# Farm Produce Demand: An Analysis of Price, Discount and Seasonality on the UBC Farm Demand


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**ECON 490**



**Abstract**

This paper investigates the demand of UBC Farm's crops in the Market Channel. It is important for local farms to estimate the amount of produce demanded in order to efficiently manage their production and maximize their quantity of sales. A multiple linear regression model is utilized to investigate the association between the quantity of sales in the Market Channel with unit price, discount and seasonality for each crop group. The model demonstrates that summer sales for fruit and allium groups are statistically significantly larger than those in fall sales, suggesting that the UBC Farm should increase their summer crop production for these groups. Additionally, the discount effect is greater than price effect for fruit, leaf green, marrow, and allium groups, suggesting that UBC Farm should increase discount and price by the same amount to sell more produce. A larger pre-pandemic dataset is suggested for future studies to compensate the shock from the pandemic and insignificance of seasonal effects in the model.



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## I. Introduction

Food price forecasting plays a vital role in local farms' demand maximization, which helps them efficiently allocate resources and optimize their market sales. The paper, "Marketing Plan for UBC Farm", identifies two significant issues: excess demand for food products results in inefficient resource allocation, and unoptimized regulations cause farm market revenue deficits (Izadpanah et al., 2007). As a result, the primary motivation behind this research lies in developing an accurate food demand prediction model to provide future suggestions for the UBC Farm to adjust their supply and inventory stocks. We begin our investigation by categorizing UBC farm's produce into 6 crop groups based on biological families: egg, fruit, leafy green, marrow, root and allium groups. Our research question is to find the relationship between quantity demanded of UBC Farm on the Market Channel and target variables, including unit price, discount, crop group and seasonal effect using the multiple linear regression model.

A second area of motivation involves studying the relationship of price, discount and seasonal effects in respect to quantity demanded. Existing literature finds that the price either negatively affects farm demand or discount positively affects the Farm demand. Our paper contributes to the investigation of the combination of price effect and discount effects on demand to provide 'Price after Discount' suggestions for each crop group. Seasonality is also a large contributor to certain produce demand. To account for the seasonal effect, dummy variables are adopted as a result of the empirical challenge of working with a relatively small dataset. It is found that the summer sales for fruit and allium groups are significantly higher than fall sales. Additionally, the implications of multicollinearity between variables Price and Discount are considered when building the model using VIF analysis. The robustness of the model is also examined through a heterogeneity analysis.

We first begin our investigation by elaborating on the background of UBC Farm as well as discuss several literature reviews on forecasting farm demand (Section II). Next, we outline the data source used as well for data cleaning and provide a data summary (Section III). In Section IV, we provide an explanation on the multiple linear regression model utilized and test for multicollinearity between independent variables using VIF tests. Tableau is also utilized to create a dashboard for the UBC Farm in order to visualize produce demand. Next, Section V lists and interprets the results of the multiple linear regression models for each crop group. In Section VI, we discuss the reasons and implications behind the price effect, discount effect, and seasonal effect for each crop group. In addition, we look at challenges faced in our study, and offer suggestions for future studies. Finally, we summarize our findings in Section VII as a conclusion as well as look at the limitations of the study.

## II. Background

### *A. Farm Context*

The UBC Farm is a 24-hectare, organic farm that cultivates over 200 varieties of produce, including fruits, vegetables, herbs, and eggs. Its annual crop yields are distributed locally to different Channels, including nearby restaurants and Farmers Markets (UBC Farm, 2022). As per the UBC Farm’s request, this paper focuses on the Market Sales Channel which accounts for 47.6 percent of total quantity sales among all Channels (Appendix 2). The Market Sales Channel corresponds to the Farmers’ Markets held on Tuesdays, Wednesdays and Saturdays from the months of June to October. Since the harvest season of UBC Farm’s most produce is from June to October, the rest months of the year have little yields and sales, which are considered “off season markets”.

### *B. Associated Literature*

In previous studies, many researchers investigated various factors influencing the demand of farm’s produce. Barbieri and Tew (2016) utilize the multiple linear regression model to analyze the association between the percentage of farm sales derived from agritourism and physical, agritourism, and managerial farm resources based on the data from 164 agritourism farms. They find that the managerial farm resources (i.e., number of marketing methods) positively impact direct sales from agritourism (Barbieri, & Tew, 2016), which implies that the sale channel influences the farm’s demand.

Another paper shows that the quantity sold of tomatoes, as normal goods, increases as price declines during the summer market (SULI and Xhabij, 2013). This is in accordance with the negative effect of unit price on the quantity demanded of UBC Farm, since UBC Farm’s produce are also normal goods. In addition, a study by Dong and Leibtag reveals that a 10% discount for major fruits and vegetables in the U.S. leads to a rise of 5 to 6 percent in weekly quantity sales ( Dong & Leibtag, 2010), which indicates that discount positively affects farm demand. However, these two studies do not investigate how the combination of price effect and discount effect influences the demand. Thus, in our research, we compare the magnitude of price effect and discount effect for different crop groups on the demand to provide a more precise forecast.

Moreover, Kulshreshtha (1970) estimates and compares the future demand for several major fruits and vegetables in Canada based on their past trends and structural coefficients, suggesting the demand of most produce in the next 15 years will double the present level. However, this study only provides the change in the future trend of demand varying across crop groups, but does not look deeper into the seasonal variation during the future period. Wildt's study (1977) shows that market response (unit sales) to decision variables (promotion, price etc) has seasonal fluctuations, which can be measured by dummy variables. Therefore, in our research, we use dummy variables to forecast the change of UBC Farm's Market Sales over the appropriate seasons, which are summer and fall.

## III. Data

### *A. Source*

We use data from the UBC Farm Sales Record, which can be found on the Center for Sustainable Food Systems site under Dataverse (UBC Farm Sales Records, 2020) .

The UBC Farm sales records used are from 2019 to 2020, and key variables include:

- qty (Number of units sold)
- price (Unit price for certain good ($))
- discount (Discount amount for certain good ($))
- channel (Sales channel)
- month (Sales time divided in month)
- crop (Specific product)

To determine farm demand in market sales, we focus on the Market Channel and use a multiple linear regression model to analyze the association between the number of sales and independent variables, including unit price, discount, and group of crops. To analyze the data more conveniently and reasonably, we combine similar crops into groups and focus on the crops with sales frequencies larger than 1% of the total market sale. In addition, as market demand is determined by seasonal variation, a seasonal effect is included. Below is a summary of each variable.

*B. Data Processing*

**Price and Discount:**

First, we look at the price and discount variables from the data. Since the discount in the UBC Farm Sales Record is represented as a negative number, we negate the value to make it a positive number in order to make the data analysis and regression results easier to understand:

Table 1: summary of origin price and discount

| Variable | Obs | Mean | Std. dev. | Min | Max |
|---|---|---|---|---|---|
| qty | 5,133 | 19.95065 | 32.34027 | .0572727 | 814.9857 |
| price | 5,118 | 5.006358 | 6.939378 | 0 | 195 |
| Discount | 5,134 | 2.274371 | 4.231751 | -.2 | 60 |

According to Table 1, there exists some unreasonable data that may be attributed to human error. For instance, there are some negative discounts, which are unjustified as discounts should not make the goods more expensive. As a result, we drop all discounts less than 0. Additionally, the minimum price is zero, which is not a reasonable assumption as free goods do not generate any revenue for the farm. Therefore, we drop all prices which are zero.

Table 2 illustrates the new summary table we created after cleaning the data.

Table 2: summary of price and discount after adjustment

| | summary of price and discount |
|---|---|
| qty | 19.96<br>(32.37) |
| price | 5.02<br>(6.944) |
| Discount | 2.28<br>(4.236) |
| *N* | 5122 |

mean coefficients; sd in parentheses
$^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$

Table 2 shows that the price has the mean of 5.02, and the standard deviation of 6.944. The discount has the mean of 2.28, and the standard deviation of 4.236, which appear more reasonable. In addition, we illustrate the relationship between quantity and quantitative variables: price and discount with a scatterplot in Figure 1.

