, control roughly 45% of the U.S. foodservice industry as a whole and a similar proportion in the college and university market (Fitch and Santo, 2016; MAFSI, 2017).

Privatization of college and university foodservice brings with it several potential challenges for institutions. Divestment of control over daily operations also means a loss of influence over quality and reliability standards (Lyons, 1997), which could negatively impact school reputation and retention (Gramling et al., 2005). Foodservice provider contract structure is of utmost importance, as the defined terms of the contract will guide procurement, labor relations, and profitability for

the provider (Glickman et al., 2007; Santo and Fitch, 2018; Henshaw, 2019). In addition, an increased use of preferred provider purchase agreements between campus foodservice providers and their suppliers has raised concerns over the real ability an institution has to encourage values-based sourcing (Santo and Fitch, 2018). Preferred provider contracts offer incentives to the institutional foodservice provider for purchasing a given percentage or dollar value of product from a particular supplier. The nature and extent of these contracts is often not known by the institution itself and may dramatically impact the purchasing habits of the provider (Fitch and Santo, 2016; Barlett, 2017; Santo and Fitch, 2018; Gaddis, 2019).

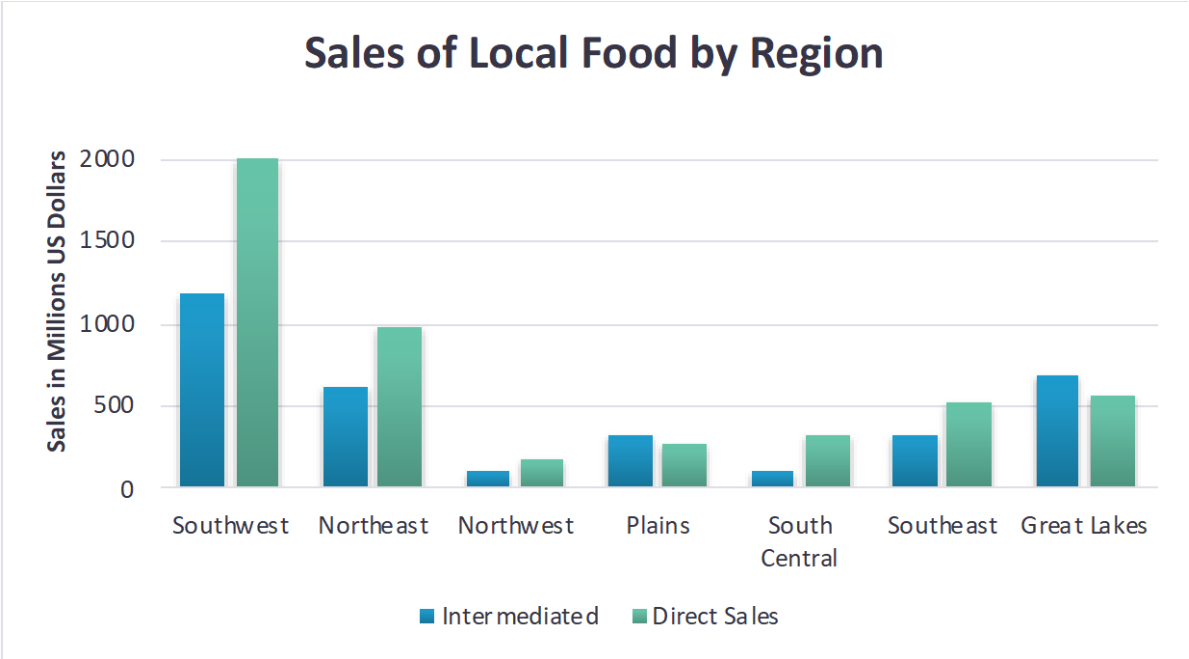
Foodservice Provider Structure and Regionality

This work uses three distinct foodservice management structures to analyze the potential for institutional engagement in values-based purchasing. Self-operated (self-op) dining services are those operated by the institutions themselves as embedded organizational structures. Self-op services generally have a greater level of flexibility in purchasing given their independent nature. Purchasing decisions can be made to meet the values of the institution and are less tied to, though not exclusive of, preferred provider contract arrangements (Lieb et al., 2012). In a sample of New England colleges and universities, self-op providers acquired local foods at a significantly higher rate than their outsourced counterparts. Local food purchases at self-op institutions accounted for 27.5% of annual food budgets as compared to 17.9% at institutions that outsourced to a foodservice management company (FINE, 2017). The second and third structures are both forms of outsourced contract foodservice management companies. Conventional foodservice management companies (broadline) focus on the provision foods at the most affordable price. We utilize the term "broadline" here in reference to the acquisition of the majority of products from a handful of broadline suppliers (Howard, 2016). Broadline management companies tend to be tied more closely to corporate menu development and supply structures that allow for efficiency and price reduction across a variety of institutional accounts (Henshaw, 2019). Finally, "fresh-prep" providers are management companies that espouse corporate values associated with cooking from scratch rather than heat-and-serve meals. Corporate oversight of menus and purchasing mandates are less stringent for fresh-prep providers, offering greater flexibility in sourcing at an individual institutional level (Henshaw, 2019). While the obligation to purchase locally is highly variable based on institutional contracts and mandates, fresh-prep providers have, with proper motivation, yielded local purchasing rates of greater than 35% of annual food budget at institutions in the Great Lakes region (Henshaw, 2019). No single provider structure guarantees higher rates of local food purchasing, but there is sufficient evidence of variability between provider type to warrant continued evaluation of these structures.

Little research has engaged with patterns of regional variability in higher education foodservice outsourcing. The potential for providers to source greater quantities of local and regional product is tied directly to the presence of sufficient regional production and supply chain infrastructure that allows for consistent supply (Feenstra et al., 2011; Berti and Mulligan, 2016; Goger 2018). Distinct regional patterns exist in both direct-to-consumer marketing and intermediated marketing of consumer products within short supply chains. Both forms of sales are highest in the Northeast, Southwest, and Great Lakes regions (see Figure 1) (Low et al., 2015). The primary differentiation

between farms that direct market and those that utilize intermediated markets is urban proximity, based on a higher density of farms and greater aggregation infrastructure (Low and Vogel, 2011; Dimitri and Gardner, 2018). We expect to see higher concentrations of self-op and fresh-prep foodservice providers in regions with more direct market capacity.

Given increased interest in the transformative capacity of institutions to enhance a regional food economy and the complexity of an intermediated food purchasing environment in the institutional context, increased understanding of the relationship between institutions and providers is valuable.



Source: USDA NASS, 2015 Local Food Marketing Practices Survey[1]

Figure 1. Intermediated Sales and Direct-to-Consumer Sales by Region in Millions of Dollars

Methods

A list of residential institutions of higher education was created using the publicly available Integrated Postsecondary Education Data System (IPEDS) 2016–2017 institutional data. IPEDS is an annual survey conducted by the U.S. Department of Education. Participation is compulsory for all colleges, universities, and technical and vocational institutions that participate in federal student aid programs. An initial list of 7,224 institutions was narrowed to 1,595 by excluding all institutions that did not have room and board data and admissions data, as this research was primarily focused on residential institutions or institutions that had a residential option. Foodservice provider data was manually collected from institution and provider websites from September 2019 to June 2020, resulting in the final dataset of 1,404 institutions for which provider

[1] Northeast (CT, DE, ME, MD, MA, NH, NJ, NY, PA, RI, VT), Great Lakes (IL, IN, MI, OH, WI), Plains (IA, KS, MN, MO, NE, ND, SD), Southeast (FL, GA, KY, NC, SC, TN, VA, WV), South Central (AL, AR, LA, MS, OK, TX), Southwest (AZ, CA, CO, HI, NV, NM, UT), and Northwest (AK, ID, MT, OR, WA, WY).

information was available. The name and contact information for each provider was entered into Excel, and then each provider was categorized as either "self-op" or "outsourced." Outsourced providers were then broken into two categories—"Broadline" and "Fresh-prep"—following Henshaw (2019). "Fresh-prep" providers were identified as companies that made a public commitment to scratch cooking on their websites. All other providers were classified as "Broadline." Provider data were merged into existing IPEDS data using SPSS (version 27), and regional patterns were analyzed.

Graphical distribution maps were generated using QGIS (3.4) from the location data for each institution provided in IPEDS. The relationship between regions and provider type was tested using SPSS (version 27) crosstab function with X^2 test of independence and Cramer's V measure of association. Cramer's V measures the level of association between nominal variables on a scale of 0–1 with 0 being no association. Strength of association is guided by the degrees of freedom in each test following Coen (1977), where 0.04 is considered small, 0.13 medium, and 0.22 large.

Regional variability in direct-to-consumer sales and intermediated market sales was derived from the U.S. Department of Agriculture, National Agricultural Statistics Service, 2015 Local Food Marketing Practices Survey. Intermediated markets are defined as the sales to "institutions such as schools, colleges, universities, and hospitals as well as intermediary businesses such as wholesalers, distributors, processors, etc., that market locally or regionally branded products" (USDA-NASS, 2016, p. 2).

Results

Percent of Outsourced Foodservice

A contracted foodservice provider was employed by 72.7% of colleges and universities (see Figure 2). Significant [X^2 (6, N = 1397) = 36.68, $p < .001$] and moderately strong relationships [Cramer's $V = .162$] in regional variability exist in foodservice outsourcing. Foodservice outsourcing occurs at different rates in different regions with the South Central and Southeast regions outsourcing at the highest rates (> 80%), while the Northwest has the highest concentration of self-op foodservice (~45%).

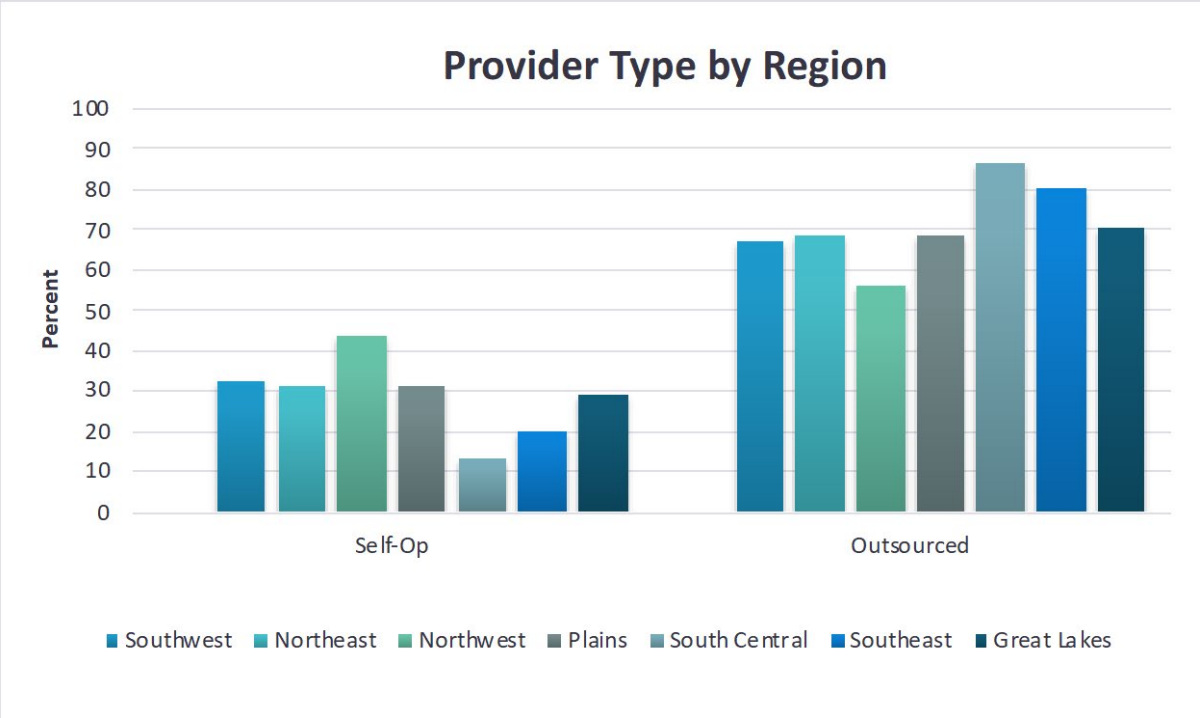


Figure 2. Percentage of Self-op and Outsourced Foodservice by Region

Regional Distribution by Provider Type

Extraction of fresh-prep providers from the outsourced total continues to indicate significant [X^2 (12, N = 1397) = 92.818, $p < .001$] and moderately strong relationships [Cramer's $V = .182$] in regional variability (see Figure 3). Combining self-op and fresh-prep providers into a single group in contrast with broadline providers indicates a strong [Cramer's $V = .232$] significant [X^2 (6, N = 1397) = 74.89, $p < .001$] relationship in regional variability (see Figure 4).

