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Organic Produce Retail Premiums Vary Across Regions and by Attributes

Jebaraj Asirvatham[1, *], Katie Bell[2]

[1]Agribusiness Economics, Southern Illinois University, Carbondale, USA

[2]University of Illinois Extension, Murphysboro, USA

Email address:
jebaraj@siu.edu (J. Asirvatham)

[*]Corresponding author

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Abstract: Organic fruits and vegetables are becoming more popular due to the perceived benefits to consumers' health and its potential environmental benefits, such as soil health and quality. Market expansion, however, does not necessarily imply higher profits. Organic premiums, the additional amount over conventionally grown produce, have varied across products, attributes, and over time. This study analyses retail premium of organic over conventional production using USDA's Agricultural Marketing Service (AMS) data on specialty crops. Four important crops with large markets are studied here, namely apples, cucumber, strawberries, and tomatoes. Price premiums statistically differ by variety, seasons, regions, and unit of sale (or package). Cucumbers, on average, fetch high premiums in the mainland, for example. The heteroskedastic-consistent regression estimates reveal conditional average differences by various aspects. Regional differences play a large role. For example, apples and tomatoes fetch the highest premium in the Southwest region. Seasonal influences were not the same across products. Apples had lower premiums off-season, whereas strawberries generally had higher premiums during off-season. There is some evidence of second degree price discrimination in apples and strawberries. The upshot is that, in any region, organic producers could earn larger premium by choosing the right variety in the right season sold in the right package.

Keywords: Organic Premiums, Organic Retail, Regional Economics, Sustainability, Fruits and Vegetables Prices, Organic Market

1. Introduction

There is a growing concern among consumers about their food - where does it come from, and how is it grown [1]? As consumers become more conscientious about how their food is produced, we see a greater demand for organically produced crops. Since 2002, when the United States Department of Agriculture (USDA) began to regulate organic labeling, the organic food sector has been steadily growing [2]. The retail sale of organic products has increased considerably over the years. According to the Economic Research Service (ERS), total organic product sales has grown from 3.6 million dollars in 1997 to 3.2 billion dollars in 2008, and further to nearly six times increase in 11 years, to 10 billion dollars' worth of sales in 2019 (NASS. USDA. gov). Organic products are becoming commonplace on grocery store shelves, and stores are developing private organic brands [3]. A surge in demand has caused the price of organic over conventional produce to increase significantly and has resulted in an increase in imports and certified organic acreage in the US [4].

Consumers have been leaning toward a *less is more* approach when it comes to purchasing food. They are looking for products that have as few synthetic ingredients as possible. This especially applies to specialty crops that are often eaten with little or no preparation like apples, strawberries, and lettuce. The term organic has become widely associated with a higher quality of food product, and consumers are willing to pay a premium for USDA certified and organic labeled products. National Organic Program (NOP) defines organic as a labeling term used to describe agricultural products that meet specific standards of being produced in ecologically friendly ways that promote

environmental health and biodiversity. A key requirement is that products or produce should be free of synthetic fertilizers, irradiation, sewage sludge, and genetic modification [22].

During 2004-2010, organic premium for fresh produce was, on average, as high as 60%. Consumers' willingness to pay a premium for organic products suggests (or implies) opportunities for growers and retailers who are interested in expanding production, broadening their market, or using organic farming practices. A survey study on consumers in the mid-Atlantic region, for example, estimated that 38% of the consumers were willing to pay 11%-20% premiums for organic produce [5]. Most studies, thus far, have focused on retail price premiums of organic produce/products other than specialty crops, and on factors pertaining to price premiums other than being organic.

Employing a hedonic price model on Nielsen's retail data, Jaenicke and Carlson identified a number of product and consumer characteristics that contribute towards organic price premium [2]. They also found that organic premiums fluctuated over the period 2004-2010, that is, premiums for most products did not consistently either increase or decrease. The price premium for organic products is expected to naturally differ across the United States, depending on demand and supply factors. These factors include income, tastes and preferences of the consumers, and production costs and availability in a region.

Previous studies have examined premium differences between crops at terminal and shipping ports; however, most studies have not directly compared the organic premium difference between distinct geographical regions for the crops focused here. Past studies have looked into the factors that contribute to organic price premiums from the consumer, retail, and producer angle on organic price premiums of products, including dairy, meat, eggs, and specialty crops. Location is an important factor to consider when assessing the nature of the price premiums and the selection of areas for data collection. Jaenicke and Carlson's study uses Nielsen's data to analyze bagged carrots, canned soup, coffee and milk [2]. In contrast, we focus only on four most popular fresh produce and use panel data analytical tool for estimation.