Figure 1 - relationship between quantity and price unadjusted

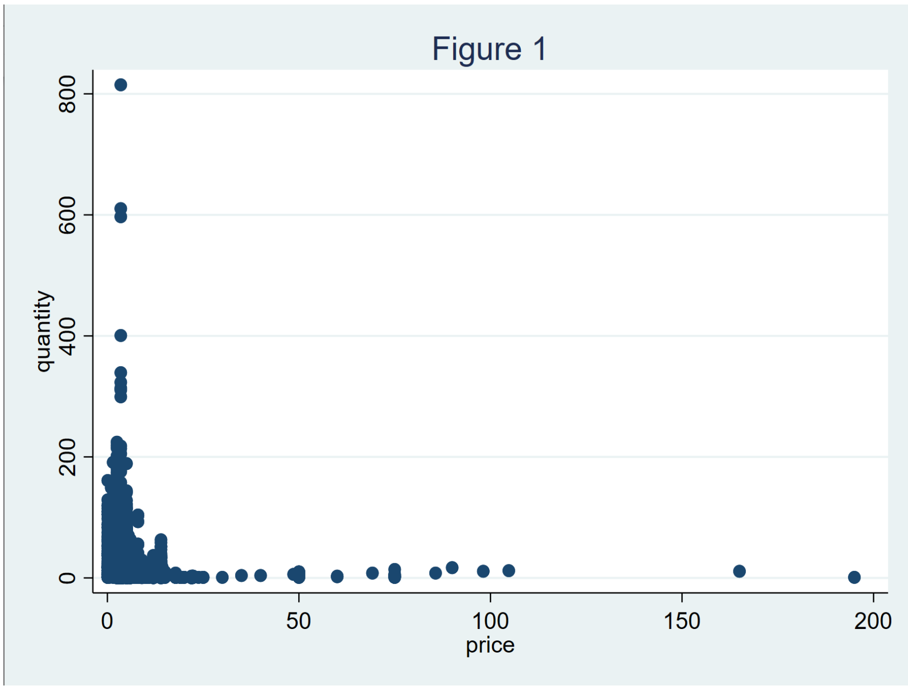
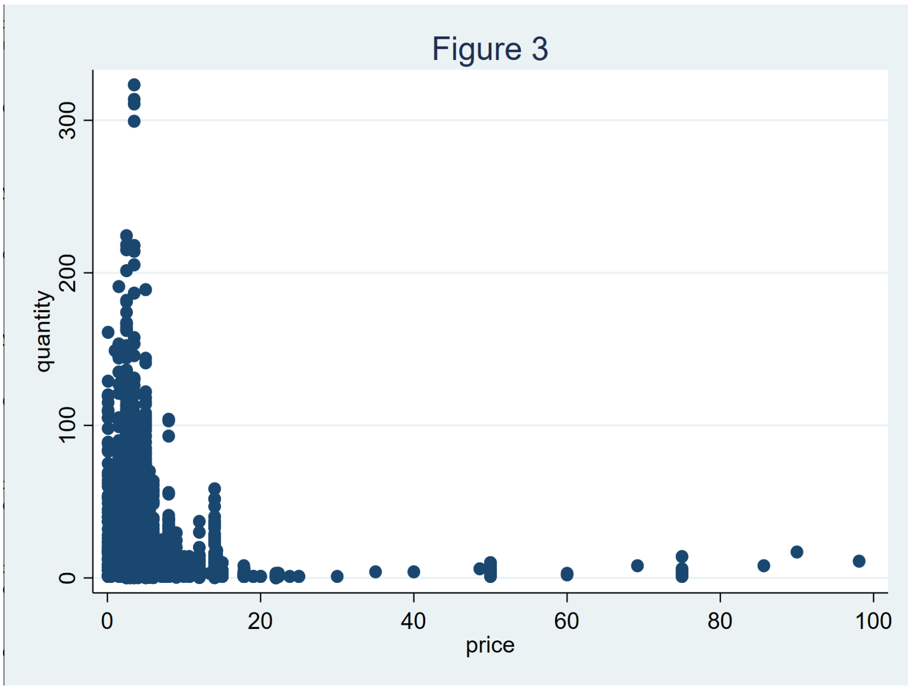



Figure 1 shows the relationship between quantity and price. While most data points are clumped to the left, there are a few outliers lying to the right of the graph. As a result, we drop the outliers where 'price' > 100 and illustrate this in a new scatterplot (Figure 3).

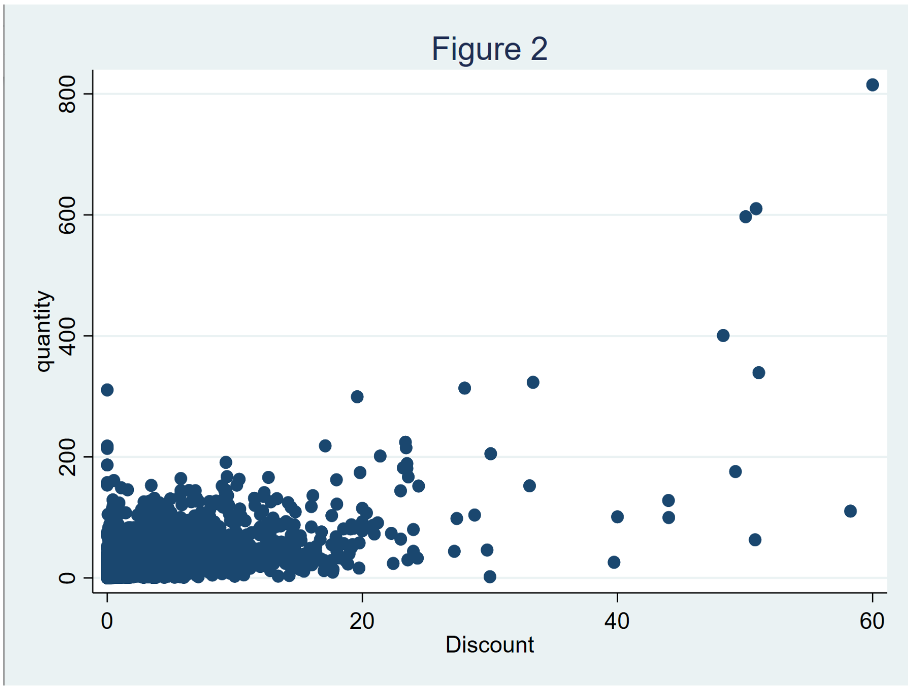
Figure 3 - relationship between quantity and price adjusted




According to Figure 3, the quantity has a negative relationship with price. However, it does not show a clearly linear relationship.

Next, we study the relationship between quantity and discount, as illustrated in Figure 2.

Figure 2 - relationship between quantity and discount unadjusted




To analyze the data, we drop the outliers where ‘discount’ > 40 and illustrate this new relationship in Figure 4.

Figure 4 - relationship between quantity and discount adjusted

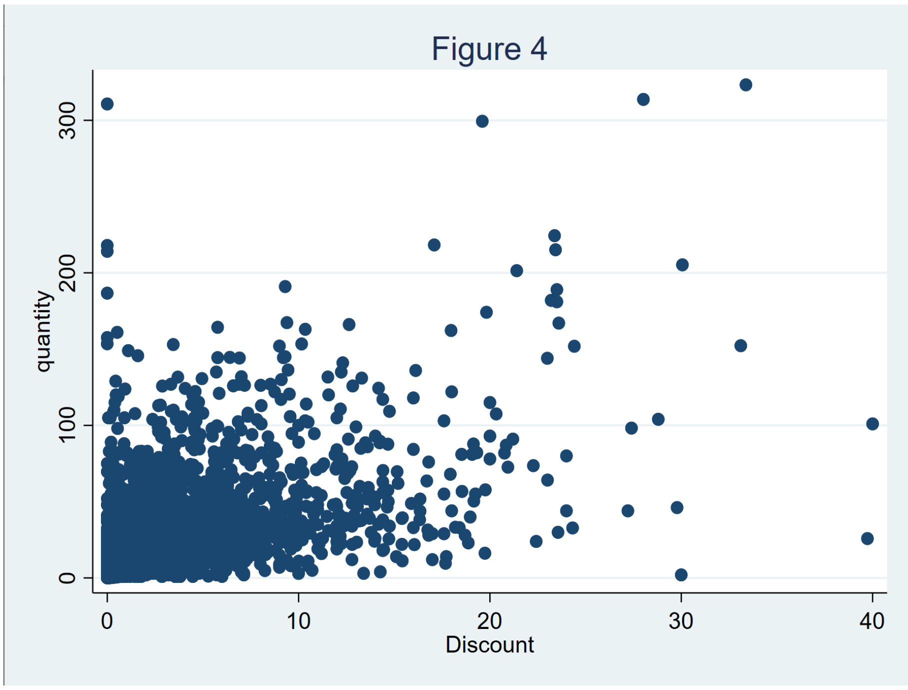


Figure 4 does not show a clear linear relationship between the quantity and discount. However, the quantity increases as the discount goes larger in common sense. We will do further analysis in the result and discussion.