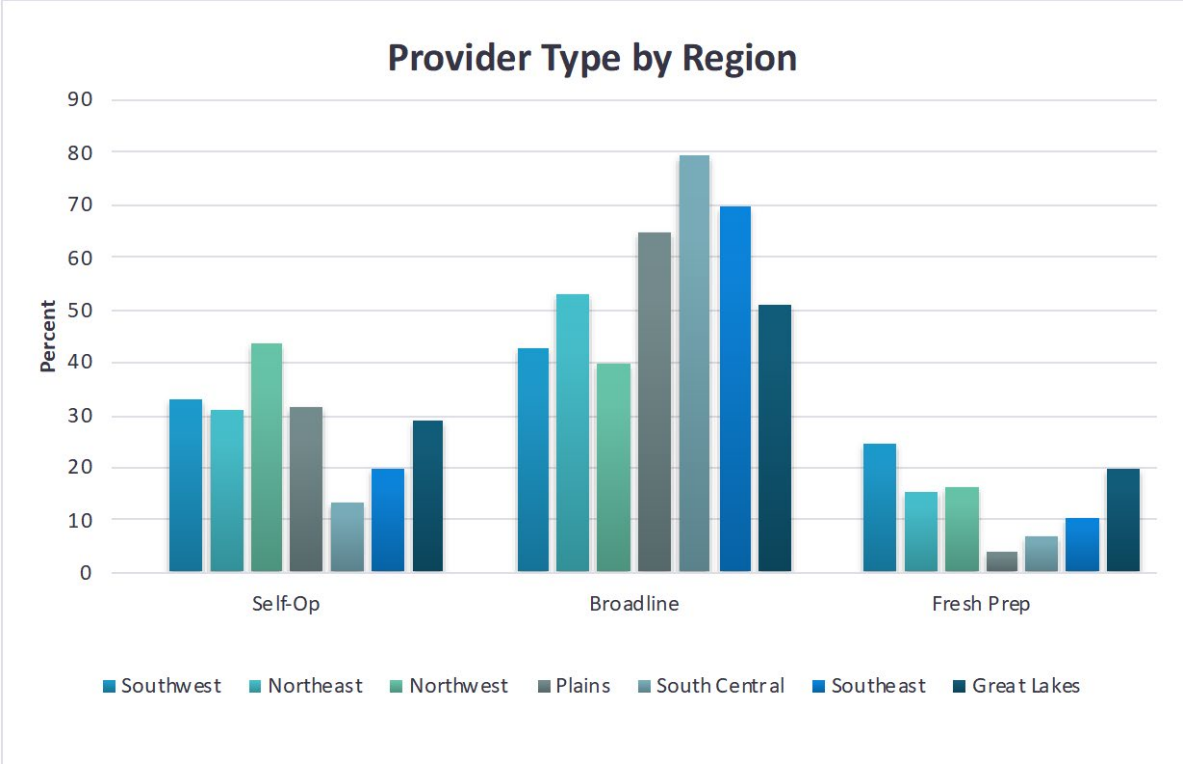


Figure 3. Percent of Providers by Type and Region Including Fresh Prep

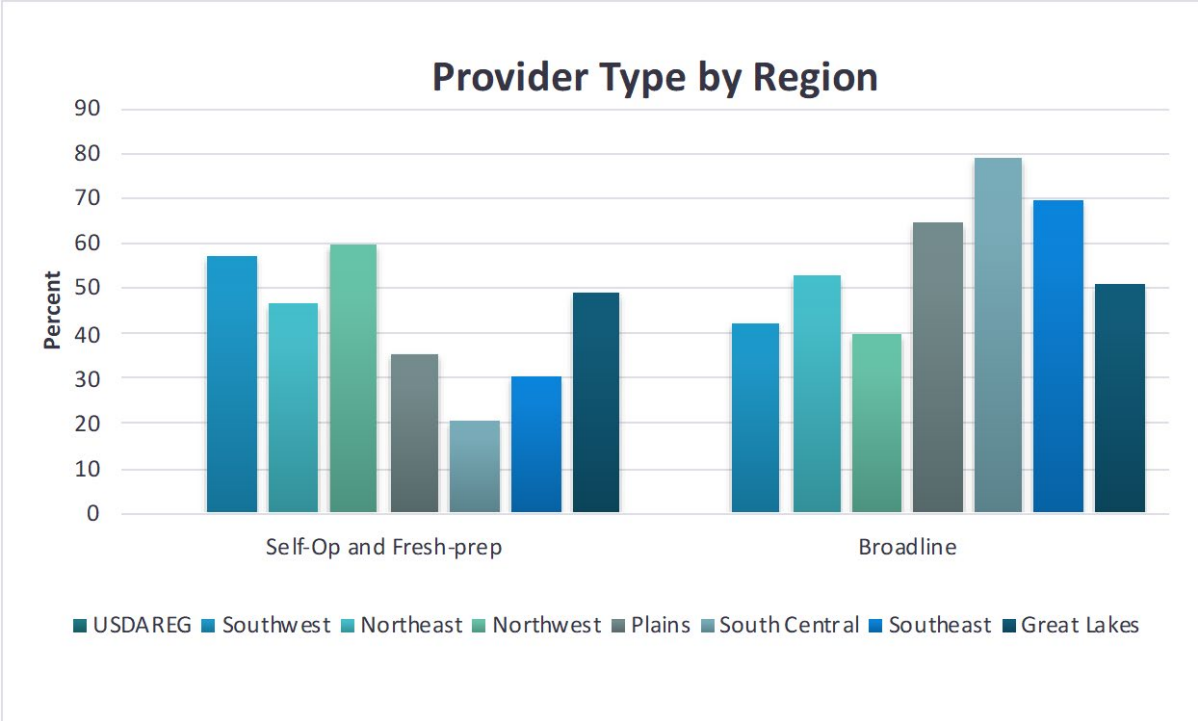


Figure 4. Percent of Providers by Type and Region: Self-op and Fresh-prep Combined

Dot distribution maps of the three provider categories are presented in Figures 5, 6, and 7.

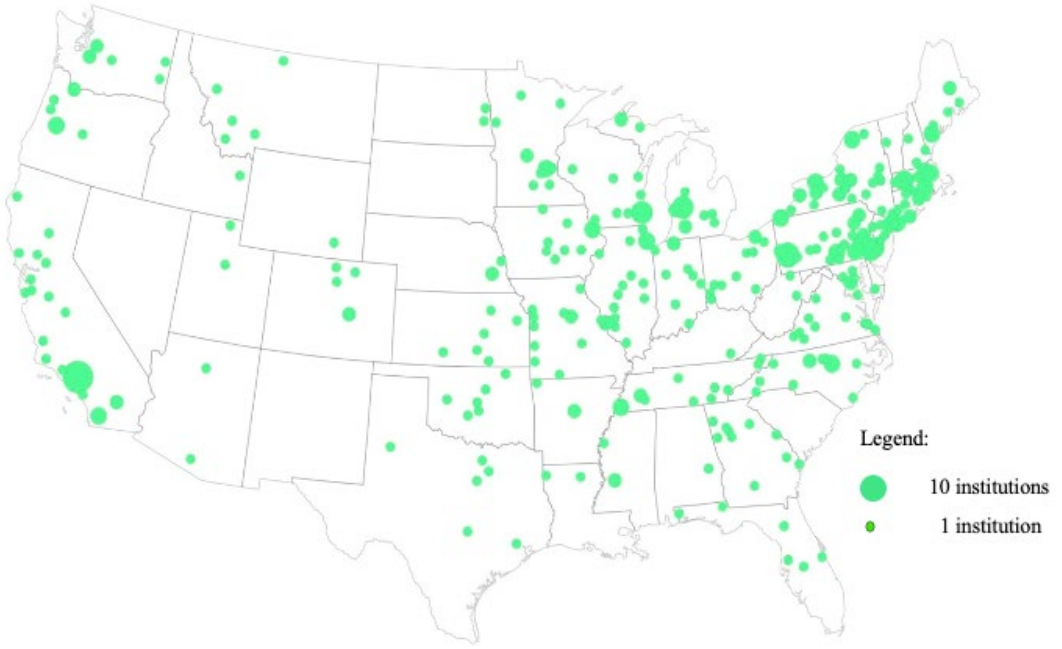


Figure 5. Self-operated Dining Services at Colleges and Universities in the Continental United States

Figure 6. Broadline Dining Services at Colleges and Universities in the Continental United States

Figure 7. Fresh-prep Dining Services at Colleges and Universities in the Continental United States

Discussion

Rates and Regional Variability in Outsourcing

This analysis of outsourcing trends is the most comprehensive one currently available (1,397 total institutions) and shows a continued pattern of expansion in outsourcing. Rates have continued to increase at each documented interval, from 25% (King, 1997) to 50% (Gupta, 2005) to 72.7%.

Significant relationships exist between regions and the type of foodservice provider used by institutions of higher education. This is a novel result as regional patterns of foodservice outsourcing have not been previously noted in the literature. A simple division between self-op and outsourced foodservices shows marginal variability in regional percentages with all regions outsourcing between 55%–85% of their foodservice. This variation may reflect a variety of decision-making parameters not captured in this study, including regional concentrations of public versus private institutions (Gupta et al., 2005), decreases in state-level funding (Wekulo, 2017), or the state and regional political atmosphere.

The extraction of the fresh-prep provider data from the outsourced total enhances patterns in regional variability. Institutions in the Plains states, while not outsourcing at a greater rate than other regions, appear to be making a dichotomous decision between self-op and broadline provision. The contracting of fresh prep providers in the Southwest, Northeast, Northwest, and Great Lakes regions (> 15% of all providers) serves to highlight the inclination of institutions in

the Southeast (69%) and South Central (79%) regions not just to outsource, but to outsource to broadline providers.

When combined, self-op and fresh-prep providers represent roughly half (45%–60%) of all providers in the Southwest, Northeast, Northwest, and Great Lakes regions. In three of these regions (Northeast, Southwest, and Great Lakes), the greater presence of self-op and fresh-perp foodservice providers is consistent with local farm sales to both direct and intermediated markets (Low et al., 2015; USDA-NASS, 2016). The greater willingness or capacity of self-op and fresh-prep providers to engage in local purchasing (FINE, 2017; Henshaw 2019) may be coincident with the presence of greater infrastructure for processing and distribution in the region (Feenstra et al., 2011; Berti and Mulligan, 2016; Goger, 2018). While there is no indication in this analysis of the timing of the emergence of fresh-prep providers relative to other infrastructural projects, the coexistence of these actors speaks to the capacity of new institutional markets to integrate into value chain supply channels at a regional level.

One region, the Northwest, is highly anomalous to this trend. The Northwest has both the highest percentage of self-op providers and the highest total percentage of self-op and fresh-prep providers. It is, however, also the region with the lowest combined regional sales through direct and intermediated markets. This break from the broader pattern may very well be an artifact of the U.S. Department of Agriculture sales region creation that combines dense Northwest urban populations of Seattle and Portland with sparsely populated regions of Wyoming, Montana, and Idaho. However, it does indicate that attention should be given to subregional variability as we consider regional agglomeration in food purchasing.

Implications for Local and Regional Food Purchasing

The place of the conscious consumer in the development of local food value chains is one of utmost importance (Thottathil, 2019). The capacity of the system to scale into midsized production and distribution is dependent largely on stable markets that value differentiated products (Diamond and Barham, 2012). This work contributes to a relatively small body of literature that engages these institutional structures. Regional relationships between local food infrastructure and higher education foodservice providers with a propensity toward local foods purchasing is optimistic for the role of colleges and universities as conscious consumers. Substantial utilization of the fresh-prep provider in regions with high local food infrastructure indicates a pathway for values-based purchasing that does not require the reintegration of foodservice back into institutions that have made past outsourcing decisions.

While there is no inherent relationship between any provider type and a willingness to purchase food in a conscious manner (Henshaw, 2019), there do appear to be opportunities for expansion and growth in the higher education market. It is important to recognize that investments in regional infrastructure and purchasing do not happen in a vacuum. Purchasing by institutions that encourages growth in aggregation, processing, or production will likely have spillover effects in the market as a whole, making products more available to a broader spectrum of consumers and accounts.

Conclusion

As our understanding of values-based food supply chains increases, there is a growing need for analysis of actors that will play a role in the development of opportunities in this market segment. The sheer size of the higher education foodservice sector means that significant gains in integrating local and regional food purchasing into higher education could be transformative for local food economies. There is good reason to believe that colleges and universities have the capacity to act as conscious consumers. However, increasing percentages of outsourced foodservice (now 75% nationally) bring into question the nature of the institution-consumer relationship. This research indicates that those patterns are more complex than a simple focus on the percentage of outsourced providers might indicate. There is significant regional variability in outsourcing. This regionality highlights both opportunities for market growth and areas in which that growth may be more challenging. In addition, the use of the fresh-prep provider indicates that the decision to outsource may take multiple pathways and not, in and of itself, be exclusionary to the growth of local and regional purchasing in higher education.

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Wine and Wildlife: An Exploratory Study of the Depiction of Animals on Wine Labels Available in the United States

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Abstract

Wine labels that depict animal imagery could draw on consumers' interest in wildlife and biodiversity, but this topic has received little attention. We document the frequency of the depiction of animals on a sample of wine labels available in the United States. We found that

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animals were depicted on 16.7% of labels overall. Birds and mammals were the most commonly depicted animals, and certain types of birds, especially hawks, eagles, owls, ducks, and birds in the crow family, were especially common. We suggest that animal depictions on wine labels could communicate environmental values attractive to consumers

Keywords: label, eco-label, marketing, birds, consumer, wine, biodiversity

Introduction

Increasingly, consumers extract environmental and ethical values and aesthetic emphases from food package attributes and labels (Rokka and Uusitalo, 2008; Grunert, Hieke, and Wills, 2014). While much research has been aimed at understanding the power and limitations of eco-labels and certifications to communicate brand values, motivate customers, and effect change (Teisl, Roe, and Hicks, 2002; Rex and Baumann, 2007; Thøgersen, Haugaard, and Olesen, 2010; Yokessa and Marette, 2019), less attention has focused on the use of environmental imagery and iconography invoking animals and biodiversity in food advertising (Baker, 2001; Phillips and McQuarrie, 2004; Hansen and Machin, 2013). Recent evidence indicates that consumers' interest in biodiversity specifically can affect product choices (van Riemsdijk et al., 2017; Foti et al., 2019), including willingness to pay higher prices (Mazzocchi, Ruggeri, and Corsi, 2019; Ruggeri, Mazzocchi, and Corsi, 2020), so a better understanding of biodiversity-related imagery on labels is needed.

