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Pricing Discrepancies in The Washington State Cherry Market

Foster L. Peebles
Central Washington University, fosterlpeebles@gmail.com

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Foster Peebles

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Accepted by:

____	__________
Charles Wassell, Professor, Dept. of Economics	Date
____	__________
Robert Carbaugh, Professor, Dept. of Economics	Date
____	__________
Dominic Klyve, Associate Professor, Dept. of Mathematics	Date

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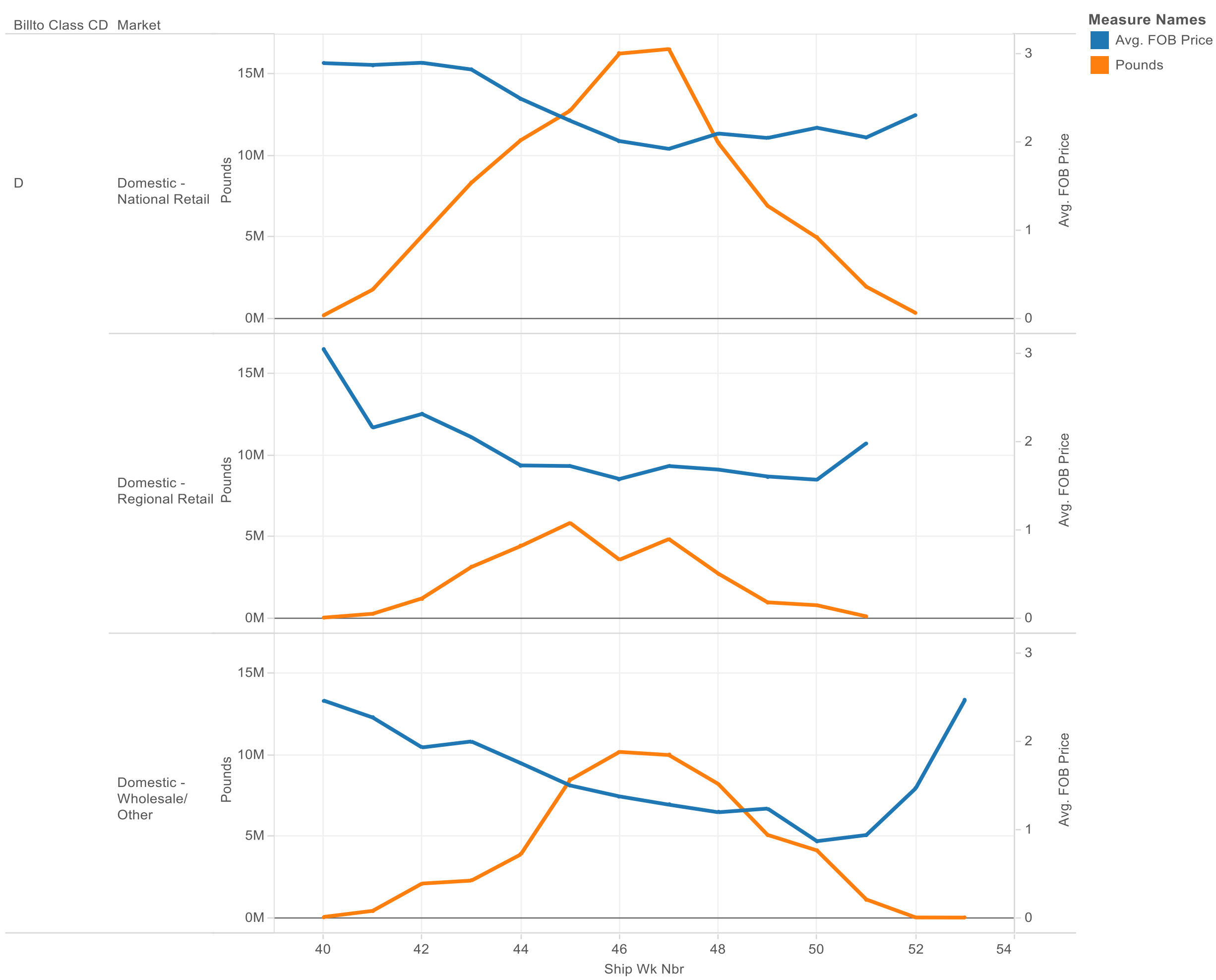
Introduction