**Seasonality:**

Next, we look at the seasonality in the Market Sales. There are 5 months in the Market Channel: June, July, August, September, and October, which we will group into two seasons for easier analysis. We group June, July, August together as a 'Summer' group, and September, October as an 'Autumn' group. The quantity of sales between Summer and Autumn are compared by creating a dummy variable for Summer.

Table 3: summary of month distribution in Market Channel

| month | Freq. | Percent | Cum. |
|---|---|---|---|
| August | 1,204 | 23.64 | 23.64 |
| July | 955 | 18.75 | 42.39 |
| June | 669 | 13.14 | 55.53 |
| October | 1,107 | 21.74 | 77.26 |
| September | 1,158 | 22.74 | 100.00 |

**Crop group:**

Finally, we investigate the crop groups by categorizing them into six major groupings. The classification method is based on the biological families which groups different crops by finding their similar characteristics. A two-steps classification method is used. Firstly, we divide the crop groups into three major groupings: Egg, Fruit, and Vegetable. Then, we divide vegetables into four main types; Leafy Greens, Marrow, Root and Allium. Under the Market Channel, as shown in Table 4. A biological classification is more explicit and practical to show the data association between UBC farm demand and other independent variables. We will refer to our new groupings as Crop Groups, which include Egg, Fruit, Leafy green, Marrow, Root and Allium.

Table 4: distribution of crop groups in different groupings

| Egg | Fruit | Leafy green | Marrow | Root | Allium |
|---|---|---|---|---|---|
| egg | blueberry | lettuce | pumpkin | potato | onion |
| | strawberry | spinach | cucumber | carrot | garlic |
| | apple | kale | winter squash | beet | leek |
| | tomato | herb perennial | summer squash | radish | |
| | pepper | herb annual | | | |
| | | flower | | | |
| | | salad mix | | | |
| | | chard | | | |
| | | arugula | | | |

## IV. Model

The purpose of this paper is to identify UBC Farm's quantity demanded, specifically in the Market Channel. The research question we have formulated is: how has the UBC Farm's demand in the Market Channel been impacted by unit price, discount, and crop group under seasonality adjustments?

Before constructing the model, we first consider the implications of multicollinearity between the variables we want to include. The independent variables like price, discount, and seasonality might be highly correlated with one another in our regression model. To avoid this, we use VIF analysis to detect the multicollinearity effect on our variables. VIF analysis, or Variance Inflation Factor analysis, is a method to determine the strength of the correlation between the independent variables. It is predicted by taking a variable and regressing it against every other variable. Therefore, the higher the value of VIF, the higher the multicollinearity with the particular independent variable. The VIF test results shown in Table 5 are all close to one, so we can conclude that there is no multicollinearity between independent variables.

Table 5: VIF Analysis for Each Crop Group

Egg group

| Variable | VIF | 1/VIF |
|---|---|---|
| Discount | 1.00 | 0.999984 |
| Summer | 1.00 | 0.999984 |
| Mean VIF | 1.00 | |

Fruit group

| Variable | VIF | 1/VIF |
|---|---|---|
| price | 1.03 | 0.974659 |
| Summer | 1.02 | 0.980125 |
| Discount | 1.01 | 0.994155 |
| Mean VIF | 1.02 | |

Leafy green group

| Variable | VIF | 1/VIF |
|---|---|---|
| Discount | 1.02 | 0.978049 |
| Summer | 1.02 | 0.981461 |
| price | 1.00 | 0.996431 |
| Mean VIF | 1.01 | |

Marrow group

| Variable | VIF | 1/VIF |
|---|---|---|
| Summer | 1.02 | 0.978380 |
| Discount | 1.02 | 0.979559 |
| price | 1.01 | 0.991482 |
| Mean VIF | 1.02 | |

Root group

| Variable | VIF | 1/VIF |
|---|---|---|
| price | 1.32 | 0.760287 |
| Summer | 1.29 | 0.774636 |
| Discount | 1.08 | 0.923302 |
| Mean VIF | 1.23 | |

Allium group

| Variable | VIF | 1/VIF |
|---|---|---|
| price | 1.15 | 0.869532 |
| Summer | 1.10 | 0.911508 |
| Discount | 1.08 | 0.922294 |
| Mean VIF | 1.11 | |

Therefore, we can construct the model as: $Q_i = \beta_o + \beta_1 P_i + \beta_2 D_i + \beta_3 S_i + \upsilon_i$

In this equation, $Q_i$ stands for the quantity of sales, $P_i$ stands for the unit price, $D_i$ stands for the discount, and $S_i$ is summer to represent the seasonality, which is a dummy variable. We give the assumptions that there are linear relationships between the dependent variable and independent variables. Secondly, all variables are assumed to be multivariate normal and there is no multicollinearity effect between each independent variable. Finally, we assume variables are homoscedastic, meaning residuals i are uniform across the regression line.

## V. Results

In this section, we elaborate on the results of the multiple linear regression models for each of the classified groups.

## 1. Egg group:

Table (A) - summary results for Egg group regression

| Egg group<br>VARIABLES | (1)<br>SLR(Discount) | (2)<br>SLR(Summer) | (3)<br>MLR |
|---|---|---|---|
| Discount | 3.113*** | | 3.115*** |
| | (0.201) | | (0.199) |
| Summer | | 3.037 | 3.176 |
| | | (4.837) | (2.235) |
| Constant | 9.294*** | 22.65*** | 7.327*** |
| | (1.471) | (3.802) | (2.012) |
| Observations | 68 | 68 | 68 |
| R-squared | 0.784 | 0.006 | 0.791 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The egg group solely includes eggs, and has the same unit price, therefore the price is omitted with collinearity.

From Table (A), we can observe that an 1 unit rise in the discount will cause the 3.113 unit rise in quantity, which is statistically significant at 1% level. Compared to Autumn, Summer leads to a 3.037 unit rise in quantity. Additionally, the seasonal effect is not statistically significant. The multiple linear regression model will strengthen the relationship between quantity demanded and our independent variables. The R square increases to 0.791, meaning a 1 unit rise in the discount will cause a 3.115 unit rise in quantity, which is statistically significant at 1% level. Compared to Autumn, Summer leads to a 3.176 unit rise in quantity, with a statistically insignificant seasonal effect.

## 2. Fruit group:

Table (B) - summary results for Fruit group regression

| Fruit group<br>VARIABLES | (1)<br>SLR(price) | (2)<br>SLR(Discount) | (3)<br>SLR(Summer) | (4)<br>MLR |
|---|---|---|---|---|
| price | -0.608*** | | | -0.522*** |
| | (0.199) | | | (0.163) |
| Discount | | 4.099*** | | 4.061*** |
| | | (0.244) | | (0.238) |
| Summer | | | 11.78*** | 13.57*** |
| | | | (3.050) | (2.503) |
| Constant | 28.07*** | 9.581*** | 18.08*** | 6.004*** |
| | (1.991) | (1.540) | (2.198) | (2.188) |
| Observations | 603 | 603 | 603 | 603 |
| R-squared | 0.015 | 0.320 | 0.024 | 0.358 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

From Table (B), we can observe that a 1 unit rise in the price will cause a 0.608 unit fall in quantity, which is statistically significant at 1% level. And 1 unit rise in the discount will cause the 4.099 unit rise in quantity, which is statistically significant at 1% level. Compared to Autumn, Summer leads to a 11.78 unit rise in quantity. The seasonal effect is also statistically significant at 1% level.