Improved understanding of the use of animals and other elements of biodiversity on labels is particularly important in the wine industry. Since wine consumers typically cannot taste or smell the wine while in a store, and because product perception is rapid in retail settings, wine packaging is the product until the wine has been consumed (Ksenia, 2013; Monteiro, Guerreiro, and Loureiro, 2020). With increased interest in the environment and animals, especially among younger wine consumers vital to the industry's persistence and growth (Wolf and Thomas, 2007), more work is needed to investigate the depiction of animals on wine labels.

This research requires at least two steps, examining how animals are currently depicted on wine labels and investigating consumers' responses to such depictions. This study focused on the first step. Our objective was to document the frequency of the depiction of animals on wine labels and examine whether their depiction varies among factors such as the type, region of origin, and price of wine. Since birds were the most frequently depicted wild animals on wine labels in our study (see Results section), we also sought to describe patterns in the depiction of birds by investigating whether particular types of birds are more likely to be depicted, and whether birds are depicted as simple icons, or if they are intended to communicate environmental values.

Literature Review

Synthesis of Environmental Labels, Animal Depiction, and Wine Marketing

A large body of literature affirms that images and language on packaging communicate brand meanings and values which, in turn, shape brand identity and reputation (Davis, 1993; Underwood and Klein, 2002; Oswald and Oswald, 2012; Black and Veloutsou, 2017). Many food products are selected in stores at the point of purchase, where they compete to attract favorable attention and consumer choice (Mueller and Lockshin, 2008; Chandon et al., 2009). Packaging attributes attract and sustain attention (Nancarrow, Wright, and Brace, 1998), helping consumers identify with the product and affecting their perceptions of a brand's quality, values, and image (O'Guinn, Allen, and Semenik, 2009).

Research conducted in the last couple of decades has revealed the capacity for some food labels to attract the growing market of environmentally concerned consumers by including natural imagery and, in some cases, information communicating a brand's environmental values (Davis, 1993; Rokka and Uusitalo, 2008; Grunert, Hieke, and Wills, 2014). Indeed, the rise of "eco-labels"—third-party certifications that enable consumers to quickly and easily identify products that meet specific environmental performance criteria—clearly shows the relevance of the environment in food labeling, including for wines (Delmas and Grant, 2014). However, consumers' interests in "the environment" are highly varied, from concern about greenhouse gas emissions stemming from food production or distribution (Bonini, Hintz, and Mendonca, 2008), to the use of chemical pesticides that could affect human or environmental health (Dunlap and Beus, 1992), to the accidental impacts on animals not intended to be harvested (Treves and Jones, 2010), to a loss of biodiversity associated with food production (Gatti et al., 2022). Substantial work has been conducted on the role of eco-labels and certifications (Teisl et al., 2002; Rex and Baumann, 2007; Thøgersen, Haugaard, and Olesen, 2010; Yokessa and Marette, 2019; Gatti et al., 2022), but far less research has examined the use of animal imagery in food advertising (Baker, 2001; Phillips and McQuarrie, 2004; Hansen and Machin, 2013).

Within the wine sector, research shows that packaging and brand are the most important factors in consumers' choice of wine (Barber and Almanza, 2006; Mueller et al., 2010; Mu, 2011). The visual appeal of front labels on wine bottles is seen as the predominant and first line of communication between the consumer and wine producer (Rocchi and Stefani, 2005; Halstead, 2012). Indeed, "the first taste is almost always with the eye" (Mueller and Lockshin, 2008; Tonder and Mulder, 2015). Furthermore, wine labels carry more social relevance than do labels of other food products because wine is often shared socially, with the wine bottle placed on a table, sideboard, or countertop visible to guests. Wine labels say something about the hosts' tastes, aesthetics, and values (Olsen et al., 2003).

The wine industry is an increasingly saturated and highly competitive global market (Sogari, Mora, and Menozzi, 2016), where individual wineries and growers respond by differentiating wines in ways that appeal to particular consumers (Tait et al., 2019). With the top 10 manufacturers generating less than 12% of the industry revenue (IBISWorld, 2019), low revenue concentration and high levels of competition combine to propel wine merchandisers to distinguish themselves beyond traditional differentiators, such as grape variety, origin, and price (Williams, 2018). A growing body of research demonstrates consumer interest in environmental attributes of wine (Barber, 2010; Pomarici and Vecchio, 2014; Pomarici, Amato, and Vecchio, 2016), which can be communicated with label imagery (Schmit, Rickard, and Taber, 2013; Kelley, Hyde, and Bruwer, 2015). In particular, wine labels that depict animal imagery could draw on consumers' interest in wildlife and biodiversity, but this topic has received little attention. In one of the only studies to include documentation of wine labels with animals, Wolf and Thomas (2007) found that while animal depiction was only slightly related to wine label desirability overall, its desirability was rated higher by younger generations than by Baby Boomers.

However, evidence for environmental labels boosting wine sales are mixed, and brand positioning strategies (Ries and Trout, 2002; Dressler and Paunovic, 2021) may render animal depiction on

wine labels favorable for only certain wines. In an analysis of over 13,000 wine sales records from 1998–2005, Delmas and Grant (2014) showed that certifying wine with some form of sustainability criteria increased the price by 13%, but including an eco-label reduced the price by 20%, and concluded that eco-labels can exert a penalty to wines at higher price points and from prestigious regions (Delmas and Grant, 2014; Delmas and Lessem, 2017). Thus, animal and other environmental imagery may be more relevant for inexpensive wines, and less valuable for wines drawing from a rich heritage better depicted with traditional imagery, such as chateaus and heraldic images and fonts (Pelet, Durrieu, and Lick, 2020). However, the availability, prices, and consumer perceptions of environmentally friendly food products are rapidly changing, and much remains unresolved (Di Vita et al., 2019). A recent review (Schäufele and Hamm, 2017) indicates that consumers from a broad range of countries generally report a willingness to pay a premium for wine with characteristics of sustainable production. Lim and Reed (2020) also found persistent positive effects of sustainable certifications on price, especially for wines from less prestigious regions. Moreover, consumers are now beginning to differentiate various dimensions of eco-labels and sustainability certifications. Recent work with consumers of California sauvignon blanc revealed their stronger interest in management of pests and disease as well as conservation of water resources than in energy sustainability or biodiversity management in particular (Tait et al., 2019). Even the choice of animals used in label and icon imagery can affect consumers' perception, because people find some types of animals more appealing than others, or associate favorable attributes and values with certain species (Roberge, 2014). For example, among "flagship" species depicted on nature magazines and organizational logos, large and charismatic species of birds and mammals are by far the most common (Clucas, McHugh, and Caro, 2008). The popularity of bird watching and birds in the United States (Kane, 2018; USDI, 2018) suggests birds may be especially prominent in wine labels.

Literature-informed Testable Hypotheses

Based on the literature reviewed above, we examined several hypotheses for the depiction of animals on wine labels. First, we hypothesized that the depiction of animals on wine labels is relatively common, and that it varies among regions and price points of wines based on a brand's positioning strategy. Specifically, we predicted that animals would be less commonly depicted on wines aimed at consumers valuing a winery's tradition and heritage, including higher-priced wines and bottles from regions with long wine traditions, such as France, Italy, and Spain. Second, we hypothesized that popular animals are the most commonly depicted on wine labels, predicting birds are especially frequent, and that certain types of charismatic bird species are more commonly depicted than others. Third, we hypothesized that the depiction of animals on wine labels is commonly linked to environmental value rather than as simple iconography, predicting that wine labels with animals also include information on the label indicating the brand's wildlife-friendly practices or other commitment to the environment.

Methods

Sampling

We obtained two samples of wine labels. First, we sampled 828 wine bottles from 10 shops located in eight states to represent a sample of retail wine bottles commonly available to American wine consumers (see Table 1). States were selected opportunistically based on our locations and travels, but also strategically to provide a wide range of consumer markets, though midwestern regions were underrepresented. The ten shops included grocery stores as well as wine and liquor stores. In each store, we either recorded data from all available bottles (for stores with small inventory) or we used systematic sampling (e.g., sampling every 10th bottle in stores with large inventories) to avoid bias toward eye-catching label characteristics. This sample was used to document the rate of animal depictions on wine labels. Among the 828 bottles were 537 unique wine labels (i.e., 291 labels were recorded in more than one store), and this sample of unique labels was used for examining variables associated with labels that did and did not depict animals. Multiple labels from the same wine maker were included if the labels differed.

Second, we augmented the sample of labels depicting animals obtained from the above survey by scan sampling in shops for additional labels depicting animals. This scan was done for the bottles not systematically sampled in the stores with large inventories described above, as well as in an additional 14 stores (24 in total) (see Table 1). While this scan sample was opportunistic, we aimed to obtain as large a sample as possible of labels with animals in order to describe patterns in their depictions. This sample included 296 unique labels depicting one or more animals.

Table 1. Grocery and Wine or Liquor Stores Where Wine Bottles and Labels Were Sampled

State	Store Type	Name and Location	Sample
AK	Wine/liquor store	Oaken Keg Anchorage	1 and 2
AZ	Grocery store	Clark's Market, Sedona	1 and 2
CA	Wine/liquor store	Dean & Deluca, St. Helena	1 and 2
CA	Grocery store	Safeway, Arcata	1 and 2
CA	Wine/liquor store	Backroom Wines, Napa	2
CA	Wine/liquor store	Wineshoppe, Ferry Bldg, San Francisco	2
CA	Grocery store	Ranch Market Too, Yountville CA	2
CA	Grocery store	Raley's Napa	2
CA	Grocery store	Wildberries, Arcata	2
CA	Grocery store	Safeway, American Canyon	2
CA	Grocery Store	Costco, Eureka	2
CA	Grocery store	Eureka Natural Foods, Eureka	2
CA	Grocery store	Safeway, Lodi	2
CA	Wine/liquor store	BevMo, San Luis Obispo	2
CO	Wine/liquor store	Divino Wine Shop, Denver	1 and 2
CO	Grocery store	Marczyk Fine Foods, Denver	2
NY	Grocery store	Trader Joe's Wine Shop, New York	1 and 2
NY	Wine/liquor store	Bayville Wines & Liquors, Bayville	1 and 2
OH	Wine/liquor store	House Wines, Columbus	1 and 2
OH	Grocery store	Kroger's, Columbus	2
OR	Grocery store	Fred Meyer, Hillsdale	1 and 2
OR	Grocery store	Whole Foods, Portland	2
OR	Grocery store	Cork & Bottle Shoppe, Corvallis	2
VA	Wine/liquor store	Wine Gallery, Alexandria	1 and 2

Note: Sample 1 refers to 828 wine labels sampled systematically. Sample 2 refers to a scan sample of 296 wine labels depicting animals.

Recorded Variables

For every label, we recorded whether it visually depicted one or more animals, as well as the wine color (red, white, or rosé), varietal, region of origin (the United States, Europe, South America, South Africa, Australia/New Zealand), location of origin (U.S. state or country), and price of the wine to the nearest U.S. dollar. Varietals were collapsed to fewer categories to maintain a minimum sample size of 20 in each, resulting in five reds (Cabernet Sauvignon, Merlot, Pinot Noir, Zinfandel, or red misc., which included blends), three whites (Chardonnay, Sauvignon Blanc, or white misc., which included blends), and one rosé (rosé misc., which included blends).

For labels that depicted one or more animals (in either sample), we recorded the type of animal (bird, mammal, reptile, amphibian, insect, other invertebrate, or mythical [e.g., Pegasus]), its lowest possible taxonomic identification, whether it was domesticated, wild, or unknown, and whether the depiction was realistic, silhouetted, generalized, or abstract. An image was

characterized as generalized if it was recognizable but lacked enough detail for any detailed identification, or if it was fictionalized but identifiable (e.g., a generalized hawk). Abstract images were more fantastical or abstract in color or shape, but appeared to depict a real rather than mythical animal (see Figure 1 for examples). Wild birds were the most commonly depicted animals (see Results section), so for birds we also recorded the taxonomic Order and Family to examine taxonomic representation.

Note: Labels were categorized as realistic (a), generalized (c, e, h), silhouetted (b, g), and abstract (d, f, i), and from several types of animals, including birds (f), mammals (g, h), reptiles (a), amphibians (b), fish (i), insects (d, e), and other invertebrates (c).

Figure 1. Example Depictions of Animals on Wine Labels

We also examined whether the label made textual reference to the animal, such as in the wine name or text on the back of the bottle. We distinguished wine labels with animals as simple iconography versus depictions that aim to communicate or evoke environmental value. Labels with animals were considered simple iconography if there was no textual reference at all to the animal, if it was referenced textually only in the name of the wine, or if it was referenced textually on the label but not in a way related to the environment (e.g., a poem). We classified labels with animals as communicating environmental value if there was textual reference to the animal depicted in a way that related to the environment (e.g., by indicating that the species lives on the vineyard, the vineyard attempts to provide habitat or refrains from using pesticides that might impact biodiversity, etc.).