This study focuses on four commonly consumed and popular specialty crops, namely apples, strawberry, tomato and cucumber. Fresh produce is also more relevant to local farming. Our main objective is to assess regional variation by considering the regions of production. Crops grown in US are spread over regions rather than states. Regions with comparative advantage may have higher premiums. Beside the main objective, this study is unique in several ways. Firstly, we create a longitudinal data, more commonly known as pseudo-panel data, by using information on region, variety, and unit size. This allows us to control for characteristics that are time invariant across regions, variety and unit size. Secondly, on-season and off-season price movements are examined by including seasonal variables in the models that was created using month info. Thirdly, we include year info in two different econometric specifications to tease out annual trends and to estimate year-specific retail price variations. The latter is accomplished by estimating a year fixed-effects model. Panel data methods address correlation among observations from the same region, variety and package. A similar study done by Jaenicke and Carlson examined soup, coffee, milk and bagged carrots, and they did not distinguish variety [2].

Knowing which region has the greatest price premium would be valuable to organic specialty crop growers and purchasers of organic products. Growers who are planning to expand their organic operations or begin growing organics may choose to locate in regions with higher organic price premiums. Retailers with a broader knowledge of regional markets could negotiate better prices considering associated costs, such as transportation costs of purchasing from other regions. While retail consumers cannot feasibly travel to regions that offer the lowest premiums, this information may help them to be more informed about what varieties and packaging sizes have higher premiums. Because market price is an equilibrium outcome of supply and demand forces, the premium differences across the regions may also offer insight into how consumers value organic specialty crops over conventional crops in the marketplace.

2. Organic Premiums: Producers' Perspective

Organic price premiums are based in general on the amount of extra effort that is put into producing certified organic crops. Organic premiums could be attributed to organics being more labor-intensive, employing alternative costly pest prevention practices, and the stringent certification requirements [2, 6]. Premium could vary greatly depending on the type of crop and the steps involved in organic production. Most premium price fluctuations occurred in fresh fruits and vegetables [2]. Seasonality of the crop impacted the premium so that greater seasonal variability had larger premiums [6].

Several studies examined challenges organic farmers face when deciding to produce organically. A survey of 116 Tennessee farmers, conducted by Liyanage and Bhavsar, found that those currently using organic methods faced higher costs of production, certification, and labor [7]. Pest incidence was among the biggest challenges in production. Additionally, non-organic farmers who were considering adopting organic practices were most concerned about similar issues as well as the labor-intensive nature of producing organic specialty crops. Size and years of experience could also play some role in the relatively higher costs of organics. Most organic farmers had relatively smaller farms (under 50 acres) and the majority owned their own farm. A large percentage of farmers had 5 years or less of experience in organic production.

In a meta study looking at 362 published articles, Ponti, Rijk and Ittersum found organic yields were on average 80% of conventional crops but with substantial variation of about

one-fourth of the yield gap, i.e., 21% standard deviation [8]. Liyanage and Bhavsar's study found that the input costs and labor intensity is greater when producing organically [7]. Cost of producing organically is higher in the United States as well. Overall, organic farmers show a greater variability in inputs used and face varied input costs [9].

Organic markets are relatively slow to respond to market shocks or policy changes. In particular, changes in the cost of production take time to be transmitted to consumers. A price transmission study of carrots, for example, found that the rate of price adjustment was slower for organic carrots compared to conventional ones in both retail and terminal markets [10]. Inefficient price adjustments of organic produce could have significant impacts on producer decisions concerning joining the organic market. Slower price transmission in the organic market also raises the risk of producers as weather pattern changes across the globe. Ro and Frechette, for example, found that organic premiums had some correlation with variation in temperature and heat index when weather patterns affected a crop's normal growing conditions [11].

Most organic farms are either small- or medium-sized that could affect market opportunities for organic produce. There is some evidence of this in Michigan and in Tennessee [1, 7]. Small and midsized operations may also have difficulty forming business relationships with a wholesale distributor or large retailer. Martinez, Conner, Bingen, and Reardon suggest that decreases in organic prices are leading to more interest in organic produce by processers and other bulk purchasers of fruits and vegetables [12]. A survey of organic produce traders, which included all market participants except consumers and producers, indicated their interest in working closely with organic farmers to supply produce to retail and food service outlets [12]. Such growing interest reveals opportunities for the small and midsized farms who wish to work with large retailers and wholesale buyers.

While organic farmers do incur higher production expenses compared to their conventional counterparts, Serra, Zilberman, and Gil caution that exact comparisons should not be made because the quantity and quality of the inputs vary between the two production methods and therefore are not interchangeable [13].

3. Organic Premiums: Consumers' Perspective

Organic retail sales increased from $3.2 billion in 2008 to $10 billion in 2019 [3]. This six-fold increase in just over a decade indicates substantial growth in the market for organic products. Food and beverage sales from grocery and specialty stores during that same period increased by less than half times. Over the last decade, the demand for organic products grew considerably each year. Much of the research conducted thus far examines the problem from the perspective of retail consumer demand as suggested by Smith, Lin, and Huang [6]. Their study, based on Neilson Homescan data, focuses on other components that might contribute towards the premium, such as product attributes and consumer characteristics. In that study, consumers with higher income and younger than 40 years old paid higher premiums on produce, and those who had at least some college education paid more for organic vegetables.