The multiple linear regression model will strengthen the relationship between quantity and independent variables. The R square increases to 0.358. This means 1 unit rise in the price will cause the 0.522unit fall in quantity. And 1 unit rise in the discount will cause the 4.061 unit rise in quantity. Both price and discount are statistically significant at 1% level. Compared to autumn, summer leads to a 13.57 unit rise in quantity. The seasonal effect is also statistically significant at 1% level.

**3. Leafy green group:**

Table (C) - summary results for Leafy green group regression

| Leafy green group<br>VARIABLES | (1)<br>SLR(price) | (2)<br>SLR(Discount) | (3)<br>SLR(Summer) | (4)<br>MLR |
|---|---|---|---|---|
| price | -0.412*** | | | -0.558*** |
| | (0.110) | | | (0.0918) |
| Discount | | 4.311*** | | 4.404*** |
| | | (0.165) | | (0.165) |
| Summer | | | -1.920* | 1.431 |
| | | | (1.101) | (0.923) |
| Constant | 16.95*** | 8.655*** | 16.53*** | 9.883*** |
| | (0.689) | (0.498) | (0.910) | (0.904) |
| Observations | 1,616 | 1,616 | 1,616 | 1,616 |
| R-squared | 0.009 | 0.296 | 0.002 | 0.313 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

From Table (C), we can observe that a 1 unit rise in the price will cause the 0.412 unit fall in quantity, which is statistically significant at 1% level. And a 1 unit rise in the discount will cause the 4.311 unit rise in quantity, which is also statistically significant at 1% level. Compared to Autumn, Summer leads to a 1.92 unit fall in quantity, which is statistically significant at 10% level.

The multiple linear regression model will strengthen the relationship between quantity and independent variables. The R square increases to 0.313. This means a 1 unit rise in the price will cause the 0.558 unit fall in quantity, which is statistically significant at 1% level. And 1 unit rise in the discount will cause the 4.404 unit rise in quantity, which is also statistically significant at 1% level. Compared to Autumn, Summer leads to a 1.431 unit rise in quantity. However, the seasonal effect is not statistically significant.

## 4. Marrow group:

Table (D) - summary results for Marrow group regression

| Marrow group VARIABLES | (1) SLR(price) | (2) SLR(Discount) | (3) SLR(Summer) | (4) MLR |
|---|---|---|---|---|
| price | -1.088*** | | | -0.874*** |
| | (0.267) | | | (0.222) |
| Discount | | 4.596*** | | 4.555*** |
| | | (0.276) | | (0.276) |
| Summer | | | -2.664 | 1.197 |
| | | | (2.532) | (2.088) |
| Constant | 33.36*** | 16.70*** | 30.52*** | 19.38*** |
| | (1.456) | (1.239) | (1.393) | (1.655) |
| Observations | 591 | 591 | 591 | 591 |
| R-squared | 0.027 | 0.319 | 0.002 | 0.338 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

From Table (D), we can observe that a 1 unit rise in the price will cause a 1.088 unit fall in quantity, which is statistically significant at 1% level. Additionally, a 1 unit rise in the discount will cause a 4.596 unit rise in quantity, which is also statistically significant at 1% level. Compared to Autumn, Summer leads to a 2.664 unit fall in quantity. However, the seasonal effect is not statistically significant.

The multiple linear regression model will strengthen the relationship between quantity and independent variables. The R square increases to 0.338, meaning a 1 unit rise in the price will cause the 0.874 unit fall in quantity. Additionally, a 1 unit rise in the discount will cause the 4.555 unit rise in quantity. Both price and discount are statistically significant at 1% level. Compared to autumn, summer just leads to a 1.197 unit rise in quantity. However, the seasonal effect is not statistically significant.

## 5. Root group

Table (E) - summary results for Root group regression

| Root group VARIABLES | (1) SLR(price) | (2) SLR(Discount) | (3) SLR(Summer) | (4) MLR |
|---|---|---|---|---|
| price | -16.74*** | | | -9.846*** |
| | (2.024) | | | (1.680) |
| Discount | | 5.901*** | | 5.581*** |
| | | (0.260) | | (0.262) |
| Summer | | | -14.51*** | 4.879* |
| | | | (3.550) | (2.784) |
| Constant | 92.37*** | 18.15*** | 45.43*** | 48.74*** |
| | (6.808) | (1.531) | (2.572) | (5.425) |
| Observations | 501 | 501 | 501 | 501 |
| R-squared | 0.121 | 0.509 | 0.032 | 0.541 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

From Table (E), we can observe that a 1 unit rise in the price will cause the 16.74 unit fall in quantity, which is statistically significant at 1% level. Additionally, a 1 unit rise in the discount will cause the 5.901 unit rise in quantity, which is statistically significant at 1% level. Compared to Autumn, Summer leads to a 14.51 unit fall in quantity, which is also statistically significant at 1% level.

The multiple linear regression model will strengthen the relationship between quantity and independent variables. The R square increases to 0.541. This means a 1 unit rise in the price will cause the 9.846 unit fall in quantity. Additionally, a 1 unit rise in the discount will cause the 5.581 unit rise in quantity. Both price and discount are statistically significant at 1% level. Compared to autumn, summer leads to a 4.879 unit rise in quantity, which is statistically significant at 10% level.

**6. Allium group:**

Table (F) - summary results for Allium group regression

| Allium group<br>VARIABLES | (1)<br>SLR(price) | (2)<br>SLR(Discount) | (3)<br>SLR(Summer) | (4)<br>MLR |
|---|---|---|---|---|
| price | -0.997*** | | | -1.450*** |
| | (0.258) | | | (0.242) |
| Discount | | 1.733*** | | 2.179*** |
| | | (0.228) | | (0.221) |
| Summer | | | 5.680** | 5.263** |
| | | | (2.443) | (2.205) |
| Constant | 29.52*** | 17.09*** | 21.21*** | 22.06*** |
| | (1.953) | (1.397) | (1.553) | (2.213) |
| Observations | 319 | 319 | 319 | 319 |
| R-squared | 0.045 | 0.154 | 0.017 | 0.274 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

From Table (F), we can observe that a 1 unit rise in the price will cause the 0.997 unit fall in quantity, which is statistically significant at 1% level. Moreover, a 1 unit rise in the discount will cause a 1.733 unit rise in quantity, which is also statistically significant at 1% level. Compared to autumn, summer leads to a 5.68 unit rise in quantity. The seasonal effect is statistically significant at 5% level.

The multiple linear regression model will strengthen the relationship between quantity and independent variables. The R square increases to 0.274, meaning 1 unit rise in the price will cause the 1.45 unit fall in quantity. Moreover, a 1 unit rise in the discount will cause the 2.179 unit rise in quantity. Both price and discount are statistically significant at 1% level. Compared to autumn, summer leads to a 5.263 unit rise in quantity. The seasonal effect is statistically significant at 5% level.

## VI. Discussion

As discussed in the previous section, a multiple linear regression model was created for each of the identified crop groups in respect to price, discount and seasonality. In this section, we will further elaborate on the price and discount, as well as seasonality effects for each group, as well as problems we faced and how to overcome them to better answer the research question.

### *A. Analysis*

**Price and discount effect**

As we discussed in the results above, we find that the quantity of sales can increase by a lower price or higher discount. In order to make the analysis comparable, we label 'price' - 'discount' as a new variable, called 'Price after Discount,' and keep the variable constant. We can then provide recommendations by comparing the price effect and discount effect in each crop group. The quantity of sales can be increased by a lower price, or higher discount.

Table (G) - 95% Confidence Interval for Egg group

| qty | Coefficient | Std. err. | t | P>\|t\| | [95% conf. | interval] |
|---|---|---|---|---|---|---|
| Discount | 3.11455 | .1993483 | 15.62 | 0.000 | 2.716424 | 3.512676 |
| Summer | 3.175929 | 2.235277 | 1.42 | 0.160 | -1.288227 | 7.640085 |
| _cons | 7.326666 | 2.012066 | 3.64 | 0.001 | 3.308293 | 11.34504 |

Table G shows the 95% CI for discount is [2.72, 3.51] in egg.