Analysis

The "consumer encounter rate" was calculated as the percentage of all 828 examined bottles in the systematic survey that depicted one or more animals. This sample included duplicate labels observed in more than one shop because frequently encountered labels are more available to consumers than are rare ones. The "retail label rate" was calculated from the 537 unique labels in the 828-bottle sample (avoiding duplicates), and these 537 labels were used to examine whether animal depiction varied with any of the label variables described above. Sample size was sufficient to examine the effect of location of origin within a region only for wine from the United States (disaggregated by state) and from Europe (disaggregated by country). Analysis of the patterns in the depiction of animals was conducted on the 296-label opportunistic scan sample. All variables were categorical except price, which was normally distributed. We used a logistic regression and backward variable selection to examine the association of wine type, varietal, region, location, and price on the presence or absence of animal depiction varietal, starting with the global model and sequentially removing the least selective variable until reaching a null model. Candidate models were then ranked with Akaike's Information Criterion corrected for small sample size (AIC_c), with models within 2 AIC_c of the top model considered competitive. To aid interpretation, we also performed univariate χ^2 tests of independence and *t*-tests to examine categorical and continuous (price) variables, respectively. To compare the distribution of birds on wine labels to their taxonomic distribution, we restricted analysis to birds in the United States identifiable to Order or Family, and used the species tally of Cornell's Laboratory of Ornithology Bird Guide (2020) as the null distribution in a χ^2 goodness-of-fit test. To examine preference for popular bird species, we restricted analysis to depicted birds from the United States identifiable to species, and we used the popularity score for all birds in the United States provided by Schuetz and Johnston (2019). Bird popularity scores range from -2 to +2, with a mean of 0, and summarize the relative abundance of Google searches for each species based on Google Trends data in the United States from 2008 to 2017 (Schuetz and Johnston, 2019). We used a 1-sample *t*-test to compare the mean popularity score of bird species depicted on wine labels to the expected null hypothesis of mean popularity (0). Likewise, to examine preference for large species, we used a 1-sample *t*-test to compare the mean mass (log_{10} transformed) of bird species depicted on wine labels to the expected null hypothesis of the mean body mass of all bird species in the United States from Schuetz and Johnston (2019; mean log_{10} mass = 1.983 or 96 g). All analyses were performed in *R studio* (R Core Team, 2017).

Results

Overall, 139 of the 828 bottles surveyed depicted one or more animals, for a consumer encounter rate of 16.7%. This rate was slightly higher in grocery stores (17.9%) than in wine/liquor shops (15.9%), but this difference was not significant ($\chi^2 = 0.58$, df = 1, $P = 0.44$). Based on this sample, a wine customer in the United States is most likely to encounter birds and mammals on bottles, which were depicted on 7.4% and 7.0% of the bottles surveyed, respectively. All other animal types were detected on fewer than 1% of bottles surveyed. The depiction of animals on wine labels did not vary strongly among the variables examined, though there were differences based on region. Of the 537 unique labels in the sample, 94 depicted one or more animals, for a retail label rate of 17.5%. As hypothesized, birds are the most frequent animals on labels, appearing on 8.9% of the labels, followed by mammals at 5.4% of the labels. The top model for variation in animal depiction on wine labels included region and price as predictors, though the model with region as the only predictor was competitive (see Table 2). Together these two models carried 95% of the model weight in the candidate model set (see Table 2). The rate of animal depiction on wine labels varied significantly among regions of origin, being lower in Europe (9%) than in other regions (Table 3). It was also high (33%) for wines from South Africa, though this amount was based on a small sample ($n = 9$). In Table 3, statistics for χ^2 tests of independence of animal depiction versus wine type, varietal, region, and location within Europe and the United States are provided. Sample sizes for labels with or without birds or mammals specifically were large enough only for wine type and region, and these were not statistically significant. Statistics for *t*-tests of differences in mean price for wine with and without animals are also provided. See Table 2 for logistic regression model selection results.

Table 2. Model Selection Results for Logistic Regression Analysis of Factors Associated with Presence or Absence of Animal Depiction

Model #	Parameterization	*K*	AIC_c	Δ_t	W_i
1	Global (Type+Varietal+Region+Location+Price)	23	509.29	14.28	0.00
2	Varietal+Region+Location+Price	21	509.68	14.68	0.00
3	Varietal+Region+Price	14	510.22	15.22	0.00
4	Region+Price	6	495.01	0.00	0.61
5	Region	5	496.14	1.13	0.34
6	Null	1	500.13	5.12	0.04

Note: A total of 537 unique wine labels were analyzed, showing the model parameterization, number of parameters (*K*), Akaike Information Criterion corrected for small sample size (AIC_c), difference in AIC_c score between a given model and the topic model (Δ_t), and model weight (W_i) in the candidate set.

Table 3. Frequency of Wine Labels Depicting Animals (Any) and Those Depicting Birds and Mammals Specifically

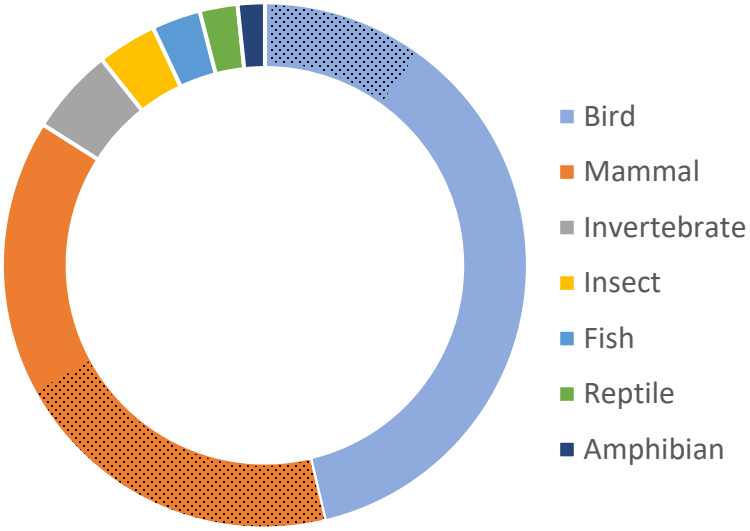
Variable	Labels with Animals	Labels with Birds	Labels with Mammals	Labels without Animals	Total
Overall	94 (18%)	48 (9%)	29 (5%)	443	537
Type ($\chi^2 = 1.34$, df = 2, $P = 0.60$)					
Red	56 (16%)	28 (8%)	17 (5%)	285	341
White	35 (19%)	20 (11%)	10 (5%)	149	184
Rose	3 (25%)	0 (0%)	2 (17%)	9	12
Varietal ($\chi^2 = 4.20$, df = 8, $P = 0.84$)					
Cabernet sauvignon	14 (16%)	7 (8%)	3 (4%)	71	85
Merlot	5 (26%)	2 (11%)	2 (11%)	14	19
Pinot noir	14 (18%)	9 (11%)	2 (3%)	65	79
Zinfandel	3 (30%)	1 (0%)	1 (10%)	7	10
Red misc.	21 (14%)	9 (6%)	9 (6%)	128	149
Chardonnay	17 (21%)	9 (11%)	7 (9%)	64	81
Sauvignon blanc	5 (17%)	3 (12%)	1 (4%)	20	25
White misc.	13 (18%)	8 (10%)	2 (3%)	65	78
Rose misc.	2 (18%)	0 (0%)	2 (18%)	9	11
Region ($\chi^2 = 11.37$, df = 4, $P = 0.02$)					
Australia/New Zealand	6 (24%)	3 (12%)	2 (8%)	19	25
Europe ($\chi^2 = 13.55$, df = 3, $P < 0.01$)	14 (9%)	7 (5%)	5 (3%)	135	149
France	3 (5%)	2 (4%)	1 (2%)	54	57
Italy	5 (10%)	1 (2%)	2 (3%)	55	60
Spain	0 (0%)	0 (0%)	0 (0%)	13	13
All others	6 (32%)	4 (3%)	2 (2%)	13	119
USA ($\chi^2 = 2.53$, df = 3, $P = 0.47$)	67 (21%)	35 (11%)	18 (6%)	259	326
California	46 (19%)	25 (10%)	12 (5%)	195	241
Oregon	14 (26%)	8 (15%)	3 (6%)	39	53
Washington	3 (16%)	2 (11%)	3 (16%)	16	19
All other states	4 (31%)	0 (0%)	0 (0%)	9	13
South Africa	3 (33%)	2 (22%)	1 (11%)	6	9
South America	4 (14%)	1 (4%)	3 (11%)	24	28
Price, mean ± 1 SE	$26.00	$29.45	$20.93	$30.66	$29.88
($t = 1.33$, df = 155, $P = 0.19$)	± $3.09	± $5.45	± $2.05	± $1.69	± $1.50

Note: Labels are disaggregated by wine type, varietal, region and location of origin and include mean price for labels with and without animals.

Among European wines in our sample, most wine labels surveyed originated from France, Italy, or Spain (87%), with the remaining from Austria, Georgia, Germany, Greece, Hungary, Moldova,

Portugal, and Romania. The rate of animal depiction was higher among these rare countries pooled (32%) than it was in France, Italy, and Spain, but sample sizes were too small to examine the rare European countries separately. These findings are consistent with our hypothesis that wineries positioning themselves as traditional heritage brands, such as those from France, Italy, and Spain, are less likely to use animal imagery on their labels. The depiction rate of birds specifically was higher among the rare European countries pooled than it was in France, Italy, and Spain; it did not vary with any other examined variable (all $P > 0.10$). Within the United States, most wine labels surveyed overwhelmingly originated from California, Oregon, or Washington (96%), and the rate of animal depiction did not vary statistically based on state. The animal depiction rate was statistically similar among wine types and varietals. The depiction of birds versus mammals also did not differ among wine types, varietals, or production region (all $P > 0.10$). The mean price of wines depicting animals was slightly lower than those without animals, and price contributed to model fit (see Table 2), but this difference was not significant (see Table 1), showing relatively little support for our hypothesis for an effect of price on animal depiction. The mean price of wines depicting birds was higher than the price of wines depicting mammals, but price was highly variable, and this difference was not statistically significant ($t = 1.46$, df = 59, $P = 0.15$).

As hypothesized, among the labels that depicted animals, certain types of animals were disproportionately common. Among the augmented sample of labels depicting animals ($n = 296$ labels), 45% depicted birds, and 37% depicted mammals; other animal types were comparatively rare but included invertebrates (e.g., oysters, crabs), insects (e.g., bees, wasps, dragonflies, butterflies, ladybugs), fish (e.g., salmon), reptiles (e.g., snakes, a chameleon), and amphibians (e.g., frogs [see Figure 2]). The proportion of animal types (collapsed to birds, mammals, other vertebrates, and all invertebrates for analysis) did not vary by region of origin ($\chi^2 = 13.14$, df = 12, $P = 0.36$) or by wine color ($\chi^2 = 3.93$, df = 6, $P = 0.69$). Of the birds and mammals that could be determined to be domesticated or wild (i.e., omitting mythical or unidentifiable birds and mammals), over half (55%) of the depicted mammals were domesticated, whereas the vast majority of depicted birds were wild (84%); this difference was highly significant ($\chi^2 = 37.42$, df = 2, $P < 0.01$). Among mammals, the most commonly depicted species were horses (28%), domestic dogs (8%), bears (8%), pigs (6%), and lions (6%). Other depicted mammals were highly varied (e.g., alpaca, beaver, elephant, rhinoceros, zebra, etc.) but were rare; each was depicted on ≤ 3 labels.



Note: The portion of birds and mammals that were domestic is indicated with stippling.

Figure 2. Frequency of Types of Animals among a Sample of 296 Wine Labels Depicting Animals

For wine labels that depicted birds, some Orders or Families were overrepresented. Of the 22 Orders of birds commonly occurring in the United States, only 10 were depicted in our sample of wine labels with animals (see Table 4). Songbirds (Passeriformes, 28% of bird depictions), waterfowl (Anseriformes, 18%), and hawks and eagles (Accipitriformes, 18%) were the most commonly depicted. After restricting the available pool of species to these 10 Orders, some Orders were strongly overrepresented relative to their number of species commonly occurring in the United States ($\chi^2 = 65.7$, df = 9, $P < 0.01$). Specifically, hawks and eagles (Accipitriformes), waterfowl (Anseriformes), and owls (Strigiformes) were overrepresented on wine labels, whereas songbirds (Passeriformes) were underrepresented (i.e., 28% of bird depictions were songbirds, but songbirds comprise 64% of species commonly occurring in the United States). However, within the songbirds, the crow family (Corvidae) was strongly overrepresented, with 60% of all songbirds depicted on wine labels being corvids, whereas corvid species comprise only 6% of all songbird species commonly occurring in the United States.