A study of consumers in the mid-Atlantic region of the US found that those with incomes of $100,000 or more and have Graduate or advanced degrees were willing to pay higher premiums for organic produce [5]. Consumers who value quality and taste are willing to pay higher premiums for organic produce [14–17].

Consumers, who have health concerns about pesticides, antibiotics or GM technologies, have a higher willingness to pay for organic over conventional produce [18, 19]. Similar trends are seen in international markets. A study on Argentinian consumers found a willingness to pay higher price premiums for organic leafy vegetables [20].

Asymmetric information pervades the organic market, particularly on what consumers view organic as [21]. This usually arises because the commercial businesses focus on certain marketable attributes and not emphasizing the holistic set of attributes of the entire organic spectrum.

4. Model Considerations

Survey analysis is the most commonly adopted method to assess willingness to accept and willingness to pay premiums. Most studies use either the linear regression methods or logistic regressions methods depending on the variable. A key assumption going forward is that retail price reflect an equilibrium of demand and supply forces at a given time. Thus, the equilibrium across regions reflect those unique supply and demand factors that determine price in those regions. This argument is more in line with hedonic price models that have been used to determine the premium in terms of dollar amounts [2, 6]. We measure organic premium as the percentage of organic price above the conventional produce. Organic premium is calculated as:

$$P_{curvt} = \frac{OP_{curvt} - CP_{curvt}}{CP_{curvt}} \times 100$$

where, P, OP, and CP are premium, Organically produced crop, and Conventionally produced crop, respectively. Each letter in the subscript 'curvt' stands for crop, unit of sale, region of sale, variety of the crop, and time of sale.

The regression model for each of the four regression models is given as follows:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \varepsilon_i,$$

where X_1 is a vector for regions, X_2 is a vector for the seasons, X_3 is a vector for unit of sale, X_4 is a vector for the varieties, and X_5 is years. See Table A1 in the appendix for a full list of dummy variables for a full list of the variety dummy variables. The above model is a general representation but is modified for each crop. For example, the unit of sale will be excluded from the tomato regression because all price entries were only sold by the pound.

Strawberry has only one variety in the dataset and hence that regression model does not have a variable for variety. A series of dummy variables will be used to account for any differences in variety, unit of sale, and season. Omitted variables in each regression model are the most popular variety, smallest package, and the main growing season.

Region represents multiple demand and supply factors that are unique to each region. The strength and direction of this result may depend on the particular crop, the demand in the area, and availability. The Southwest region, containing California, is expected to have a positive effect. California is well known for its large-scale organic produce farms, and should be considered in a study such as this. Some other regions to note are the Northeast and Southeast. Both of these regions contain large cities and the Southeast contains large production areas for specialty crops. Tomatoes may have lower premiums in the Southeastern region because of the lengthened growing season. Premiums may be larger in the Northeast for tomatoes and strawberries, but may be lower for apples due to cooler climes. The Northwest may also show smaller premiums for apples because of the abundance of apple production in the region.

The dataset contains both months and years. Year is introduced in the models in two ways. One model includes a single year variable to capture a broad secular trends in organic premiums. Another set of models allow varying annual premiums by introducing year fixed effects. The year fixed effects models allow coefficients of individual years to vary or for premiums to fluctuate over year-over-year. Consistent with previous studies, we do not observe steady time trend in the majority of crops which implies a time fixed effects model would be more appropriate (for example, Jaenicke and Carlson) [2].

Months are rearranged into seasons since retail price varies with season. During the harvest or the main season, there is excess supply that reduces the price. Apples are expected to have a slightly higher premiums in summer compared to the main growing season, which is fall. Thus, fall season is used as the base season for apples. Tomatoes prefer warm summer-like weather and hence summer is omitted for this crop. Similarly, Spring season is excluded for strawberries and cucumber. Tomatoes fetch slightly higher price in the spring due to the added premium of being early to the market. Strawberries may have lower premiums in the summer after the main growing season in the spring, but overall may show high premiums. Smith, Lin, and Huang also used strawberries in their analyses and noted their seasonal nature as a contributor to the high premium [6]. The main growing season for cucumbers is late spring to early summer and they remain in high demand for most of the summer; therefore, they are expected to show a higher premium in the summer. The winter season may have differing effects on the price premium of the crops. Cucumbers and tomatoes may show lower premiums due to a lack of demand during winter months. On the other hand, apples and strawberries may have higher or at least comparable premiums because of their relative scarcity during winter.

The unit of sale was considered in this study to shed light on second degree price discrimination which is based on quantity sold. Quantity information is captured by the package size. The data is collected at the retail level so it is reasonable to expect some level of price discrimination. If price discrimination is a factor then the coefficients for unit of sale will reflect this by being negative when larger units of sale are compared to smaller. For example, a five-pound bag of apples will most likely show a negative premium when compared to a one- or two-pound bag.

Variety is controlled for in this study but is not considered a major focus. It is expected, however, that varieties that are most popular and easily recognized might have higher premiums. Heirloom tomatoes may also have a higher premium due to their difficulty to grow organically.