This research is focused on finding a pricing model for Washington State cherries. Each year a significant number of cherries are not sold, or are sold at a price close to or under cost, due to issues with program cherry purchases and pricing models. This research looks at two specific markets: the program fruit business and the wholesale markets. The program fruit business is comprised of companies such as Kroger, Wal-Mart, Costco, and others that “pre-purchase” their fruit at a specific price for delivery at a later date, much like a futures market for other commodities. The wholesale market, also referred to as the spot market, is made up of companies that purchase fruit for immediate delivery after it has already been packaged. In recent years there has been a gap between the pricing of wholesale and program markets. Specifically, the fruit that is sold to program business is at a price high enough that wholesale customers are able to sell fruit to traditional program customers at a lower price than the initial firm selling the fruit. The issue is fairly clear: firms are undercutting their own business by not being able to determine the correct pricing for program and wholesale business.

Cherries by nature are perishable, and with good storage techniques cherries are able to survive about fourteen days. As a result of the high perishability, cherries must be sold quickly in order to avoid the fruit going bad before reaching the final customer. During the peak of the Washington state cherry harvest, prices are at their lowest point. The problem being faced by marketing firms exists because prices charged to retail customers are too high, and prices to spot market customers are too low. This occurs because the retail market does not demand an unlimited quantity of fruit at high prices.

The chart below details the price of cherries and the volume of fruit being sold during each week of the cherry season for the crop years of 2011, 2012, 2013, and 2014. In this chart, and the rest of the paper, the FOB price refers to the price of cherries paid by a customer, per pound, in U.S. dollars. Specifically, the FOB price refers to the price paid for fruit before any shipping or packaging costs are incurred; FOB price is the price that will be returned to the grower of the fruit. Figure 1 is broken down by national retail business, regional retail business, and the wholesale or spot market business. Each one of these markets show price decreases to allow the sale of all fruit as the volume of cherries produced increases.

Figure 1 - Display of Domestic Market's Supply and Price



Literature Review

"The Market for "Lemons": Quality Uncertainty and the Market Mechanism," was written by Nobel Prize winner George Akerlof. Akerlof studied at Yale and the Massachusetts Institute of Technology. Currently, Akerlof is a Professor at Georgetown University. Akerlof's article was published in *The Quarterly Journal of Economics* in 1970, and discussed attributes of the car market regarding 'lemons' (bad cars) and 'peaches' (perfect cars). Akerlof's work goes into great detail about buyer's expectations and how expectations, particularly expectations of a fair price, change when the quality of a specific good becomes disclosed. Because produce is sold based on its grade, or quality, it is important to understand how buyers react to quality changes.

Akerlof's research is relevant to cherries as cherries are sold based upon their quality (also referred to as grade) and size. In the cherry market retail business typically takes priority of larger and higher quality fruit, and as a result retail business pays a higher price for it.

The next piece of research was written by Joshua Angrist and Jörn Pischke. *Mastering Metrics: The Path from Cause to Effect* is a book published by Princeton University Press which looks into applied econometrics and using modeling techniques with real world examples. An economics professor at MIT since 1989, Angrist is known for his research regarding effects of economic policies. Pischke is a German economist who received his Ph.D. from Princeton in 1992. Currently, Pischke is a professor at the London School of Economics; he is well known for his research in the field of applied econometrics. *Mastering Metrics* discusses modern theory in the field of econometrics.