Table 4. Number Of Wine Labels Depicting Wild Birds Disaggregated by Order, with the Number of Bird Species of Each of these Orders Commonly Occurring in the United States

Bird Order	# Labels (%)	# Species Commonly Occurring in the United States (%)
Accipitriformes (hawk, eagles, kites)	13 (18%)	21 (5%)
Anseriformes (waterfowl)	13 (18%)	45 (10%)
Caprimulgiformes (hummingbirds, swifts)	4 (5%)	23 (5%)
Coraciiformes (kingfishers)	1 (1%)	1 (< 1%)
Falconiformes (falcons)	2 (3%)	7 (2%)
Galliformes (grouse, pheasant, quail)	7 (9%)	23 (5%)
Gaviiformes (loons)	2 (3%)	3 (1%)
Passeriformes (songbirds)	21 (28%)	281 (64%)
Pelecaniformes (pelicans, egrets, herons)	3 (4%)	18 (4%)
Strigiformes (owls)	8 (11%)	16 (4%)
Total	74	438

In addition, for wine labels that depicted birds, popular and large species appear to be preferred. A total of 25 identifiable bird species from the United States were depicted on 44 wine labels (see Table 5). The average popularity score of these species was significantly higher than 0 (0.71 ± 0.16; $t = 4.92$, df = 24, $P < 0.01$), indicating a strong preference for depicting popular species on wine labels in our sample. Similarly, the average body mass of depicted species was significantly higher than the average of all birds in the United States (976 ± 264 vs. 96 ± 1.1 g; $t = 3.59$, df = 24, $P < 0.01$), indicating a strong preference for depicting large species on wine labels in our sample.

Table 5. Birds Species on Wine Labels and Their Popularity and Body Mass

Species	# Labels	Popularity Score	Body Mass (g)
American crow	2	-0.13	447
American kestrel	1	0.41	115
Anna's hummingbird	1	-0.27	4
American robin	1	1.12	79
Bald eagle	5	1.9	4,677
Barn owl	5	1.84	407
Belted kingfisher	1	-0.06	170
Black-billed magpie	2	-0.2	219
California quail	1	0.91	186
Canvasback	1	0.87	1,202
Chipping sparrow	2	-0.13	12
Common goldeneye	2	-0.35	912

Table 5 (cont.)

Species	# Labels	Popularity Score	Body Mass (g)
Common loon	2	0.41	5,012
Common merganser	1	-0.06	1,445
Common raven	3	1.73	933
Great blue heron	2	1.01	2,512
Mallard	1	1.41	851
Northern pintail	3	0.96	955
Osprey	1	1.55	1,660
Peregrine falcon	1	1.65	759
Red-tailed hawk	2	1.13	1,096
Red-winged blackbird	1	0.5	51
Spotted owl	1	1.79	589
Steller's jay	1	0.28	129
Violet-green swallow	1	-0.51	14
Mean ± 1 SE		0.71 ± 0.16	977 ± 264

Note: Tables only includes identifiable bird from the United States; popularity score is from Scheutz and Johnston (2019)

Most birds were depicted realistically (48%) or were generalized (28%), with fewer depicted abstractly (15%) or as silhouettes (10%). Birds that were depicted realistically or generalized were far more likely to be identifiable to Family (97% and 75%, respectively) than were silhouetted or abstractly depicted birds (53% and 36%, respectively; $\chi^2 = 36.66$, df = 3, $P < 0.01$). Overall, 37% of the 136 labels depicting birds included textual reference to the bird (e.g., in the wine's name or on the back of the label). Labels with realistically depicted birds were also far more likely to also include textual mention of the bird (54%) than were labels with birds depicted as generalized (30%), silhouetted (20%), or as abstractions (14%, $\chi^2 = 15.41$, df = 3, $P < 0.01$). Neither the popularity score nor the size (mass) of species differed among labels that did or did not include textual reference ($t = 0.90$ df = 23, $P = 0.37$; $t = 0.87$ df = 23, $P = 0.39$, respectively). Of those labels that included textual acknowledgment of the bird depicted ($n = 50$), 52% only referenced the bird in the name of the wine (see Figure 3). Other textual mentions of depicted birds ranged in the detail to which they referenced birds, from a nursery rhyme vaguely connected to the species (e.g., Mirth Chardonnay), to brief mention of a local native species (e.g., Lava Cap Zinfandel), to acknowledgement of the bird's presence on the vineyard and possible pest control (e.g., Z. Alexander Brown Pinot Noir), to more detailed natural history, environmental protection, and even acknowledgment of a share of profits donated to conservation funding (e.g., Mohua Sauvignon Blanc [see Figure 3 for examples]).

Contrary to our hypothesis, birds on wine labels appeared to be used most often as aesthetic icons rather than to explicitly communicate environmental values. Overall, we estimated that 89.7% of wine labels depicting birds did so with simple iconography, as evidenced by labels that made no textual mention of the birds depicted, or did so only in name and without reference to environmental value. Only 10.3% of wine labels depicted birds and made textual reference to their

ecology, environmentally friendly practices, sustainability, biodiversity conservation, or other indicator of environmental value.

Note: Species of hawks and eagles (i), waterfowl (a, g), owls (b, c), and the crow family (f) were all overrepresented relative to their taxonomic distribution in the United States. Depictions varied from simple iconography (a, b, c) to labels that included text (usually on the back label) about environmental values relevant to birds or other forms of biodiversity (d-i). The backs of two such labels that donate a portion of profits for conservation are shown (e, h).

Figure 3. Example Wine Labels Depicting Birds

Discussion

Our study found that animals are commonly depicted on wine labels available to consumers in the United States. Overall, 17% of the bottles surveyed had labels depicting animals, with birds and mammals being by far the most frequent. About half of all mammals depicted were domestic animals, such as horses, dogs, pigs, and sheep. Though these wine labels rarely made textual reference to these animals, their depiction may be intended to evoke images of rural landscapes and bucolic sentiments. In contrast, most birds depicted were wild species (see Figure 2). It is likely that these labels are intended to connect with consumers' interest in birds in some capacity, as the bird species depicted were on average much more popular and larger than the average bird species in the United States. Indeed, the two most commonly depicted bird species in our sample, Bald Eagle (*Haliaeetus leucocephalus*) and Barn Owl (*Tyto alba*), are the fourth and seventh most popular bird species in the United States according to Google search records (Schuetz and Johnston, 2019).

Certain bird types were disproportionately common on wine labels, especially hawks and eagles, waterfowl (mainly ducks), owls, and one particular family of songbirds, Corvidae, which is composed of crows, ravens, and jays. These species all possess attributes and characteristics admired and favored by people, such as power and fierceness (hawks), national symbology (eagle), beauty and relation to hunting (waterfowl), human-like faces and association with mystery and mythology (owls), and intelligence and curiosity (corvids) (Plous, 1993; Clucas et al., 2008; Zmihorski et al., 2013; Roberge, 2014). Confirming whether these patterns reflect the preferences of winemakers and their label design teams, or whether they are intended specifically to draw on consumers' interests awaits future study. Regardless, most depictions of birds were iconographic, as only 37% of labels with birds mentioned them in label text, and just over half of those did so in the name of the wine only. We observed that only 10% of wine labels with birds also included text explicitly linking bird imagery to ecology, environmental values, or sustainable practices.

This study did not examine consumer behavior, so future research should examine how consumers perceive wine labels depicting birds and other animals. In particular, it will be informative to examine the extent to which consumers respond to simple iconography versus imagery that is implicitly or explicitly used to index or symbolize a wine producer's environmental values, a point we return to below. Nonetheless, our results complement recent research on consumers' preferences in wine labels, which suggest that departures from traditional imagery (e.g., chateaus and vines) can be favored by some consumers. For example, in a study of wine consumers in central California, Wolf and Thomas (2007) found that label characteristics achieving the highest desirability rating included eye-catching, unique, stylish, creative, colorful, elegant, and artistic. In a study of online wine customers, Pelet et al. (2020) found that label characteristics associated with "authenticity" were favored, including heraldic colors and low visual complexity. In an analysis of South African wine consumers, Tonder and Mulder (2020) found that preferred label descriptors included uncluttered, minimalistic, and unpretentious, whereas designs that were too formal or traditional were less preferred. These findings suggest preferences that could be realized with animal depictions, and future work should examine consumer preference in relation to the meanings perceived by wine customers. Celhay and Remaud (2018) confirmed that a semiotic

analysis of wine labels can be a reliable tool for managers to design labels according to the brand's meanings they seek to communicate to their customers, but a full semiotic analysis of animal depictions on wine labels has not yet been conducted.

Several lines of evidence coalesce to suggest a potential for wine producers to reach consumers interested in animals. First, many Americans identify favorably with animals, and in particular, birds. The U.S. Department of Interior estimated that 40% of the U.S. population over the age of 16 —more than 100 million people—participated in wildlife-related activities in 2016, such as hunting, fishing, and wildlife-watching (USDI, 2018). Birdwatching is especially popular, with 45.1 million birdwatchers in the United States (aged 16 years or older), roughly 18% of the US population (USDI, 2018). Furthermore, a staggering 57 million people participate in feeding wild birds in their yards. Once considered a hobby of mainly older white people, the birdwatching population is rapidly diversifying and becoming younger, with urban Millennials being the fastest growing sector in the birdwatching community (Green, 2018; Kane, 2018). Moreover, birdwatching has experienced a spike in interest since the start of the COVID-19 pandemic, which could persist even after public safety has improved (Glusac, 2020).

Second, wine consumption is increasing sharply in the United States among Millennials and other younger consumers, who often look to wine labels to make their purchasing decisions (Thach and Olsen, 2006; Williams, 2018). Attracting these consumers is especially important to the wine industry as consumption declines from the aging Baby Boomer generation upon which the US wine industry formerly relied. Millennials were quick to adopt wine as a favorite beverage, and this generation is part of the reason for the increased popularity of wine in the early 2000s (Castellini and Samoggia, 2018; LaTour, Joy, and Noujeim, 2020). The emotional and sensorial characteristics of Millennials' values and consumptive behaviors should inform wine label design (Wolf, Carpenter, and Qenani-Petrela, 2005; Iazzi et al., 2020). Though not all are of legal wine-drinking age yet, Gen Z consumers also show a high degree of eco-consciousness in their food choices (Su et al., 2019). Thach (2005) reported that younger wine consumers respond more favorably to unconventional and fun labels with bright and unique color schemes than to old world stylings and imagery, such as chateaus and elaborately scripted fonts. Wolf and Thomas (2007) found that wine labels with animals were rated more highly desirable by younger generations than by Baby Boomers. Though not a proper study of wine labels, Franson (2006) also noted shifts in label designs aimed at younger consumers. This included an apparent rise in the depiction of animals on wine labels, especially for non-European wines, an anecdote confirmed in our study by a significantly lower rate of animal depiction on European wines than on wines from other regions. Though it may be coincidence, it is worth noting that based on sales reported by the Beverage Information & Insights Group (Swartz 2020), several of the fastest-growing wine brands in the United States in 2019 depicted animals on their labels, including Winking Owl (generalized owl), Meiomi (silhouetted bear), Duckhorn (realistic Mallard), Decoy (realistic North Pintail [duck]), Starborough (generalized starfish), and Z. Alexander Brown (realistic Barn Owl).

Third, Millennials' interest in social and environmental responsibility is widely recognized to manifest in demand for sustainably produced food products (Smith and Brower, 2012; Grunert et al., 2014), including wine (Barber, Taylor, and Strick, 2009; Forbes et al., 2009; Pomarici and

Vecchio, 2014; Pomarici, Amato, and Vecchio, 2016; Sogari, Mora, and Menozzi, 2016), and that communicating environmentally friendly production practices to these consumers could command higher premiums (Schmit, Rickard, and Taber, 2013; Kelley et al., 2015). Combining this point with the two previous lines of evidence—the popularity of birds and other animals among young Americans and the recent rise in wine consumption by Millennials responsive to innovative wine labels—suggests animal depictions on wine labels could be attractive to younger wine consumers. However, wine producers should recognize consumers' interests not just in animal images and iconography, but in agricultural practices that actually favor biodiversity. Indeed, using choice experiments with Italian wine consumers, Mazzocchi, Ruggeri, and Corsi (2019) and Ruggeri, Mazzocchi, and Corsi (2020) recently found that consumers are willing to pay a higher price for biodiversity-friendly wines. Animal imagery on front labels and text on back labels should complement one another to communicate environmental meaning to consumers. Rocchi and Stefani (2005) confirmed that the role of the front label is as an evocative agent, while the back label primarily provides more technical information to interested customers. Jaud and Melynk (2020) showed that wine labels combining text with matching images outperform text-only labels and labels where images and text do not match. Yet results from our study suggest wine makers are only rarely connecting animal imagery on labels to agricultural or production practices that could benefit biodiversity, which is clearly important for some consumers. For example, among 136 wine labels depicting birds, only 10% included text about environmental values relevant to birds or other forms of biodiversity (see Figure 3 for examples). Interestingly, some animal labels in our study related to both the management of pests and to biodiversity conservation, as labels mentioned the use of artificial nest boxes or perches to attract owls and other raptors depicted on the label (e.g., Owl Post), which is an area of active ecological research (Johnson et al., 2018; St. George and Johnson, 2021).

Conclusion

We found that animals were depicted on 16.7% of wine labels overall, with birds and mammals being the most commonly depicted animals. As predicted, the depiction of animals was less common on wine labels from Europe than other regions, likely because many European wines use traditional imagery, such as chateaus and heraldic images and fonts, to attract consumers valuing a winery's heritage. Certain types of birds, especially hawks, eagles, owls, ducks, and birds in the crow family, were especially common. We also found that only 10% of wine labels with birds also included text explicitly linking bird imagery to ecology, environmental values, or sustainable practices. We suggest that animal depictions on wine labels could be a powerful way to communicate environmental values attractive to consumers, especially younger wine drinkers, but that wine makers should do more than use birds as simple icons.