Table (H) - 95% Confidence Interval for Fruit group

| qty | Coefficient | Std. err. | t | P>\|t\| | [95% conf. | interval] |
|---|---|---|---|---|---|---|
| price | -.5218084 | .1631896 | -3.20 | 0.001 | -.8423018 | -.2013151 |
| Discount | 4.060636 | .2378027 | 17.08 | 0.000 | 3.593608 | 4.527665 |
| Summer | 13.57279 | 2.502897 | 5.42 | 0.000 | 8.657269 | 18.48831 |
| _cons | 6.004423 | 2.188267 | 2.74 | 0.006 | 1.706815 | 10.30203 |

Table H shows the 95% CI for price is [-0.84, -0.2] and 95% CI for discount is [3.59, 4.53]. The discount effect is greater than the price effect in fruit.

Table (I) - 95% Confidence Interval for Leafy green group

| qty | Coefficient | Std. err. | t | P>\|t\| | [95% conf. | interval] |
|---|---|---|---|---|---|---|
| price | -.5576401 | .0918303 | -6.07 | 0.000 | -.7377594 | -.3775208 |
| Discount | 4.404374 | .1653686 | 26.63 | 0.000 | 4.080014 | 4.728734 |
| Summer | 1.431131 | .9226756 | 1.55 | 0.121 | -.3786388 | 3.240901 |
| _cons | 9.882941 | .9043973 | 10.93 | 0.000 | 8.109023 | 11.65686 |

Table I shows the 95% CI for price is [-0.74, -0.38] and 95% CI for discount is [4.08, 4.73]. The discount effect is greater than the price effect in leafy green.

Table (J) - 95% Confidence Interval for Marrow group

| qty | Coefficient | Std. err. | t | P>\|t\| | [95% conf. | interval] |
|---|---|---|---|---|---|---|
| price | -.8740976 | .2217567 | -3.94 | 0.000 | -1.309631 | -.4385644 |
| Discount | 4.555481 | .2759455 | 16.51 | 0.000 | 4.013521 | 5.097442 |
| Summer | 1.197167 | 2.088484 | 0.57 | 0.567 | -2.904644 | 5.298978 |
| _cons | 19.37891 | 1.654509 | 11.71 | 0.000 | 16.12943 | 22.62839 |

Table J shows the 95% CI for price is [-1.31, -0.44] and 95% CI for discount is [4.01, 5.1]. The discount effect is greater than the price effect in marrow.

Table (K) - 95% Confidence Interval for Root group

| qty | Coefficient | Std. err. | t | P>\|t\| | [95% conf. | interval] |
|---|---|---|---|---|---|---|
| price | -9.845935 | 1.679978 | -5.86 | 0.000 | -13.14667 | -6.5452 |
| Discount | 5.580759 | .2616622 | 21.33 | 0.000 | 5.066658 | 6.09486 |
| Summer | 4.87867 | 2.783522 | 1.75 | 0.080 | -.5902515 | 10.34759 |
| _cons | 48.74158 | 5.424765 | 8.99 | 0.000 | 38.08328 | 59.39988 |

Table K shows the 95% CI for price is [-13.15, -6.55] and 95% CI for discount is [5.07, 6.09]. The root has a greater price effect than the discount effect.

Table (L) - 95% Confidence Interval for Allium group

| qty | Coefficient | Std. err. | t | P>\|t\| | [95% conf. | interval] |
|---|---|---|---|---|---|---|
| price | -1.449788 | .2418342 | -5.99 | 0.000 | -1.925603 | -.9739736 |
| Discount | 2.178684 | .220858 | 9.86 | 0.000 | 1.744141 | 2.613227 |
| Summer | 5.262765 | 2.205056 | 2.39 | 0.018 | .9242657 | 9.601264 |
| _cons | 22.05696 | 2.212979 | 9.97 | 0.000 | 17.70287 | 26.41105 |

Table J shows the 95% CI for price is [-1.93, -0.97] and 95% CI for discount is [1.74, 2.61]. The discount effect is greater than the price effect in allium.

Next, we look at the implications of the price and discount effects to provide suggestions to the UBC Farm.

Since eggs are sold at one price, the egg group solely includes a discount effect. A larger discount will increase the quantity of sales.

Looking at the other groups, we observe that the root group has a greater price effect than the discount effect. In this case, a price reduction will lead to a larger increase in demand as compared to a discount increase. As a result, we recommend UBC Farm to remove the discount, and reduce the ‘price after discount’ to that of ‘price’ - ‘discount.’

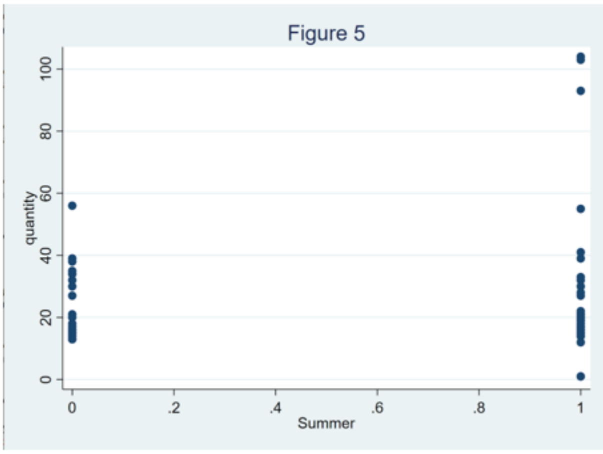
In contrast, the discount effect is greater than the price effect in the fruit, leafy green, marrow and allium groups. Here, an increase in discounts will lead to a larger increase in demand as compared to a price decrease. We recommend UBC Farm to increase their discounts as much as allowed by internal policies, and increase the ‘price’ to ensure that ‘price after discount’ is unchanged.

**Seasonal effect**

As the result analysis above, we find that the seasonal effect coefficients are positive in all crop groups. This means that the quantity of sales in the Summer is better than Autumn. However, based on the multiple linear regression analysis, the seasonal effect is not statistically significant in the egg, leafy green, and marrow groups under the 5% p-value. Therefore, we cannot conclude that the quantity of sales in the Summer is greater than Autumn in these groups. We require more data and information to do further analysis. For the Fruit, Root and Allium groups, the seasonal effects are statistically significant which indicates a higher demand for these crops in the Summer as compared to Autumn. As a result, the UBC farm should increase their supply for these crop groups in the summer season.

Next, we compare the variance of sales in the Summer and Autumn seasons to study implications of heterogeneity.

seasonal distribution of sales for egg group




seasonal distribution of sales for fruit group

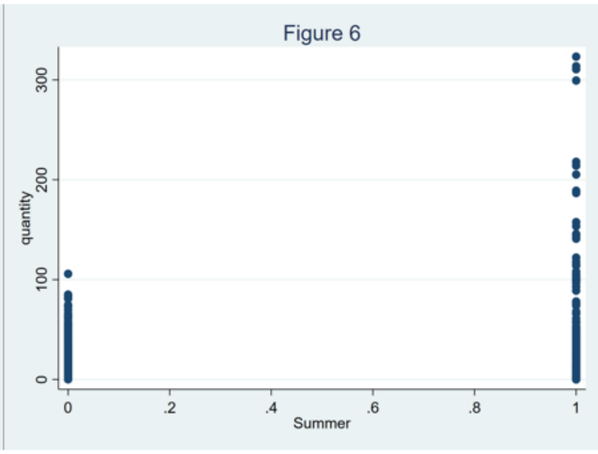
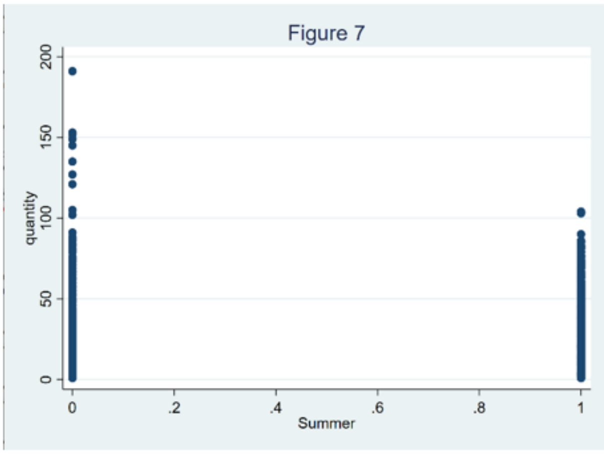



Figure 5 and figure 6 show that the variance of sales in the Summer is different from Autumn for both Egg and Fruit groups.