Mostly Harmless Econometrics: An Empiricist's Companion is also written by Joshua Angrist and Jörn Pischke. Similar to *Mastering Metrics*, this book provides more examples and builds upon predefined knowledge. The authors explain more complex forms of regression and also express some doubts about when these models have been implemented. This book points out common errors in regressions and how to avoid higher level biases in the data.

Written by Gerard Tellis and published in the *Journal of Marketing Research* in 1988, "The Price Elasticity of Selective Demand: A Meta-Analysis of Econometric Models of Sales," provides insight to the relationship between pricing and market share. Gerard Tellis is a marketing professor at the University of Southern California. The article was relevant to this research because of the relatively short shelf life of cherries. Throughout a cherry season, different geographical locations take turns going through their respective peaks in harvest. Because of its location, Chelan sees a peak in cherry volume as other major production regions' output begins to dwindle. Within my model I believe that 'week of the season,' will be a very important factor in pricing, and the elasticity of pricing. By further isolating price changes due to market share, it gives me a more accurate model for price.

Lester Telser is a professor of Economics at the University of Chicago. Telser is most notable for his research in game theory. Game theory is similar to economics because of its underlying principles of trade-offs. Harlow Higinbotham received his PhD in economics from the University of Chicago. He is current Senior Vice President at NERA Economic Consulting. Together, Telser and Higinboth am authored "Organized Futures Markets: Costs and Benefits." Published in the *Journal of Political Economy* in 1977, this paper reviews the theory and importance of futures markets. Although this is not directly tied with constructing a cherry model, it is important to understand why and how other commodities are traded. Futures markets deal with set prices and with standard deviations which act as money markets. Within the cherry market only a portion of the fruit is sold in a market similar to a futures market. If futures markets are a more viable option than selling fruit in a spot market, then one must be created.

"Efficiency Tests of Agricultural Commodity Futures Markets in China" looks at soybean and wheat markets in China in an attempt to uncover whether cash or futures markets are able to provide a better market for each product. What they discover is that each commodity has its own difficulties and must be sold in different styles of markets. One of the authors, Holly Wang, was an associate professor at Washington State University before becoming a Professor of Agricultural Economics at Purdue University. The other author, Bingfan Ke, was a former graduate assistant at Washington State University.

Charles Wilson's article "The Nature of Equilibrium in Markets with Adverse Selection," was published in *The Bell Journal of Economics* in 1980. This paper is based upon Akerlof's used car market research, and it further builds on this research by looking at three distinct scenarios. Wilson considered when an auctioneer sets the price, when a buyer sets the price, and when the seller sets the price. Wilson discovered the only scenario where a true market equilibrium is met occurs when the auctioneer sets the price. When a buyer sets the price it is below what some sellers will produce at, and as a reverse some sellers will refuse to produce unless they receive a price higher than an auctioneer's equilibrium. Both cases have either an excess of supply or excess of demand. The cherry market is largely determined by the seller in the beginning, when a seller predicts its volume and what it desires to receive from it. However, as fewer buyers are willing to pay such a high price the price of cherries quickly plummets to the buyer's requests. This research revolves around determining a pricing structure which represents both sides more accurately, like an auctioneer would.

Introduction to Econometrics was written by Jeffrey Wooldridge. Wooldridge earned his Ph.D. in economics from the University of California, San Diego and is now a professor at Michigan State University. The fifth edition of his book, is largely focused on developing economic models. The textbook discusses different biases that models may cause, and explains different effects variables may have on the outcome of an economic model. The methods described in his book will be pivotal in creating an accurate model that not only includes all relevant data, but also provides an accurate estimate.