5. Data Description

Data used in this study was gathered from the USDA's Agricultural Marketing Service (AMS) custom average tool (CAT). This study uses monthly retail price data on apples, cucumber, strawberries, and tomatoes. The data period was 2007-2019, with a total of 8,298 observations. Information used in the analysis include year, month, unit of sale or package size, variety, region, average monthly price, and product type (organic or conventional).

One of the main facets of this study is the price premium variations across regions. The entire US geographical area is broken up into eight regions, which offer a representative eight distinct locations in the United States. The regions are Alaska, Hawaii, Midwest, Northeast, Northwest, Southcentral, Southeast, and Southwest. As with the other nominal variables, they were recoded into dummy variables with Midwest used as the base for all four commodities. The Midwest was chosen as the base because it is a central location among standardly defined regions of the US. The average monthly retail price collected from the CAT application is a weighted average price of the crop or commodity across the region's retail outlets on a given date for each commodity was collected. Weighted average price is reported for each region. Organic price of only those with a corresponding conventional (or nonorganic) price were included in the study. The monthly prices were collected from 2007 to 2019. The average organic and conventional or nonorganic price. Any retail price observation that did not have a corresponding conventional price by crop, variety, unit of sale, region, month and year is excluded from the analytic dataset.

Variety is an important contributor to price premium. Apples had the most varieties, with nine different varieties, including red delicious, gala, and fuji (see Table A1 for the complete list of varieties). Gala was chosen as the base for the variety dummy variables in the apple regression due to its popularity. All of the dummy variable bases chosen will be the most commonly purchased variety according to this data set. Cucumbers only had two varieties included in the data: long seedless and other. The long seedless variety was

chosen as the base. There were four tomato varieties including heirlooms and vine-ripe, which was used as the base. No variety was given for strawberries therefore variety variable was omitted from the regression for strawberries.

Smith, Lin, and Huang found significant difference in the prices of fresh produce based on the packaging and weights the produce was sold in [6]. Tomatoes, in Smith, Lin and Huang's study were found to have a higher price premium when sold in packaged form as opposed to by random weight. In this study a variable to capture differences in packaging was implemented in the form of unit of sale. This variable will capture premium differences that may be effected in part by various units of sale. Apples were sold in one-, two-, three-, and five-pound units. Each of these were recoded into dummy variables and one pound was used as the base unit of sale. Strawberries were offered in one- or two-pound packages. Again, both were recoded into dummy variables and the one-pound package was selected because of frequency. The unit of sale for all the tomato data entries was one pound. Because only one unit of sale was included in the data set; unit of sale is excluded from the tomato regression. Cucumbers were either sold as per pound of each. The unit of sale "each" was selected to as the base year because cucumbers are most commonly priced per piece. Package size also implies second degree price discrimination.

Months are modified and introduced in the model to capture seasonality. Months are grouped into four seasons, namely spring, summer, fall, and winter. Each seasonal variable reflects associated premiums in those seasons. Spring consisted of premiums collected in March, April, and May. Summer premiums were collected in June, July, and August. Likewise, the premiums from September, October, and November, were classified as Fall. Lastly, Winter was composed of December, January, and February. This was done to capture premium changes that may be affected by the seasonality of specialty crops like those included in this paper. For example, apples are generally produced and most demanded in the fall. The seasons will be further recoded into dummy variables in order to be used in the multiple regression model. The base for each commodity was selected depending on the season in which the commodities are most available. Apples have a base season of fall because apples are typically harvested at this time. Summer is the base season for strawberries and tomatoes. Cucumbers have spring as the base season because this season had the most premiums reported at this time.

Year is included in two ways. One, a single year variable captured linear trends. Two, each year is included as dummy variable. The latter is also a year-fixed effects model. Including individual years allows capturing heterogeneity over years. This is especially the case for price of agricultural commodities that do not follow secular trends of increasing, decreasing, or constant over a long period of time. Indeed, we find some evidence of that which is discussed below. A previous study by Jaenicke and Carlson using panel data showed year-to-year fluctuations but no consistent increase or decrease over the years, 2004-2010 [2]. They observed that most volatility of premiums occurred in 2007 and earlier when the organic market was not fully established. A detailed analysis by Darbandi and Saghaian offered evidence that price differences between organic and conventional fresh carrots converged in the long-run [10]. That is, as years go by, premium on organic products is expected to decrease.

Organic premiums are shown in Table 1 across different aspects or characteristics of the crop. Across every region and for each attribute, organic produce fetches a higher premium. There's only one exception among the four crops discussed here, strawberry in Hawaii. In Hawaii, conventional strawberries have a higher price than organic ones.