seasonal distribution of sales for leafy green group




seasonal distribution of sales for marrow group

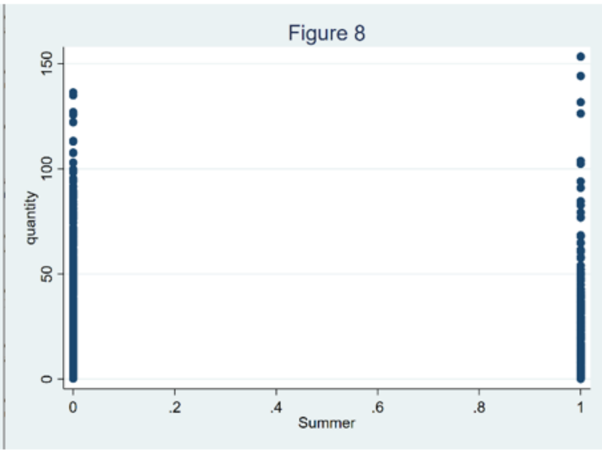
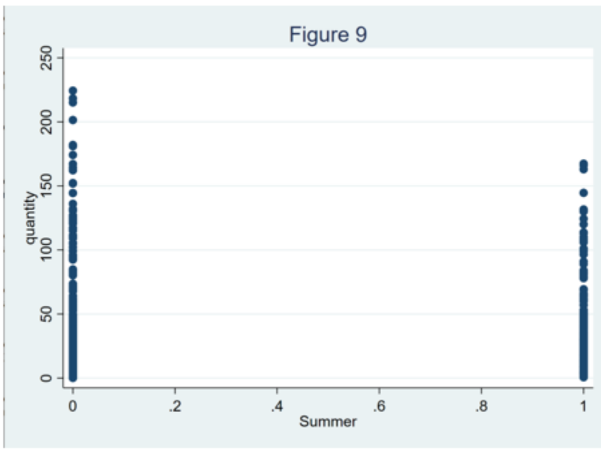



Figure 7 shows that the variance of sales in the Summer is different from Autumn for the Leafy green group. Figure 8 shows the variance of sales in the Summer is close to Autumn for Marrow.

seasonal distribution of sales for root group




seasonal distribution of sales for allium group

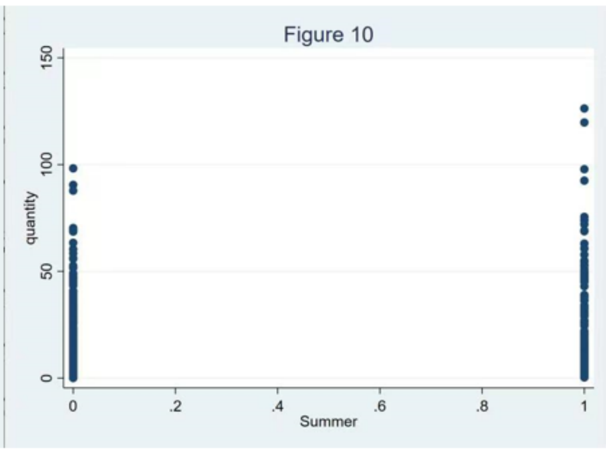


Figure 9 shows that the variance of sales in the Summer is different from Autumn for the Root group. Figure 10 shows the variance of sales in the Summer is close to Autumn for Allium.

So, the two-way graphs above show the variance of sales in Summer and Autumn for all groups. We find that the variance of sales in the Summer is different from Autumn for most groups, except for Marrow and Allium. Therefore, this suggests that the distribution of sales in seasons is heterogeneous. The adjusted multiple linear regression results show below:

Table (M) - adjusted MLR by switching homogeneity to heterogeneity

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| VARIABLES | MLR(Egg) | MLR(Fruit) | MLR(Leafy) | MLR(Marrow) | MLR(Root) | MLR(Allium) |
| | | | | | | |
| Discount | 3.115*** | 4.061*** | 4.404*** | 4.555*** | 5.581*** | 2.179*** |
| | (0.328) | (0.575) | (0.328) | (0.352) | (0.456) | (0.379) |
| Summer | 3.176 | 13.57*** | 1.431 | 1.197 | 4.879* | 5.263** |
| | (2.156) | (2.551) | (0.981) | (1.959) | (2.633) | (2.220) |
| price | | -0.522*** | -0.558*** | -0.874*** | -9.846*** | -1.450*** |
| | | (0.106) | (0.142) | (0.328) | (1.298) | (0.183) |
| Constant | 7.327*** | 6.004*** | 9.883*** | 19.38*** | 48.74*** | 22.06*** |
| | (2.149) | (2.218) | (1.065) | (1.911) | (4.645) | (2.021) |
| | | | | | | |
| Observations | 68 | 603 | 1,616 | 591 | 501 | 319 |
| R-squared | 0.791 | 0.358 | 0.313 | 0.338 | 0.541 | 0.274 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

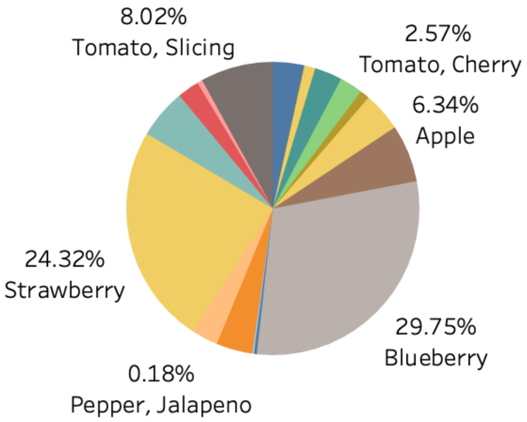
To increase robustness of the model, table M shows the regression we revised by switching the homogeneity to heterogeneity.

Next, we will delve deeper to analyze potential reasons for a significant or insignificant seasonal effect for each group.

The fruit group is found to have a significant seasonal effect, and indicates a 13.57 unit rise in quantity in the summer as compared to autumn. It is composed of crops which have seasonal availability from June to October.

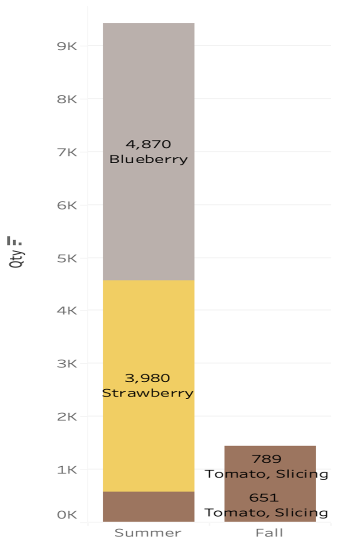
Figure (11) illustrates the percentage of quantity of products in the fruit group as a Pie Chart.

Figure (11) distribution of sales in fruit group



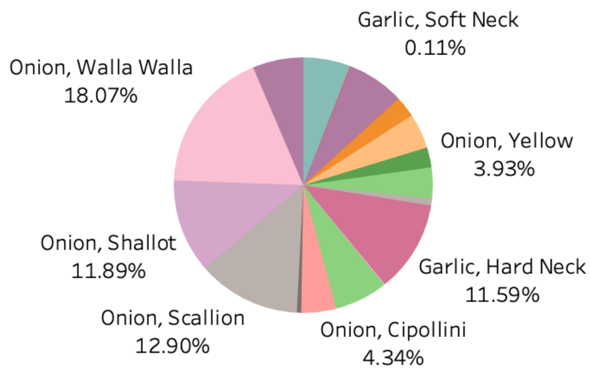

We can see that the top three selling fruits are 'blueberries', 'strawberries', and 'tomato, slicing'. These three crops compose more than 62% of all fruit sales. From the UBC Farm's "Produce Seasonal Availability" chart, the seasonal availability of 'blueberries' and 'strawberries' are from June to July, while that of 'tomato, slicing' is from August to September (UBC Farm, 2021). As these crops are mostly available during the Summer season, the seasonal significance can be attributed to more supply of popular products in the Summer as compared to Autumn, as shown in Figure (11).