Methodology

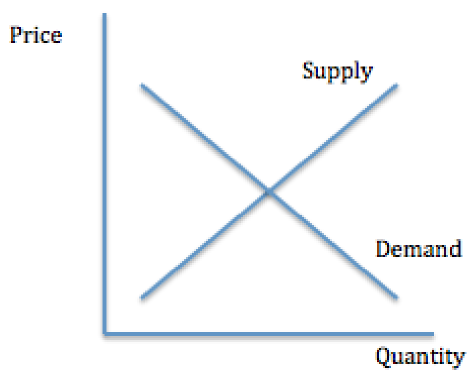
The data collected for this research stems from two sources. The first source is the internal sales data from Chelan Fresh Marketing. The second source is the Washington State Tree Fruit Association. The data provided from each of these organizations includes the type of cherry (sweet, yellow, and other), the locations where the fruit was sent, the average price of the fruit sold, the week it was sold, the indexed shipment day (day one of the indexed shipment day is the first day of consecutive shipment of cherries), and other useful data points that may affect the price of the fruit. Within these data sets the dollars paid for fruit were not in real dollars (not adjusted for inflation), as the time series of data is short and experienced low inflation rates.

During this research, three main software packages were used. The first of these statistical software programs was Microsoft Excel. Excel serves a great role in being able to comb through data, as well as transform formats of data, and reorganize said data before sending it to other statistical programs. The second program used was Tableau. Tableau is a statistical program that allows users to upload Excel spreadsheets and visualize data on clearly labeled graphs. Although Tableau isn't designed for manipulating data, it gives a good idea of what to look for in data sets. The final statistics program used is R. The program, R, is a widely used statistical program that allows users to import data, plot data, manipulate data, and create forecasts and analyses. After using Excel and Tableau briefly, most research was conducted within R.

Economic Model and Analyses

Within any market there are two parties involved: buyers and sellers. Each seller has a minimum price it is willing to sell for in order to recoup the costs to produce and market its product. On the other side of the bargaining table there are buyers, or purchasers of the product, that have placed a value to the item they intend to purchase. As the price rises, suppliers are more inclined to sell more at the higher price, and buyers are inclined to purchase less. The relation between the buyers and sellers results in the market supply, and market demand curves as seen in figure 2.