Table 1. *Average premiums by region, season, unit of sale, and variety (percent).*

Variable	Apple	Cucumber	Tomato	Strawberry
Region				
Alaska	33.36	38.63	39.62	44.59
	(38.87)	(43.15)	(35.65)	(43.80)
Hawaii	59.98	35.88	58.78	-16.93
	(59.07)	(30.82)	(48.34)	(36.77)
Midwest	44.29	87.48	47.56	49.70
	(38.68)	(60.34)	(34.88)	(29.48)
Northeast	52.59	66.23	67.99	49.28
	(32.38)	(41.62)	(46.59)	(19.20)
Northwest	40.30	70.40	65.34	49.67
	(35.19)	(49.27)	(52.80)	(22.60)
South Central	38.93	86.26	61.33	45.08
	(35.54)	(45.22)	(49.21)	(26.33)
Southeast	46.26	75.38	63.25	45.47
	(34.79)	(42.95)	(38.57)	(23.64)
Southwest	58.62	90.41	72.01	50.80
	(49.04)	(93.66)	(81.80)	(26.91)
Seasons				
Spring	40.53	76.21	63.11	53.43
	(37.93)	(51.51)	(55.28)	(25.00)
Summer	48.63	80.93	60.14	39.33
	(50.18)	(51.35)	(49.56)	(22.50)

Variable	Apple	Cucumber	Tomato	Strawberry
Fall	56.60 (37.63)	77.42 (86.29)	64.72 (55.64)	36.65 (23.77)
Winter	42.74 (34.16)	76.09 (54.31)	65.69 (62.45)	64.93 (35.04)
Unit of Sale				
1 lb	47.80 (36.95)	109.1 (146.9)	62.94 (55.02)	48.00 (26.14)
2 lb	49.18 (54.33)	-	-	37.49 (35.97)
3 lb	45.91 (40.55)	-	-	-
5 lb	15.91 (34.84)	-	-	-
By count (cucumber)		0.749 (0.460)		

Table 1. *Continued.*

Variable	Apple	Cucumber	Tomato	Strawberry
Apple				
Gala	0.454 (0.315)			
Braeburn	43.95 (39.13)	- -	- -	- -
Fuji	48.85 (31.48)	- -	- -	- -
Golden Delicious	51.56 (35.00)	- -	- -	- -
Granny Smith	49.11 (45.23)	- -	- -	- -
Honey Crisp	38.61 (39.36)	- -	- -	- -
Jonagold	55.60 (39.31)	- -	- -	- -
Pink Lady	44.41 (45.09)	- -	- -	- -
Red Delicious	47.00 (39.81)	- -	- -	- -
Cucumber				
Long Seedless Excluded		0.595 (0.432)		
All Other Cucumber Varieties	-	87.84 (66.54)	25.72 (6.05)	26.26 (6.20)
Tomato (Vine Ripe Excluded)				
Heirloom	-	-	23.68 (34.80)	-
On the Vine	-	-	55.78 (31.76)	-
All Other Tomato Varieties	-	-	100.8 (74.21)	-

Note: ***, **, and * represent significance levels at 1%, 5%, and 10%, respectively.
The dashes (-) represent omitted or non-applicable variables.
No Unit of Sale for Tomato.

6. Results

Individual regression models are run for each of the four crops, i.e., apples, cucumbers, tomatoes and strawberries.

6.1. General Results

Each model was statistically significant implying that the set of variables together explained significant variation in the percentage differences between organic and convention prices. The USDA price data for each crop varies by variety, region, month, year, and unit of sale. Such heterogeneous distribution of growing regions and harvesting seasons brings with it wide variation in price as well as price premiums. As expected, the OLS regression models fail the test for heteroscedasticity and hence we use feasible generalized least squares (GLS) procedure and correct for heteroskedasticity. Having price information over months

and years allow us to create a panel data for a specific produce variety sold in a specific package. Table 2 show results of the panel data GLS procedure. Compared to OLS estimates, the feasible GLS estimates are different in magnitude and some cases even in significance levels. OLS estimates are in the appendix for comparison but are not discussed in the main Results section. Percentage price premium is the dependent variable explained as a function of region, season, unit of sale, variety, and years. The discussion below would mostly focus on the most preferred model, which is the fully specified year fixed-effects panel model.

There are significant regional differences in apple premiums. However, there are no statistical differences among NorthWest, SouthEast, Hawaii and MidWest. As expected, Southwest had the highest premium at 15 percentage points higher and Alaska had the lowest premium at 18 percentage points lower relative to MW. Even though Hawaii is not different statistically, the premiums are 16 percentage points higher, 60% against 44% in MW. Therefore, lack of statistical difference is due to wide variation in premiums. Premiums for all seasons are negative and highly significant implying that Fall premiums are the highest. This could reflect the combined influence of higher organic price and a larger supply of conventional produce during the apple season, i.e., Fall. Premiums are the lowest at 15 percentage points in Spring.

The unit of sale variables do in fact show some evidence of price discrimination. Premiums are lower for the highest unit of sale observed. A five-pound bag fetches about 40 percentage points lower premium than the one-pound bag. The other two units, 2-pound and 3-pound bags were not significant. While variety was not the main focus of the study, it should be noted that three of the eight measured varieties were statistically significant. Golden delicious and Fuji fetched about 5 percentage points higher premium than Gala, whereas Honey crisp was about 9 percentage points lower. All three of these varieties are fairly common and recognized including Fuji, Golden Delicious, and Honey Crisp.