Our work did not examine consumer behavior, so future research should examine how consumers perceive wine labels depicting birds and other animals. In particular, new research should investigate the relationship between animal depictions, eco-labels, and consumer preference. A full semiotic analysis of animal depictions on front wine labels could anticipate most of the idea associations that they are likely to produce in consumers' minds (*sensu* Celay and Remaud, 2018), and surveys to assess consumers' environmental value orientations (*sensu* Fulton, Manfredo, and

Lipscomb, 1996) could be combined with consumer choice experiments to ascertain whether consumers' interest in biodiversity can be marshaled to affect product selection. Our survey methods did not include distinguishing wines that were organic or other certifications (e.g., Fish Friendly Farms), although anecdotally relatively few of the wines we surveyed visually displayed any certification on the front label. Studying the success of eco-labeling of other luxury products, such as coffee and cocoa, may provide some insights relevant for wine consumers (Tscharntke et al., 2014; Rice, 2015; van Loo et al., 2015; Gatti et al., 2022). Certifications used on coffee and cocoa that focus specifically on biodiversity, such as Bird Friendly (Smithsonian, 2020), may be appropriate for wine, given the high rate of wildlife on labels illustrated in this study and the high levels of biodiversity in Mediterranean regions where wine is grown (Viers et al., 2013). However, consumer preference for eco-labels on wine remains somewhat unresolved (Di Vita et al., 2019), and it may be shifting with public awareness, cultural trends, and changing demographics. Research on eco-labels for wine should continue, and we recommend it also include examination of consumers' interest in biodiversity specifically, including their responses to animal imagery.

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CBD and THC: Who Buys It, and Why?

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Abstract

While the market for CBD and THC products is expanding, less is known about who uses the various cannabis-derived products, their reasons for use, and their product preferences. We surveyed 963 U.S. adults and used market segmentation based on self-reported consumption to understand demand. Results suggest that age, subjective knowledge, and regulatory preferences were associated with general cannabis usage, with gender also associated with THC use. We also detected differences in reasons for product use and product preferences amongst CBD and THC users. Thus, while the CBD and THC markets were similar in certain ways, some differences merit further exploration.

Keywords: cannabis, consumer preferences, CBD, THC

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Introduction

Cannabis markets, including hemp and marijuana, have dramatically transformed over the past decade. The 2014 Farm Bill (Public Law 113-79) allowed states and universities to develop pilot hemp programs for research purposes (Agricultural Act of 2014, 2014), while the 2018 Farm Bill legalized the production, distribution, and sale of hemp and its derivatives throughout the United States (Agricultural Improvement Act of 2018, 2018). Thus, hemp is an agricultural commodity grown for industrial and agri-food purposes. Marijuana, however, remains classified by the federal government as a Schedule I drug.[1] Despite this classification, 18 states and the District of Columbia have legalized marijuana for recreational purposes, and 37 states have legalized marijuana for medicinal purposes (National Conference of State Legislators, 2021).[2]

The primary distinction between industrial hemp and marijuana is the concentration of delta-9-tetrahydrocannabinol (THC), the psychoactive component of marijuana known to provide the user with a *high*, in the cannabis plant. Whereas legal marijuana products average 20% THC (Smart et al., 2017), industrial hemp cannot, by law, have more than 0.3% THC; otherwise, it is classified as marijuana (Establishment of a Domestic Hemp Production Program, 2021). Industrial hemp has several end uses, including textiles, paper, feed, and biofuel (Fortenbery and Bennett, 2004; Das et al., 2017; Mark et al., 2020), but one growing market surrounds its cannabidiol (CBD) content.

CBD is a non-psychoactive cannabinoid in cannabis touted for its perceived health benefits (Tran and Kavuluru, 2020; Moltke and Hindocha, 2021). Google searches for *Cannabidiol* or *CBD* increased by more than 500% after the passing of the 2018 Farm Bill (Leas et al., 2019; Hurd, 2020), and its blossoming popularity has led market analytics groups to forecast that the global CBD market will reach $47 billion in sales by 2028 (Vantage Market Research, 2022). CBD is derived from marijuana and hemp alike, but only CBD derived from hemp is currently legal at the federal level. Given the murky and evolving regulatory landscape of cannabis products (Malone and Gomez, 2019; Raszap Skorbiansky, Thornsbury, and Camp, 2021) coinciding with an increase in demand for cannabis-derived products, there is merit in understanding the demand for CBD and THC products alike (Ellison, 2021).

This study examined the characteristics of CBD and THC consumers and their reasons for consumption using survey data collected from an online panel of 963 U.S. households. We determined the demographics, characteristics, and policy preferences of cannabis and non-cannabis users by estimating a multinomial logistic regression model. Then, reasons for

[1] A Schedule I drug means that the product has no accepted medical value and has a high potential for abuse (U.S. Drug Enforcement Agency, n.d.).

[2] This statistic reflects recreational marijuana legalization at the time this manuscript was prepared. Given recent legislative attempts to reform marijuana policy at the federal level, it is likely that this statistic will become outdated. Indeed, on April 1, 2022, the House of Representatives passed legislation that would legalize marijuana at the federal level (Shabad, 2022). While it remains unknown whether the bill has enough support to become law, the legislation is evidence that the marijuana regulatory landscape is evolving drastically. For a complete overview of current state marijuana policies, the reader is directed to the National Cannabis Industry Association (2021) and the National Conference of State Legislators (2021).

cannabinoid use and general product preferences were explored by partitioning the sample based on self-reported CBD and THC use.

Given the current state of the cannabis industry, several recent studies have analyzed the economic potential and market demand for hemp (Kim and Mark, 2018; Mark and Will, 2019; Kolodinsky, Lacasse, and Gallagher, 2020; Mark et al., 2020; Kolodinsky and Lacasse, 2021), but research on consumer preference for marijuana remains limited. This study most closely resembles Kolodinsky and Lacasse (2021), who analyzed consumer knowledge and the use of hemp products in Vermont. Their findings suggest that knowledge of various hemp-derived products has increased over time and that demographics (e.g., age and income) factor into consumer familiarity and use of hemp products. Our work also builds on Bhamra et al. (2021), who explored consumer uses and perceptions of hemp and marijuana products, and Moltke and Hindocha (2021), who examined the socioeconomic identities of only CBD users.

We extend the literature by focusing on the two most prevalent cannabinoids in the marketplace: CBD and THC. Identifying characteristics associated with cannabis consumption and reasons for consumption have important implications for actors across the hemp supply chain. Hemp producers must consider tradeoffs between fiber, flower, and grain in their production system, and thus understanding market demand for CBD is critical (Sterns, 2019). Also, retailers and marketing firms are concerned about identifying target audiences, understanding which factors drive purchasing behavior, and recognizing consumer preferences for specific products. Lastly, while marijuana remains illegal at the federal level, marijuana legalization has been a significant source of tax revenue for states with legalized sales (Carnevale et al., 2017). Stakeholders and policy makers must understand who consumes cannabis-derived products and why, as more states, or potentially the federal government (Shabad, 2022), liberalize marijuana policies.

The remainder of the article is organized as follows. The Methods section describes our survey instrument and estimation procedures. The Results section presents our findings, and the Discussion and Conclusions section considers the implications of our findings and identifies future research opportunities in cannabis markets.

Methods

Survey Instrument

This study used an online survey distributed by Qualtrics to U.S. households to determine who used cannabis products and for what purposes. The survey instrument, available as Supplemental Material accompanying this manuscript, received IRB approval.

Respondents first reported their demographic information. Then, respondents were asked whether there is a difference between hemp and marijuana and whether there is a difference between CBD and THC as a measure of subjective cannabis knowledge. Respondents who indicated a difference were then asked to provide a written response to what they perceived as the primary difference.

Following the qualitative questioning, respondents were asked about their usage of CBD products. Those who reported using CBD products were then asked questions to better understand product demand, including reasons for CBD use, form(s) of CBD used, place of purchase, and whether CBD was used to replace a prescription or over-the-counter (OTC) drug. The same sequence of questioning was then repeated to examine THC usage.

Once respondents reported CBD and THC usage, they were asked about regulatory preferences for hemp and marijuana separately (i.e., Should hemp [marijuana] be legal or illegal?). The survey concluded with additional questions on household characteristics, political leanings, etc.

Multinominal Logit Regression Analysis

We hypothesized heterogeneity in demographics, attitudes, and policy preferences between cannabis and non-cannabis users. Additionally, as CBD from hemp is federally legal and included in many household products available at traditional retail outlets, we hypothesized that CBD consumers would likely be different from THC users.

To explore these hypotheses, respondents were grouped into one of four mutually exclusive categories based on self-reported CBD and THC usage. Respondents were categorized as consumers of: (i) both CBD and THC, (ii) THC-only, (iii) CBD-only, or (iv) neither CBD nor THC. A multinomial logistic regression model was estimated using the consumer categories as the dependent variable to determine the factors influencing CBD and/or THC usage. The probability that individual i is in category $k = \{CBD\ and\ THC, THC\ only, CBD\ only\}$ can be specified by:

$$\mathrm{P}(Y_i = k|\mathbf{x}) = \mathrm{G}(\alpha_k + \boldsymbol{\beta_k}\mathbf{Demographics_i} + \boldsymbol{\gamma_k}\mathbf{IndChar_i} + \boldsymbol{\delta_k}\mathbf{Knowledge_i} + \boldsymbol{\zeta_k}\mathbf{LegalStatus_i}),$$

where Y_i is individual i's self-reported use, $\mathrm{G}(\cdot)$ is the standard logistic function, and *neither CBD nor THC* served as the baseline category for estimation.

The independent variable vectors **Demographics**$_i$, **IndChar**$_i$, **Knowledge**$_i$, and **LegalStatus**$_i$ represent demographics, other individual characteristics, subjective cannabis knowledge, and state-level recreational marijuana policy, respectively. Parameters α_k, $\boldsymbol{\beta}_k$, $\boldsymbol{\gamma}_k$, $\boldsymbol{\delta}_k$, and $\boldsymbol{\zeta}_k$ are coefficients specific to category k.

Demographic characteristics included gender, age, income, education, and community type. Each was modeled using a binary indicator. Gender was a binary indicator taking value 1 if individual i is male; 0 otherwise. Age was represented by including 5 dummy variables (18–24; 25–34; 35–44; 45–54; and 55–64), with 65 or older serving as our baseline. Household income was modeled using four dummies ($0–$24,999; $25,000–$49,999; $50,000–$74,999; and $75,000–$99,999), where $100,000 or more served as our baseline. Education included 5 dummies (less than high school; high school; some college, no degree; and college degree), with advanced degrees serving as our baseline. Community type was divided into rural, suburban, and urban. Two indicators for urban and suburban communities were included, and rural served as our baseline.

Individual characteristics included binary response variables for whether the individual was the primary shopper, political affiliation, and preferences for hemp and marijuana legalization. The variable for primary shopper equaled 1 if individual *i* is the primary shopper in their household; 0 otherwise. Self-reported political affiliation took four levels (Democrat, Republican, Independent, and other), and thus 3 binary response variables are included in the regression analysis; Republican serves as our baseline. Also included are indicators for the individual's preference for hemp and marijuana legalization (=1 if the respondent supported the legalization of hemp/marijuana; 0 otherwise).

Next, individuals' subjective knowledge of cannabis was likely to correlate positively with cannabis consumption. Respondents who indicated that there was a difference between hemp and marijuana and/or CBD and THC were assumed to have a higher level of subjective knowledge than those who indicated there was no difference or that they were unsure. Subjective knowledge was modeled through two indicators. For hemp and marijuana, the variable evaluates at 1 if the respondent stated there was a difference between hemp and marijuana; 0 otherwise. This was also the case for CBD versus THC.

While subjective knowledge is an imperfect proxy for objective knowledge, we evaluated the qualitative responses to gauge respondent accuracy. Some respondents did not provide the correct distinction, but the most common responses did identify the central distinction between hemp and marijuana as well as between CBD and THC. Respondents commonly cited marijuana as a drug, attributed the "high" from the THC to marijuana, and mentioned the different end uses of the two products (e.g., rope and fiber for hemp). For CBD versus THC, respondents commonly referenced THC as the cannabinoid in marijuana, leading the user to experience a high. Thus, subjective knowledge was an imperfect measure but appeared to correlate well with objective knowledge. Nonetheless, we acknowledge and accept this limitation.

We also accounted for state-level recreational marijuana policy at the time of data collection by including the vector $\mathbf{LegalStatus_i}$. Recreational marijuana policy could take one of three mutually exclusive forms: legal, decriminalized, or illegal. At the time of data collection, 11 states and the District of Columbia had legalized recreational marijuana, 16 decriminalized recreational marijuana, and 23 considered it illegal. Thus, two indicator variables were included to control for the state where a respondent resided; 1 dummy for states where recreational marijuana was legal and another 1 dummy for states where marijuana was decriminalized (states with illegal recreational marijuana served as the baseline).