Figure 2 - Supply and Demand

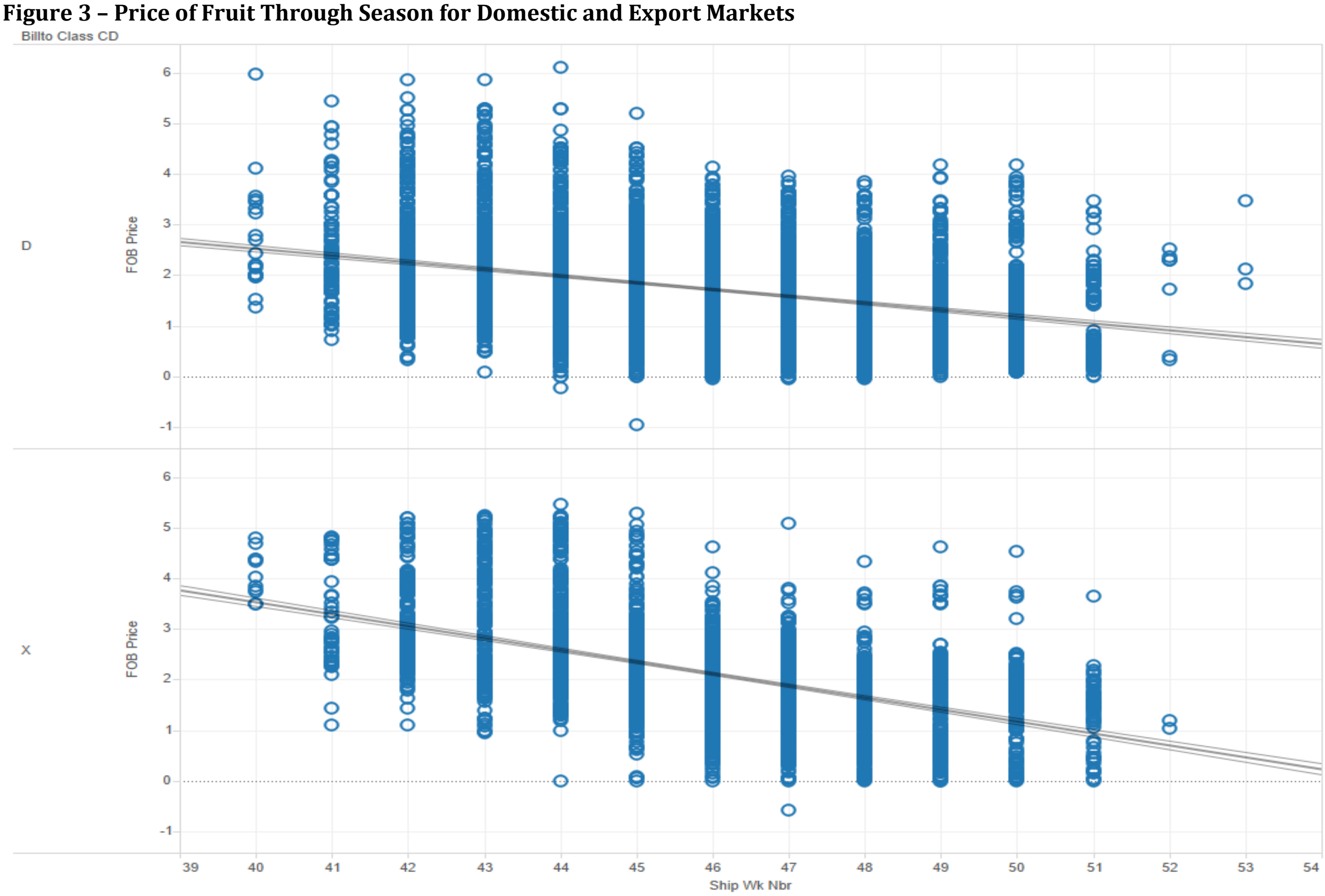


The model of market demand and supply can be seen in cherry markets. Typically, as volume increases, the supplier is willing to sell at a lower price in order to sell more product, and because the price has lowered the customer is able to purchase more. Thus, the new transactions at a lower price are able to "clear the market."

Within the particular data set provided by Chelan Fresh Marketing, a distinct price drop is noticed as the production season progresses.

As seen in the figure 3 below, prices fall as days in the season pass by. This particular chart shows price, in U.S. dollars per pound, for all transactions during the years 2012 until 2015, based upon the ship week of the season. The chart is also split into two categories. The upper chart, D, shows all pricing for domestic orders; while the bottom chart, X, shows all export orders. Each chart has a negative correlation between price per pound in USD and the ship week of the season.

Figure 3 – Price of Fruit Through Season for Domestic and Export Markets



The regression for each of these lines helps give an approximate representation of pricing for each market. For exports, on average, the price of fruit may be determined by the equation,

$$-.235624 * (Week\ Shipped) + 12.9496.$$

For the domestic market the price is approximately determined by,

$$-.1342 * (Week\ Shipped) + 7.88614.$$

This shows that in week 40, based on recent pricing, fruit sold domestically would return $2.52 per pound on average, and exported fruit will return $3.52 per pound. Using the same equation, in week 50 domestic markets would be presumed to return $1.18 on average, and exports could expect to see $1.17 on average.