The next crop to be examined was cucumbers. Four of the regions were statistically significant. It is interesting to note that all of the regions showed negative values, which indicates that premiums were lower in regions when compared to the Midwest. Hawaii had the lowest premium at 87 percentage points. This could be due to higher price for conventional produce as well. None of the season variables were statistically significant except summer at 5% significance level. This implies that there were not much seasonal variations in cucumber premiums. Cucumbers that were sold by the pound had 31 percentage points higher premium relative to those sold by count. Varieties other than long seedless fetched 26 percentage points higher premium.

Moving on to tomatoes we see a similar story to the previous two crops; four regions are statistically significant. It should also be noted that all of the significant values are positive indicating that most of the regions have a higher premium relative to Midwest. Higher premiums ranged from 11 to 14 percentage points for all four regions including Northeast, Northwest, South central, and Southeast. None of the seasons are statistically different from the main tomato season, meaning that premiums for tomatoes do not significantly vary by season. Heirlooms had a negative premium relative to Vine Ripes. This is surprising since Heirlooms have higher prices. However, both organic and inorganic Heirlooms are pricier which makes the premium relatively lower than for the other varieties.

Among all four crops, strawberries revealed the least variation across regions that were statistically significant. Unlike the other three crops, only two regions, Alaska and Hawaii, were statistically significant at a 95% level or higher and both values were negative. Hawaii had the least premium relative to the Midwest region. All season variables had a significant effect with winter having the highest premium at 21 percentage points higher than the main season, i.e., summer. This may be a result of relative scarcity of strawberries in the winter months. Similar to apples, we see some evidence of price discrimination in strawberries. The 2-pound package had premium of 10 percentage points less than the 1-pound package.

6.2. Years

The estimates on years from models discussed above are presented in Table 2. In apples, Year as a trend variable has a magnitude of two implying an annual 2-percentage point increase in organic premium during 2010 and 2019. In the preferred model, when each year was included as a dummy variable in the year-fixed effects model, each year except 2011 and 2012 were positive and significant. The premiums have fluctuated a bit relative to 2010 but most years has seen only increase during the study period. This could be indicative of demand far outstripping supply overtime.

Table 2. *Organic premiums by region, season, and unit of sale for apple, cucumber, tomato, and strawberry (panel GLS model).*

Variable	Apple		Cucumber		Tomato		Strawberry	
	Year trend	Year FE	Year trend	Year FE	Year trend	Year FE	Year trend	Year FE
Region (Midwest Excluded)								
Alaska	-14.20***	-17.63***	-48.46***	-51.18***	-0.535	-7.566	-10.14*	-13.01*
	(-4.55)	(-6.66)	(-4.57)	(-6.14)	(-0.07)	(-1.35)	(-2.31)	(-2.02)
Hawaii	10.22	2.858	-91.70***	-87.03***	13.09	11.20	-36.22***	-39.22***
	(1.95)	(0.64)	(-4.01)	(-5.17)	(1.53)	(1.59)	(-7.66)	(-5.82)
Northeast	8.053***	6.443***	-15.43*	-17.94***	23.34***	13.41***	-0.786	-2.056
	(4.78)	(5.44)	(-2.34)	(-3.80)	(5.46)	(4.31)	(-0.25)	(-0.82)

Variable	Apple		Cucumber		Tomato		Strawberry	
	Year trend	Year FE	Year trend	Year FE	Year trend	Year FE	Year trend	Year FE
Northwest	-4.273*	-2.496	-22.69***	-17.81***	18.23***	12.16***	0.0812	-3.104
	(-2.17)	(-1.60)	(-3.47)	(-3.30)	(4.22)	(3.37)	(0.03)	(-1.22)
South Central	-5.483**	-4.614**	-1.057	-4.099	17.79***	10.77**	-3.821	-3.727
	(-2.98)	(-3.28)	(-0.15)	(-0.73)	(3.99)	(3.08)	(-1.24)	(-1.49)
Southeast	1.255	1.519	-7.600	-8.054	20.67***	14.17***	-5.029	-7.401
	(0.69)	(1.32)	(-1.08)	(-1.57)	(4.64)	(4.10)	(-1.60)	(-2.70)
Southwest	14.07***	15.00***	-4.226	-6.242	28.51***	3.187	2.247	0.752
	(7.55)	(8.90)	(-0.67)	(-1.19)	(6.93)	(0.91)	(0.75)	(0.28)
Seasons‡ (main growing season excluded)								
Spring	-17.97***	-15.18***	-	-	-0.940	-3.017	13.19***	15.55***
	(-12.21)	(-13.70)	-	-	(-0.31)	(-1.25)	(6.46)	(8.88)
Summer	-11.82***	-11.48***	5.783	8.724*	-	-	-	-
	(-6.10)	(-8.19)	(1.13)	(2.44)	-	-	-	-
Fall	-	-	-2.008	-5.460	2.723	2.734	-5.494*	-6.158**
	-	-	(-0.36)	(-1.38)	(0.81)	(1.03)	(-2.27)	(-3.09)
Winter	-14.53***	-11.55***	0.596	-0.971	2.381	-4.112	21.50***	20.39***
	(-10.83)	(-12.08)	(0.11)	(-0.25)	(0.70)	(-1.53)	(8.00)	(9.21)