Figure (12) summer sales vs. fall sales of fruit group



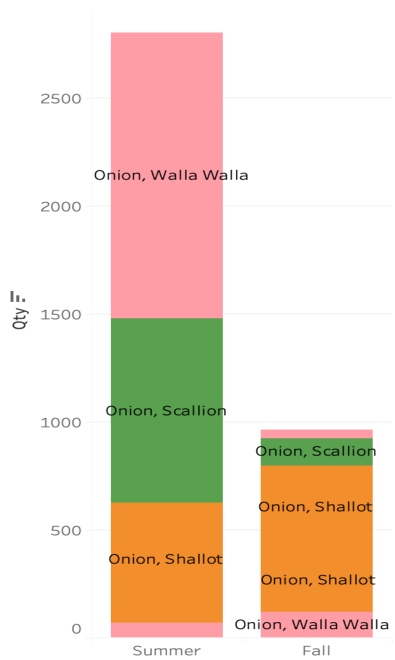

The Allium group is also found to have a seasonal effect, which indicates a 5.263 unit rise in quantity in the Summer as compared to Autumn. From Figure (13), We observe that the top selling crops include 'Onion, Walla Walla', 'Onion, Scallion' and 'Onion, Shallot.' These three crops make up approximately 43% of all allium sales.

Figure (13) distribution of sales in Allium group




Specifically, the UBC Farm's "Produce Seasonal Availability" table indicates a large range of availability for these crops (UBC Farm, 2021). 'Onion, Walla Walla' is available from July to August, while 'Onion, Scallion' and 'Onion, Shallot' are available from June to November. As seasonal availability is wide, we then look at the actual sales of the three crops. These three most sold Allium crops are graphed in Figure (14), which show that Summer sales are significantly higher than those in Autumn.

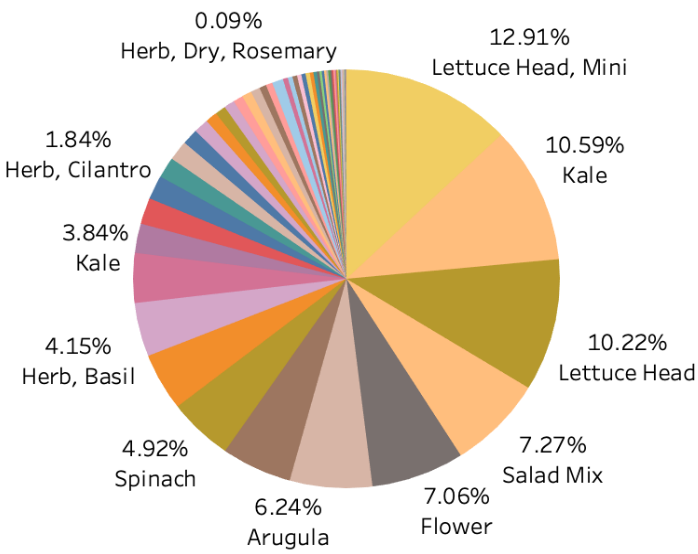
Figure (14) summer sales vs. fall sales of Allium group




For the Egg group, the seasonal effect is not statistically significant, indicating that the Summer sales of eggs are not significantly larger than those of Autumn sales. This can be explained due to the fact that eggs are a commodity, and do not have seasonal demand. Consumers purchase eggs to eat year-round, and do not consider its seasonality.

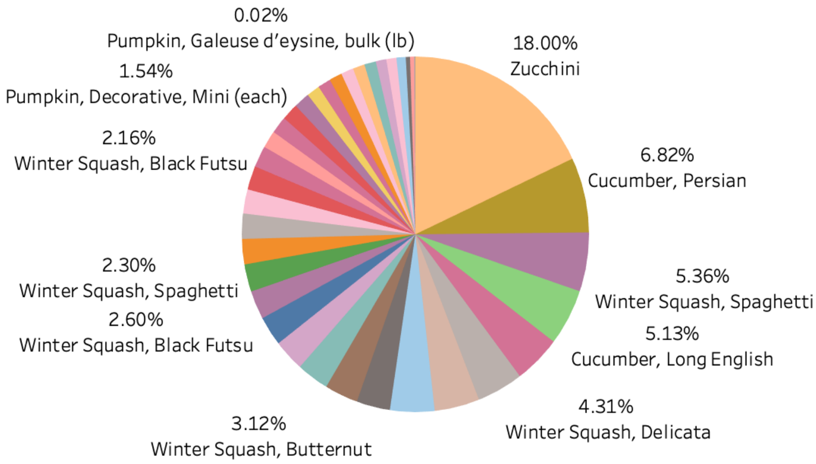
The Leafy green group includes lettuce, spinach, kale, herb perennial, flower, salad mix, chard, herb annual, and arugula. From Figure (15), we can see that sales are widely spread apart, with the three most sold crops being ‘Lettuce Head, Mini’, ‘Kale’ and ‘Lettuce Head,’ making up approximately 34% of all leafy green sales. These crops’ production seasons are mostly equally spread from June to October according to the UBC Farm Market Seasonal Availability (UBC Farm, 2021). Thus, the seasonal effect is also not statistically significant in the Summer months as compared to Autumn.

Figure (15) distribution of sales in Leaf green group



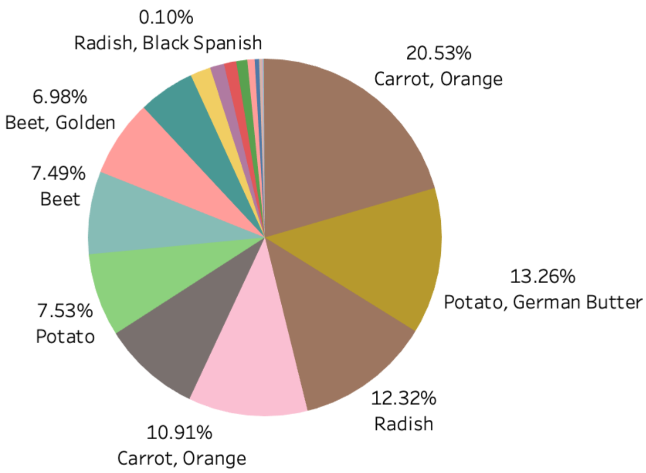

The Marrow group includes pumpkin, cucumber, winter squash, and summer squash. The crop sales for this group is widely spread among multiple crops, with the top three selling crops being ‘zucchini’, ‘cucumber’, and ‘winter squash, spaghetti,’ making up 30% of total sales from Figure (16). The season for cucumber is from mid June to mid November. The season for pumpkin and winter squash is from September to January. Therefore, the sales for the marrow group in Summer is not significantly larger than the sales in Autumn.

Figure (16) distribution of sales in Marrow group




The root group includes potato, carrot, beet, and radish. The top three selling crops include 'carrot, orange', 'potato, german butter', and 'radish,' comprising approximately 46% of all sales from Figure (17). The season for potatoes is from mid August to mid December. The season for carrots spread from June to January. The season for beet is from July to January. The season for radish is from June to September. Since their sale seasons are mainly in fall, the seasonal effect of Summer sales is not significantly larger than Autumn sales.

Figure (17) distribution of sales in root group



*B Problems Faced*

One of the major challenges we faced was the lack of a large dataset; the sample size of market sales might not be large enough to show more accurate MLR results. Specifically, the data provided in this dataset are from 2019 and 2020. In 2020, COVID-19 first started circulating in British Columbia, with health officials officially declaring a provincial state of emergency on March 18th, 2020 (Kotyk, 2021). As a result, consumer consumption behaviors drastically changed, with an initial shock due to health fears and lockdowns (Remes et al., 2021). As a result, the data from 2020 may have been impacted by the ongoing COVID-19 pandemic, creating an exogenous shock in our data. For instance, there normally are a number of events on the UBC Farm that occur over the course of the year. However, due to the pandemic, there were no other events happening on or near the farm apart from the online Apple Fest in 2020 and 2021. As this data does not accurately represent a usual market demand and supply, the predictions generated from our models may show less practical suggestions to future UBC farm market boards. To overcome these problems, a larger dataset with more years of data is required as a bigger sample size provides more accurate estimations of MLR results. For example, by adding five years of data previous to 2020 that is unaffected by the pandemic, we can provide more accurate market suggestions.