Figure 4 - Price for a Season Separated by Domestic Market

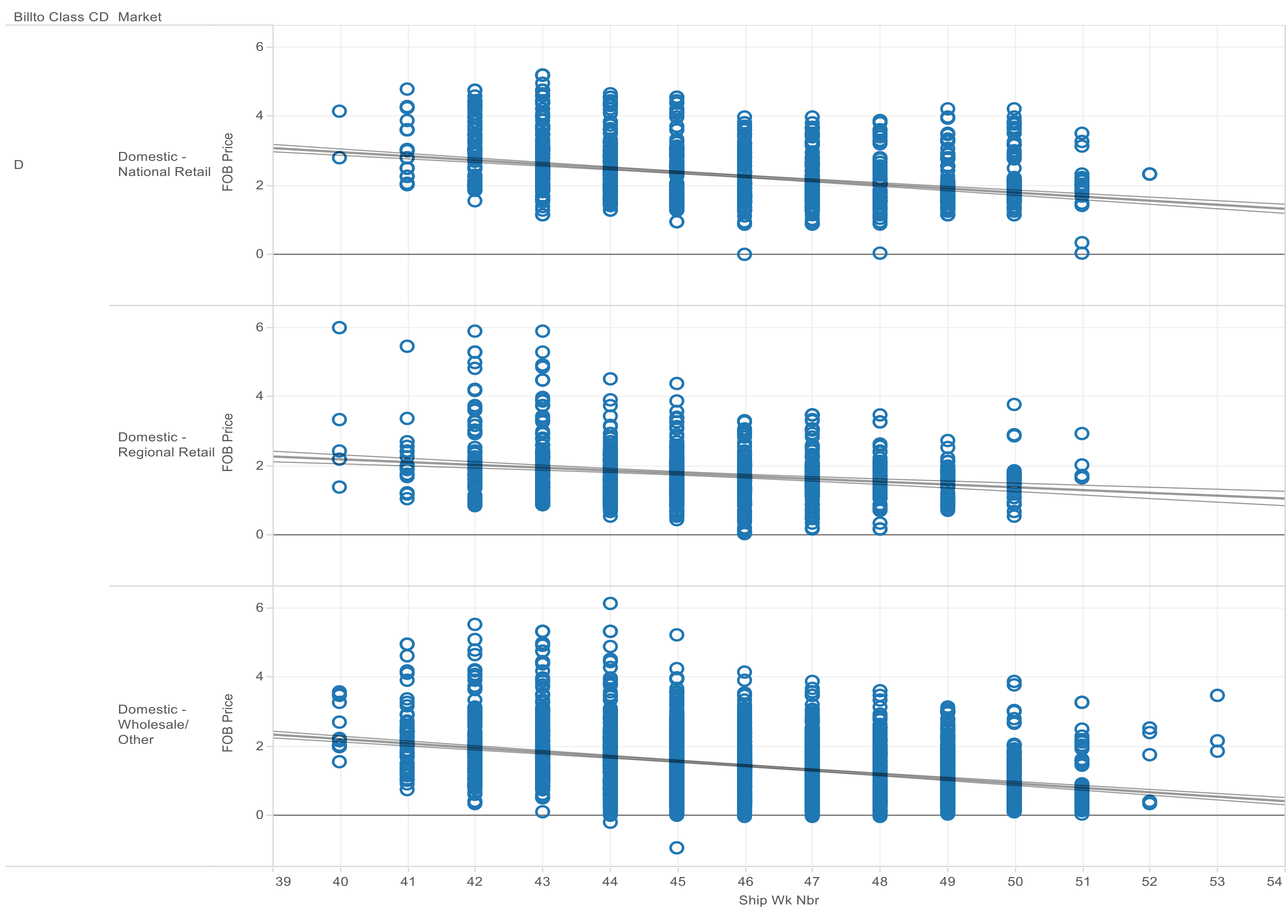


Figure 4 above shows the same information (price per pound by shipment week) strictly for domestic business broken down by national retail businesses, regional retail businesses, and other wholesaler businesses. National retail business is defined as those who fall into the classical futures market pricing model (purchasing fruit in advance for later shipment). Regional retail refers to smaller chains of stores that typically order in advance, but do not have the same national scale among distribution centers. Wholesale in this case refers to resellers or buyers who do not intend to sell fruit to a final customer. A linear regression of each market shows that national retail follows a pricing pattern of,