Results

Data were collected from 963 individuals from an online panel maintained by Qualtrics between December 3 and December 16, 2019.[3] The sample was composed of 312 (32%) self-reported

[3] In total, 1,050 individuals completed the survey, but only 963 respondents provided sufficient responses to perform analysis. Data were collected on time to complete the survey. Measured in total seconds, the average time to complete the survey was 1,051 seconds (17.5 minutes), and the standard deviation was 3,026 seconds (50 minutes). We removed responses from individuals who took longer than 1 standard deviation above the mean (i.e., 4,077

cannabis users (i.e., CBD and/or THC) and 651 individuals (68%) who self-reported as non-cannabis users. Cannabis users were further segmented into groups based on CBD and THC consumption. Of the 312 cannabis users, 147 respondents (47% of cannabis users) reported using both CBD and THC, 77 (25%) reported using THC only, and 88 (28%) reported using CBD only. Put differently, 224 (72% of cannabis users) reported using THC, and 235 (75% of cannabis users) reported consuming CBD.

Table 1 compares sample demographics with U.S. Census estimates. Several statistically significant differences were detected between the sample and U.S. Census estimates. Specifically, statistical differences were detected in sample age, education, and income relative to the U.S. population. For instance, the sample overrepresented individuals between the ages of 35–44 and 65 years or older, and the sample underrepresented individuals between 55–64. While there were larger statistically significant differences in education and income, these differences are common in online surveys (Dillman, Smyth, and Christian, 2009). Table 2 also shows the demographics of non-cannabis users and each of the three cannabis market segments: (i) CBD and THC users, (ii) CBD-only, and (iii) THC-only.

seconds, 68 minutes). This procedure removed 18 individuals, with a range of 4,217 seconds (70 minutes) to 84,867 seconds (23.6 hours). Additionally, we removed 69 individuals who did not self-report their CBD and/or THC use. Given the stigmas surrounding cannabis products in the United States (Reid, 2020), when we asked about CBD and THC use, we allowed respondents to state they were unsure, or they preferred not to answer. Here, 69 stated they were unsure or preferred not to answer for at least one of the two cannabinoid consumption questions. These observations were excluded from analysis, leaving us with a sample of 963 respondents.

Table 1. Demographics of Cannabis Consumers and Non-consumers by Proportion of Respondents

	% of Respondents					
			Cannabis Consumers			
Demographics	**U.S. Census**	**Sample [a]**	**Both CBD and THC**	**THC Only**	**CBD Only**	**Non-cannabis Users**
Gender						
Male	48.5	48.9	53.7	53.2	42.0	48.2
Female	51.5	50.8	46.3	44.2	58.0	51.6
Nonbinary or prefer not to say	---	0.3	0.0	2.6	0.0	0.2
Age						
18–24	12.6	11.7	19.7	13.0	14.8	9.4
25–34	17.8	16.9	26.5	28.6	18.2	13.2
35–44	16.4	19.6*	32.0	19.5	21.6	16.6
45–54	17.4	15.4	9.5	16.9	18.2	16.1
55–64	16.5	12.7*	6.1	10.4	8.0	15.2
65 or older	19.3	23.6*	6.1	11.7	19.3	29.5
Education						
Less than high school	12.7	3.4*	4.8	3.9	0.0	3.5
High school or GED	27.3	25.1	23.8	32.5	30.7	23.8
Some college, no degree	20.8	32.4*	32.0	35.1	38.6	31.3
Associate's or bachelor's degree	27.4	27.7	26.5	24.7	20.5	29.3
Graduate or professional degree	11.8	11.3	12.9	3.6	10.2	12.0
Income						
Less than 25,000	21.4	17.3*	15.0	22.1	12.5	18.0
25,000–49,999	22.5	21.0	22.5	23.4	20.5	20.4
50,000–74,999	17.7	22.2*	17.7	20.8	27.3	22.7
75,000–99,999	12.3	12.1	10.2	14.3	10.2	12.4
100,000 or more	26.2	27.4	34.7	19.5	28.6	26.4
Region						
Midwest	20.9	21.2	17.7	20.8	25.0	21.5
Northeast	17.3	18.2	7.5	24.7	20.5	19.5
South	38.0	39.2	43.5	31.2	37.5	39.3
West	23.8	21.5	31.3	23.4	17.0	19.7
N		963	147	77	88	651

Note: * denotes statistically significant differences between the sample and the U.S. Census estimates at the 5% level. In the survey and regression analysis, we have more granular data on age, education, income, and state, but we aggregate here to match Census categories used to set quotas in the survey. Note that several statistically significant differences exist between the Census estimates and our sample (n = 963)Cannabis consumers are individuals who self-report using either CBD products, THC products, or both CBD and THC products. Non-cannabis consumers are individuals who use neither CBD nor THC products.

Regression Analysis

Table 2 shows multinomial logistic regression results estimating THC and/or CBD usage as a function of demographics, individual characteristics, etc. Most strikingly, there was a generational divide between cannabis users and non-users. Users of both CBD and THC were more likely to be younger than non-cannabis users, with statistically significant differences detected at the 1% level for the three lowest age brackets. THC-only users are also more likely to be younger than non-cannabis users, with statistically significant differences at the 5% and 10% levels for the four youngest age brackets. The distinction in age is less apparent in the CBD-only group, suggesting hemp-derived CBD products appeal to a broader range of consumers.

Table 2. Estimated Coefficients from the Multinomial Logistic Regression Analysis

	Coef. (rbst. std. error)[a]					
Variable	**Both CBD and THC**		**THC Only**		**CBD Only**	
Male	0.622***	(0.237)	0.365	(0.283)	-0.045	(0.265)
Age						
18–24	2.573***	(0.501)	0.941*	(0.556)	0.762*	(0.459)
25–34	1.827***	(0.438)	1.161**	(0.465)	0.161	(0.405)
35–44	2.069***	(0.427)	0.862*	(0.490)	0.233	(0.413)
45–54	0.856*	(0.471)	0.879*	(0.508)	0.128	(0.412)
55–64	0.243	(0.531)	0.184	(0.545)	-0.537	(0.491)
65 or older						
Income						
$0–$25,000	-0.110	(0.365)	0.609	(0.448)	-0.389	(0.404)
$25,000–49,999	-0.114	(0.317)	0.499	(0.406)	-0.004	(0.375)
$50,000–74,999	-0.527*	(0.316)	0.118	(0.429)	-0.009	(0.342)
$75,000–100,000	-0.680*	(0.388)	0.434	(0.468)	-0.380	(0.447)
$100,000 or more						
Education						
Less than high school	0.495	(0.620)	1.104	(0.952)	-16.876***	(0.553)
High school	0.045	(0.444)	1.219*	(0.702)	0.490	(0.479)
Some college, no degree	-0.015	(0.421)	0.987	(0.672)	0.219	(0.452)
College degree	0.010	(0.412)	0.857	(0.678)	-0.099	(0.482)
Advanced degree						
Community						
Suburban	-0.242	(0.273)	0.301	(0.361)	-0.238	(0.307)
Urban	0.354	(0.301)	0.608	(0.414)	0.109	(0.366)
Rural						
Primary shopper	1.178***	(0.295)	0.279	(0.317)	0.951***	(0.326)
Political affiliation						
Democrat	0.506*	(0.274)	-0.100	(0.326)	-0.008	(0.315)
Independent	-0.055	(0.322)	-0.182	(0.354)	-0.246	(0.339)
Republican						

Table 2 (cont.)

Variable	Coef. (rbst. std. error)[a] Both CBD and THC		THC Only		CBD Only	
Policy preference						
Hemp should be legal	1.134	(0.806)	15.816***	(0.318)	0.520	(0.544)
Marijuana should be legal	1.837***	(0.697)	16.479***	(0.289)	0.689	(0.453)
Subjective knowledge						
Diff. hemp and marijuana	0.726**	(0.290)	0.406	(0.319)	0.332	(0.312)
Diff. between CBD and THC	1.715***	(0.331)	1.653***	(0.387)	1.857***	(0.354)
State marijuana policy						
Legal marijuana	1.018***	(0.269)	0.550*	(0.330)	-0.032	(0.321)
Decriminalized marijuana	0.195	(0.276)	0.403	(0.319)	0.164	(0.273)
Illegal						
Constant	-8.915***	(1.304)	-38.389***	(1.084)	-5.331***	(0.738)
N			963			
Log pseudolikelihood			-727.6			
AIC			1,621.3			
BIC			2,025.5			

Note: Single, double, and triple asterisks (*, **, ***) indicate statistical significance at the 10%, 5%, and 1% level.
The *Neither CBD nor THC* group serves as the reference group.

Relative to non-cannabis users, users of both CBD and THC were more likely to be males, whereas the result for gender was insignificant for the THC-only and CBD-only groups. The two groups containing CBD users were also more likely to be primary shoppers in the household (significant at the 1% level). Income and educational attainment had weak associations with cannabis use.

The type of community (suburban, urban, or rural) and political affiliation also had weak associations with cannabis use. The only statistically significant difference across these two categories was that self-reported Democrats were more likely to be users of both CBD and THC products. But the difference is only significant at the 10% level. The weak association of community type and self-reported political affiliation on THC usage provides further evidence that marijuana use is not as partisan as it may have been a decade ago. As expected, regulatory preferences and subjective knowledge (significant at the 1% level) were strongly associated with cannabis usage. That is, those in favor of marijuana legalization and those with greater subjective knowledge of cannabis were more likely to be THC users. Policy preferences were not significant with CBD-only consumers, though CBD-only consumers were more likely to know the difference between CBD and THC compared to non-cannabis users.

We also see the intuitive impact of the state's recreational marijuana policy on THC use. THC users were more likely to reside in states with legal recreational marijuana than in states with illegal recreational marijuana; no statistically significant differences were detected for decriminalized marijuana. Thus, having legal recreational marijuana in your state increased the probability of using THC, as is supported in the literature (Kerr et al., 2017; Cerdá et al., 2020). This finding is appealing as the legalization of recreational marijuana often establishes cannabis dispensaries,

which reduces barriers to market entry and lowers transaction costs of market participation. Thus, we should expect more self-reported THC consumers in states with legalized recreational marijuana. The state's recreational marijuana policy, however, was not strongly associated with the use of only CBD, possibly because hemp-derived CBD products are federally legal and widely available in common retail outlets.

Reasons for Cannabis Usage and Product Preferences

While the logistic regression analysis assessed the question, "Who uses CBD and THC?" it was also critical to address the question, "Why do they use CBD and THC?"

Cannabis consumers in the sample were segmented into one of three groups: (i) CBD and THC users, (ii) CBD-only, and (iii) THC-only. Individuals who reported only using CBD were expected to have considerably different preferences and reasons for usage than those who used both CBD and THC (or only THC). In other words, we hypothesized that those who purchased only hemp-derived products might have different reasons for cannabis use than those who use marijuana.

Reasons for CBD Use and CBD Product Preferences

Of the 235 respondents who reported using CBD products, 147 individuals self-reported using both CBD and THC, while the remaining 88 reported only using CBD. Table 3 presents statistics related to CBD consumption, including reasons for use, preferred form(s), etc.

Table 3. Comparing the Proportion of CBD Preferences and Habits by Consumer Category

	% of respondents			
Question	**All CBD Users**	**Both CBD and THC**	**CBD Only**	***p*-value [a]**
Why do you consume CBD? (Select all that apply.)				
Reduce stress or anxiety to help you relax	53.6	54.4	52.3	0.751
Help with joint pain	55.7	53.7	59.1	0.425
For fun or recreation	16.2	23.8	3.4	0.000
Better sleep	40.9	46.3	31.8	0.027
Other	7.2	4.8	11.4	0.087
What forms of CBD do you use? (Please choose all that apply.)				
Edible (CBD-infused food or drink)	42.1	50.3	28.4	0.001
Drop or spray	42.1	44.2	38.6	0.402
Vaping device	23.8	29.9	13.6	0.002
Topical rub or cream	30.6	26.5	37.5	0.086
Cigarette/smokable form	17.5	25.9	3.4	0.000
Pill or capsule	14.9	17.0	11.4	0.222
Other	3.8	2.0	6.8	0.107

Table 3 (cont.)

	% of respondents			
Question	**All CBD Users**	**Both CBD and THC**	**CBD Only**	***p*-value [a]**
Where do you purchase CBD? (Please choose all that apply.)		56.5		0.000
A cannabis dispensary	41.3		15.9	
A retail store	44.3	40.1	51.1	0.104
An online retailer	28.9	26.5	33.0	0.304
Other	8.5	6.8	11.4	0.255
Did you use CBD to replace a prescription or over-the-counter drug?				
Yes	39.1	45.6	28.4	0.008
N	**235**	**147**	**88**	**---**

[a] The p-value denotes the results of a 2-sided *t*-test assuming unequal variances between the "Both CBD and THC" group and the "CBD only" group.

The most common reason for CBD consumption was to *help with joint pain* (56%), followed by to *reduce stress or anxiety to help you relax* (54%), and *for better sleep* (41%). These results mostly align with the CBD marketing initiatives as well as recent literature (Bhamra et al., 2021; Moltke and Hindocha, 2021). CBD was seen as a substitute for prescription or OTC drugs by approximately 39% of CBD consumers.[4] This implies that nearly 10% of the sample had replaced a prescription or OTC drug with CBD.[5] The research on the medical effectiveness of cannabis has progressed rapidly, though it has thus far remained limited, and warnings regarding potential uses have been notable (Hutchison et al., 2019; Lachenmeier and Diel, 2019). Yet consumers across the country have embraced the potential for this cannabinoid (Maa and Figi, 2014). Importantly, consumers who substitute CBD (or THC) for a prescription or OTC drug may do so without their doctor's knowledge (Boehnke et al., 2021), creating additional concerns for disease or general health treatment.