Table 2. *Continued.*

Variable	Apple		Cucumber		Tomato		Strawberry	
	Year trend	Year FE	Year trend	Year FE	Year trend	Year FE	Year trend	Year FE
Unit of Sale†								
1 lb	Excl.	Excl.	38.20***	31.18***	-	-	Excl.	Excl.
			(4.81)	(5.92)				
2 lb	-0.908	5.892	-	-	-	-	-12.77***	-10.23**
	(-0.31)	(1.77)					(-4.38)	(-2.62)
3 lb	-2.315	-1.128	-	-	-	-	-	-
	(-1.79)	(-1.10)						
5 lb	-33.40***	-40.88***	-	-	-	-	-	-
	(-4.91)	(-26.95)						
Variety (Gala excluded)								
Braeburn	0.694	-0.735	-	-	-	-	-	-
	(0.31)	(-0.42)	-	-	-	-	-	-
Fuji	4.458**	2.697*	-	-	-	-	-	-
	(2.63)	(2.57)	-	-	-	-	-	-
Golden Delicious	6.662**	6.179***	-	-	-	-	-	-
	(3.10)	(4.07)	-	-	-	-	-	-
Granny Smith	3.138	0.971	-	-	-	-	-	-
	(1.70)	(0.66)	-	-	-	-	-	-
Honey Crisp	-11.00***	-13.69***	-	-	-	-	-	-
	(-4.61)	(-7.86)	-	-	-	-	-	-
Jonagold	3.666	2.109	-	-	-	-	-	-
	(0.89)	(0.59)	-	-	-	-	-	-
Pink Lady	0.404	-3.926	-	-	-	-	-	-
	(0.18)	(-1.91)	-	-	-	-	-	-
Red Delicious	2.960	1.700	-	-	-	-	-	-
	(1.64)	(1.28)	-	-	-	-	-	-
All Cucumber Varieties (Long Seedless Excluded)	-	-	25.72***	25.89***	-	-	-	-
			(6.10)	(7.90)				
Tomato								
Heirloom	-	-	-	-	-26.55**	5.698*	-	-
					(-6.33)	(2.34)		
On the Vine	-	-	-	-	7.721*	7.721*	-	-
					(2.42)	(2.34)		
All Other Tomato Varieties (Vine Ripe Excluded)	-	-	-	-	51.27***	35.94***	-	-
					(15.11)	(9.53)		

Note: ‡ season varies by crop. Fall season was excluded for Apple, Summer for Tomato, and Spring was excluded for Cucumber and Strawberry.
Year FE (fixed effects) column has estimates from models that have each year included as a dummy variable. Year trend column has estimates from models with year a single time variable.
***, **, and * represent significance levels at 1%, 5%, and 10%, respectively.
The dashes (-) represent omitted or nonapplicable variables.
† Sold by unit is Excluded for Cucumber.

Cucumbers also had a coefficient that was significant but negative suggesting a downward trend in premiums over the

10-year period from 2010 through 2019. These results coincide with Jaenicke and Carelson who found no steady increase or decline in price premiums over a six-year period for most crops [2]. There is no blanket trend in organic price premium. It, in fact, varies with crop. However, when individual years are included as dummy variables in another model, each year dummy variable is negative but none of them is significant, year 2018. This essentially tells that while the premium has decreased consistently and there was no significant difference in most years relative to 2010.

Year trend variable for tomatoes is insignificant and so were most of the year dummy variables. Thus, suggesting no specific trend in organic premiums for tomatoes. The magnitude was larger than 45 percentage points in all years but was significant only in two. Years 2008 and 2014 were not only significant and positive but also had very large coefficient. In both years, the premiums rose 65 percentage points, a significant spike in those years.

Trend in strawberry premiums is positive, although very small in magnitude, 1.2 percentage points. Looking at the fixed effects models, initial years were not significantly different from the base year, 2006. Starting in 2014, the premiums were higher in all years except 2018. The magnitude was also higher with the highest in 2019 at 34 percentage points and the lowest in 2017 at 16 percentage points.

7. Discussion

When all of the information is combined, we can get a good picture of what factors among those considered here make a difference to farmers. Given the high costs of growing organic produce, it is vital that organic farmers take these into consideration. It is important to keep in mind that the organic premium is the difference between organic and conventional produce expressed in percent. Hence, the premium is affected by the relative difference and not absolute. There is wide regional variation for all four crops but there are differences across regions when compared to premiums in the Midwest. Apple premiums vary region to region, being both positive and negative in comparison to the Midwest. On the other hand, cucumber premiums are negative for all of the considered regions. Tomatoes, in contrast, have positive premiums for all of that statistically significant variables. Season was statistically significant for apples and strawberries, but no influence on for cucumbers or tomatoes. This may be because of the ability to easily grow cucumbers and tomatoes in green houses and high tunnels to avoid adverse weather conditions. Apples and strawberry yields can be highly effected by weather events such as frost. The unit of sale generally showed price discrimination as previously discussed. Overall, apples were most significantly effected by: region, season, and unit of sale; cucumbers were affected by: region and unit of sale; tomatoes were affected by: region in a positive way; and strawberries were most effected by: season and unit of sale.