## VII. Conclusion

The multiple linear regression model utilized in this paper is used to study the relationship between quantity demanded and independent variables, including price, discount and seasonality. We determined that for the Fruit and Allium groups, seasonality is statistically significant, indicating that there are more summer sales than fall sales in these groups. As a result, we recommend the UBC Farm to produce more crops in the Fruit and Allium groups in the Summer in order to meet customers' high demands. However, the seasonal effect for other four groups, including egg, leafy green, marrow, and root group, is not statistically significant due to the seasonality of produce. In addition, when studying the discount and price effects, we ascertained that the discount effect is greater than the price effect for Fruit, Leaf green, Marrow, and Allium groups. This implies that the UBC Farm could increase discount and price by the same amount for these crop groups to increase quantity sales. On the other hand, the root group has a higher price effect than discount effect. In this case, we suggest the UBC Farm to cancel the discount and decrease price by the same amount to stimulate the quantity sales.

A limitation of this study is the small dataset available for analysis. To minimize the issues of a small dataset, we formed the data into groups in order to show more accurate multiple linear regression results. For instance, while it would be more useful to analyze each crop group independently, we grouped them into larger Crop Groups due to the small dataset. Additionally, this sample of 2019 and 2020 data results may be influenced by the Pandemic. As consumer purchase behaviours drastically changed during the COVID-19 Pandemic, and lockdowns forced the UBC Farm to reduce or change their ways of selling their produce, the data does not represent a normal demand in quantity. In order to combat these problems, a larger dataset of at least five years of pre-pandemic sales record is recommended to provide more accurate predictions.

In conclusion, our model shows how price, discount and seasonality influences each Crop Group's demand in quantity in the Market Channel. This paper also provides recommendations for each Crop Group to help UBC Farm with increasing future consumer demand.

**References:**


2021 UBC Farm Produce Seasonal Availability (2021). Centre for sustainable Food System at UBC Farm. Retrieved from: https://lfs-ubcfarm-clone-2018.sites.olt.ubc.ca/files/2021/06/2021-UBC-Farm-Market-Seasonal-Availability.pdf

Barbieri, C., & Tew, C. (2016). Perceived impact of agritourism on farm economic standing, sales and profits. *Travel and Tourism Research Association: Advancing Tourism Research Globally,* 34. Received from: https://scholarworks.umass.edu/ttra/2010/Oral/34/

UBC Farm Sales Records (2020). Centre for Sustainable Food Systems at UBC Farm, Scholars Portal Dataverse, V4, Retrieved from: https://doi.org/10.5683/SP2/IVR7TA,

Dong, D., & Leibtag, E. S. (2010). *Promoting fruit and vegetable consumption: Are coupons more effective than pure price discounts?* (Economic Research Report No. 96). Received from Economic Research Service, USDA, website: https://ageconsearch.umn.edu/record/94853/

Izadpanah, M., Lui, L., Ma, A., Ortner, K., Rosebush, L., Sui, J., & Weston, J. (2007). Marketing Plan for UBC Farm. *UBC Social Ecological Economic Development Studies (SEEDS) Student Reports (Undergraduate),* Retrieved from: https://open.library.ubc.ca/collections/undergraduateresearch/18861/items/1.0108174

Kotyk A. (2021, January 28). Scroll through this timeline of the 1st year of COVID-19 in B.C. *CTVNewsVancouver.* Receieved from: https://bc.ctvnews.ca/scroll-through-this-timeline-of-the-1st-year-of-covid-19-in-b-c-1.5284929

Kulshreshtha, S. N. (1970). The demand for major fruits and vegetables in Canada. *Canadian Journal of Agricultural Economics,* 18(2), 52-59.

Remes, J., Manyika, J., Smit, S., Kohli, S., Fabius, V., Fyle, S., and Nakaliuzhnyi A. (2021, March 17). The consumer demand recovery and lasting effects of COVID-19. *Mckinsey Global Institue.* Retrieved from: https://www.mckinsey.com/industries/consumer-packaged-goods/our-insights/the-consumer-demand-recovery-and-lasting-effects-of-covid-19

SULI, D., & Xhabija, G. (2013). The effects of the price change on the demand of agricultural products during summer time. *European Journal of Sustainable Development,* 2(4), 293-302.

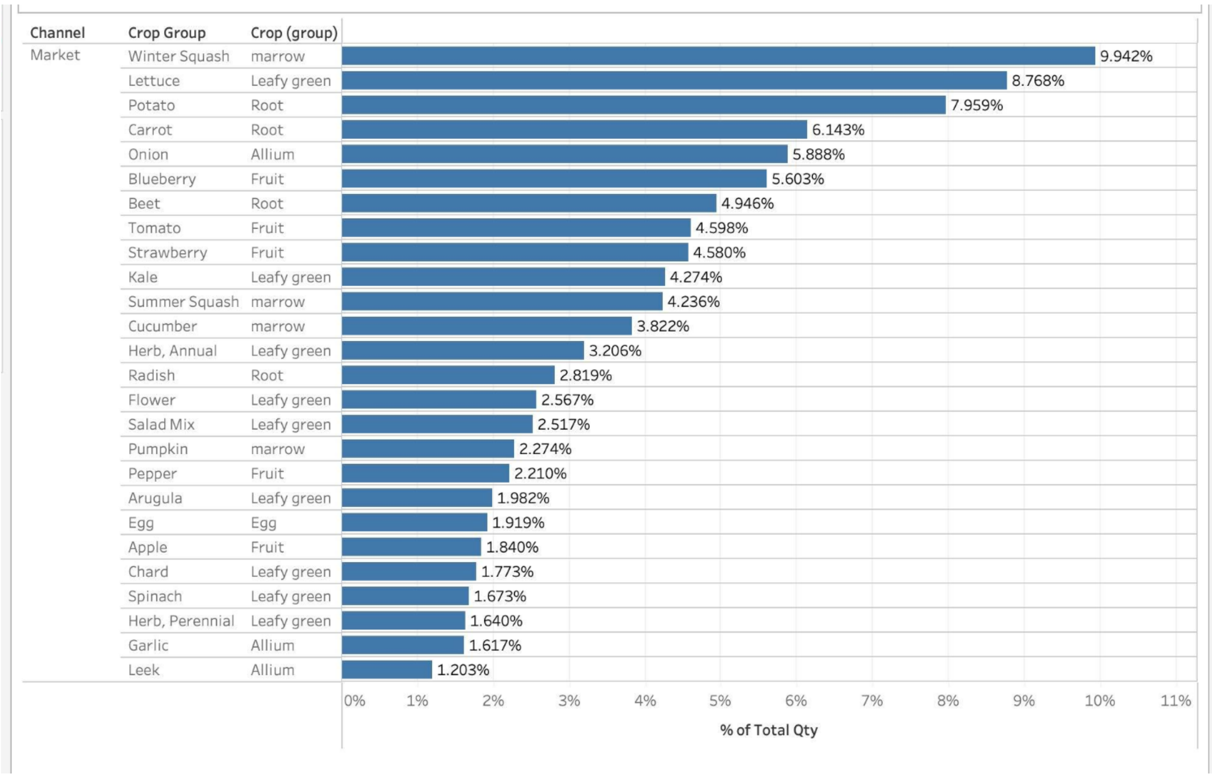
Tableau. (2021, April). How forecasting works in Tableau. Online Help. Retrieved January 31, 2022.

Wibowo, A., Yasmina, I., & Wibowo, A. (2021). Food price prediction using time series linear ridge regression with the best damping factor. *Advances in Science, Technology and Engineering Systems Journal,* 6(2), 694-698.

Wildt, A. R. (1977). Estimating models of seasonal market response using dummy variables. *Journal of Marketing Research,* 14(1), 34-41.

## Data Appendix

### Appendix Ⅰ the distribution of crop group in market channel (frequency > 1%)




### Appendix Ⅱ

### the summary of channel

| channel | Freq. | Percent | Cum. |
|---|---|---|---|
| CSA | 761 | 7.06 | 7.06 |
| Market | 5,134 | 47.61 | 54.66 |
| Miscellaneous | 2,464 | 22.85 | 77.51 |
| Wholesale | 2,148 | 19.92 | 97.43 |
| Wholesale | 3 | 0.03 | 97.46 |
| cull | 262 | 2.43 | 99.89 |
| wholesale | 12 | 0.11 | 100.00 |
| Total | 10,784 | 100.00 | |