Using a series of *t*-tests, we compare those who only use CBD and those who use both CBD and THC. Several statistically significant differences exist between these two groups. First, a significantly larger segment of both CBD and THC consumers reported using CBD *for fun or recreation* (24%) than CBD-only consumers (3%). This supports the hypothesis that individuals could derive both CBD and THC from marijuana, but it also demonstrates that some cannabis users do not differentiate between the two cannabinoids as CBD is non-intoxicating.

Pronounced differences also exist when examining product preferences. While CBD edibles (i.e., CBD-infused food or drink) were seen as the most common forms of CBD products amongst the entire group of CBD consumers, the share was much larger for those who use both cannabinoids (50%) compared to those only using CBD (28%). A much larger share of CBD and THC

[4] See McFadden and Malone (2021) for perceptions about the medical value of CBD and THC.

[5] Of the 235 individuals who reported using CBD, 92 stated they replaced a prescription or OTC drug with CBD. Thus, 93 of the 963 individuals (10%) in the sample had replaced a prescription or OTC drug with CBD. A similar calculation is used later with THC users.

consumers also used vaping devices (30%) and smokable flower (26%) compared to the CBD-only group. CBD oil drops or sprays (39%) and topical rubs (38%) were most popular among individuals that only use CBD.

Lastly, the two groups purchased CBD from different settings. Over half of the respondents who use both CBD and THC products reported purchasing their CBD from cannabis dispensaries—which are only in operation in states with legalized medicinal and/or recreational marijuana—versus just 16% for those that only used CBD. Those who only used CBD products were more likely to purchase CBD from a retail store (51%) or online retailer (33%).

Reasons for THC Use and THC Product Preferences

The sample consisted of 224 self-reporting THC consumers: 147 reported using both CBD and THC, and 77 reported using only THC. Table 4 presents stated reasons for THC consumption, product preferences, and purchasing habits, while Figure 1 juxtaposes the reasons for THC use with that for CBD use.

Table 4. Comparing the Proportion of THC Preferences and Habits by Consumer Category

	% of Respondents			
Question	**All THC Users**	**Both CBD and THC**	**THC Only**	***p*-value**
Why do you consume THC? (Select all that apply.)				
Reduce stress or anxiety to help you relax	66.5	67.4	64.9	0.720
Help with joint pain	42.9	43.5	41.6	0.777
For fun or recreation	52.2	49.0	58.4	0.179
Better sleep	56.3	58.5	52.0	0.353
Other	5.8	4.8	7.8	0.394
What forms of THC do you use? (Please choose all that apply.)				
Edible (THC-infused food or drink)	46.4	53.7	32.5	0.002
Drop or spray	18.8	23.8	9.1	0.003
Vaping device	43.3	46.9	36.4	0.127
Topical rub or cream	11.6	14.3	6.5	0.056
Cigarette/smokable form	66.5	62.6	74.0	0.077
Pill or capsule	9.4	11.6	5.2	0.084
Other	3.1	2.0	5.2	0.263
Where do you purchase THC? (Please choose all that apply.)				
A cannabis dispensary	58.9	64.6	48.1	0.019
A retail store	18.3	22.4	10.4	0.015
An online retailer	17.9	20.4	13.0	0.147
Other	24.6	15.6	41.6	0.000
Did you use THC to replace a prescription or over-the-counter drug?				
Yes	45.5	49.0	39.0	0.152
N	**224**	**147**	**77**	---

Note: The *p*-value denotes the results of a 2-sided *t*-test assuming unequal variances between the "Both CBD and THC" group and the "THC only" group.

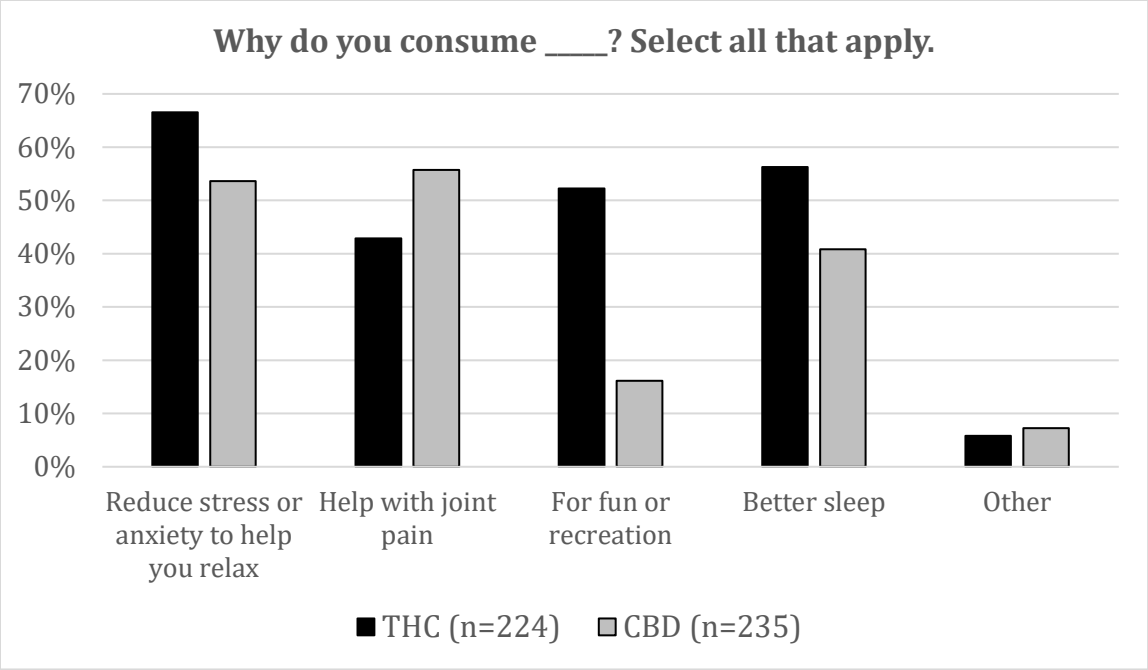

Figure 1. Reasons for CBD Use versus THC Use

The most common responses for why individuals consume THC were to *reduce stress or anxiety* (67%), followed by *better sleep* (56%), and *for fun or recreation* (52%). The majority of THC consumers stated that they purchased THC from a cannabis dispensary, but there was also evidence of shadow market engagement: 24% of respondents stated they purchased THC from outlets not listed in Table 5, with common write-in responses of "from friends" or "from a [shadow market] dealer."[6]

The federal classification of marijuana implies that the drug has no medical value. However, roughly 46% of THC consumers reported replacing a prescription or OTC drug with THC. This suggests that nearly 11% of the sample (n = 963) had replaced prescription or OTC drugs with THC, many of whom were likely self-prescribing (Boehnke et al., 2021).

Amongst the various forms of THC products, marijuana flower (cigarette/smokable form) was the most common form used (67% of consumers), followed by edibles (46%) and vaping devices (43%). Comparing THC consumer preferences with that of CBD consumers, there were clear distinctions between the two product offerings. THC products were most commonly smoked, whereas just 3% of CBD-only consumers reported using smokable CBD. Hemp-derived CBD products were most often consumed through CBD oil drops and topical creams.

[6] As many self-identifying THC users reside in states that do not have legal marijuana, we expected noisy estimates for place of purchase. The purpose of including the statistics here is to show that THC is commonly purchased through dispensaries but also through alternative markets.

Discussion and Conclusions

While cannabis policy has evolved dramatically over the past decade, research on cannabis-derived products has lagged. To provide insights on CBD and THC consumer demands, we surveyed 963 U.S. respondents, partitioned the sample into segments based on their self-reported cannabis usage, and compared consumer characteristics, reasons for consumption, and product preferences across groups.

Results show a clear generational divide between cannabis consumers and non-consumers, where cannabis users were, on average, younger than non-users. When examining the drivers of THC and CBD use, THC consumers were more likely to be younger males (who also use CBD) with higher subjective cannabis knowledge. They were also more likely to reside in states with legalized recreational marijuana. Of note, self-reported community type and political affiliation were not strongly associated with THC usage, providing further suggestive evidence that marijuana use has become increasingly bipartisan.

Gender was not strongly associated with CBD use, however, suggesting more females could be involved in hemp-derived CBD markets than in THC markets. Further, while younger consumers were more likely to self-report being CBD consumers, CBD products also appeal to older age groups (New Frontier Data, 2020). The summary statistics in Table 1 suggest that 19% of CBD-only consumers were over 65 years old. This suggests that while the youngest consumers were most likely to use CBD, older populations used these products; THC use in this age range was much lower. Thus, while there were similarities between CBD and THC consumers, there were also several differences.

These distinctions between the CBD and THC marketplace became more pronounced when exploring the reasons for use and consumers' product preferences. Alleviating joint pain was seen as the most effective use of CBD products, while THC consumers were more likely to report using THC products to reduce stress, improve sleep, and for recreational purposes. Exploring product preferences across groups, CBD consumers were more likely to report using CBD oil drops or sprays as well as topical rubs and creams sold in traditional retail outlets. THC consumers preferred smokable flower, edibles, and vaping devices sold in cannabis dispensaries (in states with legalized recreational marijuana).

Cannabis markets are on track to dramatically increase in volume over the next few decades, creating a need for the academic literature to understand the differences in how consumers approach purchasing decisions. This article emphasizes notable heterogeneity in cannabis consumption, which will likely influence the growth trends in those markets. Indeed, these differences in CBD and THC groups have important implications across the hemp and marijuana supply chains. On the farm, hemp producers make tradeoffs in their production system regarding whether to grow hemp for fiber, flower, and grain. Along with growing region, soil type, and other environmental factors, this decision depends on market expectations. Understanding the market demand for CBD (i.e., flower) is thus an important aspect of the agricultural production system. At the retailer level, from a marketing perspective, it is critical to identify end users and develop

marketing strategies to attract these consumers to new and existing CBD products. This is also true in the THC marketplace, where a murky and constantly evolving regulatory landscape exists. In identifying the primary reasons for CBD and THC use, we also show the similarities and differences between these two marketplaces. This distinction is critical as we work to understand the evolution of these marketplaces and increase consumer knowledge of the differences between the two cannabinoids.

This study is not without limitations. Primarily, respondents self-identified as CBD and/or THC consumers. As stigmas still surround cannabis products, the sample could exhibit social desirability bias (Grimm, 2010; Reid, 2020), and respondents may have had concerns over anonymity or self-incrimination. To mitigate the presence of social desirability bias, respondents could state that they "prefer not to answer" the questions on CBD and THC consumption. Individuals who responded this way were excluded from the analysis. However, it is possible that some cannabis users instead stated that they did not use CBD or THC, in which case they would be placed in our group of non-users.[7]

The second limitation is that respondents were not asked about their frequency of cannabis use, meaning we could not distinguish heavy consumers from infrequent consumers. Future research should consider the frequency of use as frequent cannabis users constitute a significant percentage of annual revenue and thus shape the market. For example, Light et al. (2014) suggest that the top 22% of marijuana consumers in Colorado make up over two-thirds of demand in the state. Attention must be given to the frequency of use and comparing demographic differences between infrequent and heavy users.

The current literature on cannabis demand is thin, leaving several avenues for future research. This includes work on the health benefits and consequences of cannabis consumption, additional marketing research on consumer use and preferences for CBD and THC products over time, and the regulatory landscape surrounding CBD- and THC-infused products and cannabis businesses (Flint and Shelton, 2019; Owens-Ott, 2020). This research is pertinent as hemp and marijuana markets have continued to grow since data collection, which suggests that consumer knowledge and use are also expanding.[8] As cannabis regulations continue to evolve, we can expect this trend to continue.

[7] There are two types of hemp-derived CBD products in the marketplace. Broad-spectrum CBD products, which have 0.0% THC, and full-spectrum CBD products, which may contain up to 0.3% THC. If an individual self-reports as a CBD-only user but uses full-spectrum products, one could argue that they are also a THC consumer. However, given that there are no euphoric effects from trace amounts of THC, we do not expect full-spectrum users to classify themselves as a THC user.

[8] While our data were collected in 2019, we believe results about CBD and THC usage and for usage are relevant for several reasons. First, with respect to CBD usage, our data were collected after the 2018 Farm Bill went into effect, so hemp products were widely available in the marketplace. While product knowledge likely increased over time amongst the general population, we capture early CBD-adopters in our data, which may correlate well with frequency of use. Additionally, legalization of recreational marijuana has occurred in relatively more liberal states; this is particularly true for the earliest adopters (e.g., Washington, Colorado, California). Further, ballot initiatives were the mechanism of deregulation in multiple states, meaning more than half of the voting population approved the measure. Therefore, we can assume a strong correlation between THC usage and the state's recreational

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marijuana policy given that individuals residing in states with recreational marijuana have more access to THC products. We can then expect the earliest adopting states to be the states that have the largest share of self-identifying THC users. If so, then this implies that the states that have not yet legalized recreational marijuana (or legalized recreational marijuana after data collection) have smaller shares of their population using THC products. With this, despite using data from 2019, we feel that our results still have tremendous relevance to the cannabis marketing literature and provide a baseline for future studies at the very least.

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