Even though the organic premium expressed in percent does not directly talk about price discrimination for a produce, it does say about the relative change in price premium over the conventional produce for a larger unit size sold. A negative estimate of a larger unit would indicate a smaller price discrimination in organic produce, which is what we observe in apple and strawberry. Cucumber showed a large, positive and significant estimate indicating relatively more price discrimination for organic cucumbers.

It is interesting that introducing year as a trend or as individual year's dummy variable does not significantly change most of the regional and seasonal variables suggesting a consistent regional premium variation. Premiums vary considerably by seasons for all except tomatoes.

8. Implications and Conclusions

Farmers that are looking to start an organic specialty crop operation should consider several factors growing primarily tomatoes and cucumbers to avoid some of the seasonality issues while keeping in mind that a higher premium may also indicate more input costs and higher labor intensity. If they are able, farmers should locate operations in regions like the Southwest and Southeast because of good growing conditions and the high demand. At the retail level, variety and unit of sale in addition to the organic quality influence premiums. Strawberries are not overly affected by region, suggesting they could be grown and sold in most regions without adverse effects. Consumers should take note of the price discrimination and may be able to purchase larger amount of organic produce at a lower premium rate.

This dataset does not explore the dynamics in the international market. For example, domestic (US) prices during season are generally lower than other seasons. Off-season demand is predominantly met by importing from other countries. Imported produce are generally cheaper which could have an impact on organic premiums. More importantly, the estimates need to be understood within the context of the data and individual crop.

Limitations of this study needs to be kept in mind when applying the results. The model may be limited by the lack of complete variety information for some crops. Additional knowledge may be gained by adding varieties of strawberries and cucumbers. This study does not take into full consideration the production or labor costs that are incurred by farmers. A survey could also be utilized to gauge the general tone of the industry and the views of farmers and terminal market participants. Future studies analyzing supply and demand of organic produce must take into the important variables that significantly make difference in premiums.

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Appendix

Table A1. *Definition of variables included in the regression.*

Variable	Definition
Dependent Variable	
Premium	((organic price – conventional price) / conventional price), recorded as a percentage
Explanatory Variables	
Unit of Sale	
1 lb	=1 if 1 lb is the Unit of Sale, =0 otherwise
2 lb	=1 if 2 lb is the Unit of Sale, =0 otherwise
3 lb	=1 if 3 lb is the Unit of Sale, =0 otherwise
5 lb	=1 if 5 lb the Unit of Sale, =0 otherwise
Each	=1 if Each is the Unit of Sale, =0 otherwise
Region	
Alaska	=1 if Alaska is the Region, =0 otherwise
Hawaii	=1 if Hawaii is the Region, =0 otherwise
Midwest	=1 if Midwest is the Region, =0 otherwise
Northeast	=1 if Northeast is the Region, =0 otherwise
Northwest	=1 if Northwest is the Region, =0 otherwise
South Central	=1 if South Central is the Region, =0 otherwise
Southeast	=1 if Southeast is the Region, =0 otherwise
Southwest	=1 if Southwest is the Region, =0 otherwise
Season	
Spring	=1 if Spring is the Season, =0 otherwise
Summer	=1 if Summer is the Season, =0 otherwise
Fall	=1 if Fall is the Season, =0 otherwise
Winter	=1 if Winter is the Season, =0 otherwise
Variety Apple	
Braeburn	=1 if Braeburn is the Variety, =0 otherwise
Fuji	=1 if Fuji is the Variety, = 0 otherwise
Gala	=1 if Gala is the Variety, =0 otherwise
Golden Delicious	=1 if Golden Delicious is the Variety, =0 otherwise
Granny Smith	=1 if Granny Smith is the Variety, = 0 otherwise
Honeycrisp	=1 if Honeycrisp is the Variety, =0 otherwise
Jonagold	=1 if Jonagold is the Variety, =0 otherwise
Pink Lady/Cripps Pink	=1 if Pink Lady/Crisp Pink is the Variety, =0 otherwise
Red Delicious	=1 if Red Delicious is the Variety, =0 otherwise
Tomato	
Heirloom	=1 if Heirloom is the Variety, =0 otherwise
Vine ripe	=1 if Vine ripe is the Variety, =0 otherwise
On the vine	=1 if On the vine is the Variety, =0 otherwise
All other tomato varieties	=1 if All other tomato varieties is the Variety, =0 otherwise
Cucumber	
Long seedless	=1 if Long seedless is the Variety, =0 otherwise
All other cucumber varieties	=1 if All other cucumber varieties is the Variety, =0 otherwise

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