$$-.116963 * (Week\ Shipped) + 7.63073,$$

regional retail sold at approximately,

$$-.0808682 * (Week\ Shipped) + 5.41471,$$

and other wholesale received a price per pound of,

$$-.12832 * (Week\ Shipped) + 7.33507.$$

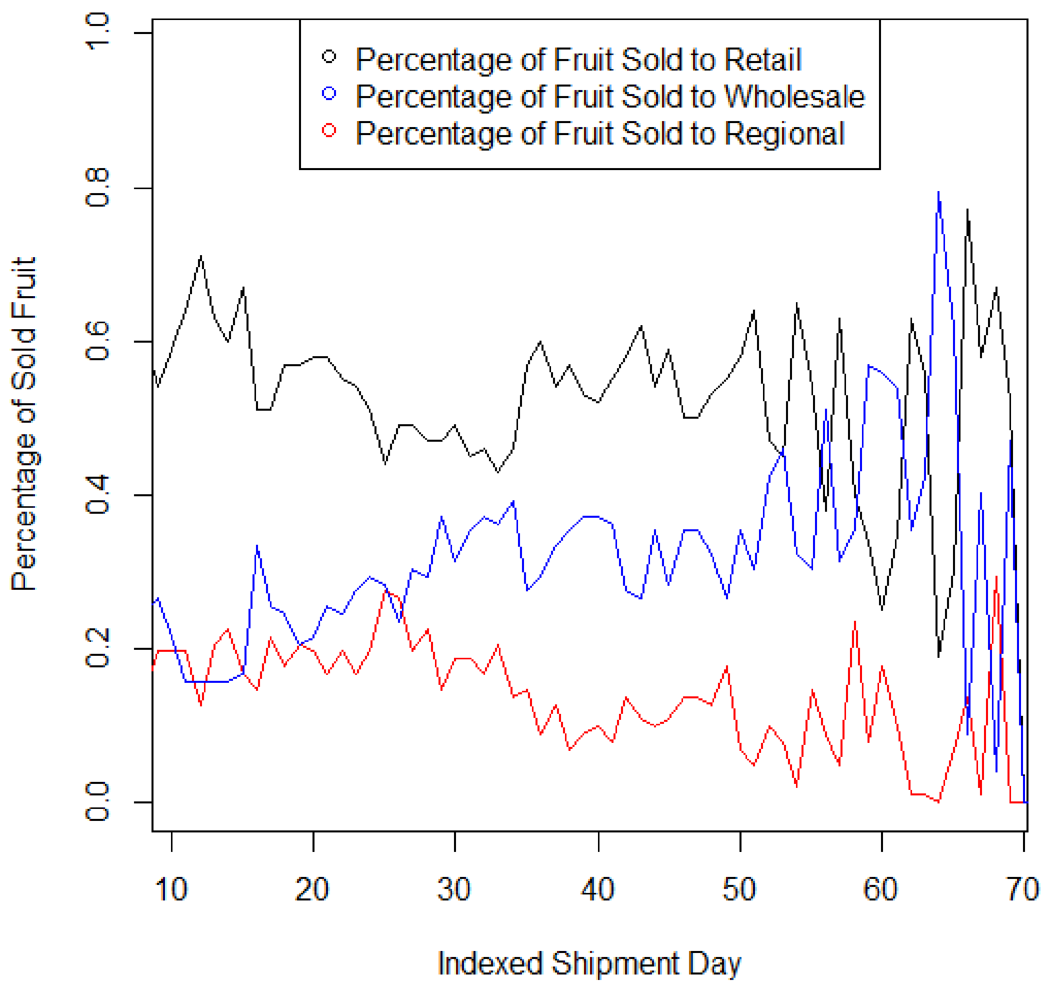
If a season lasted only from week 40 until week 50, received prices would range from $2.95 to $1.78, $2.18 to $1.37, and $2.20 to $.92, for each market respectively.

Each of these charts show some negative values that fall below the zero line indicated. These zero values are a result of orders where the fruit was not to a customer's expectations and the price was lowered. Because the cost of shipping and packaging cannot be negotiated after-the-fact, the price of sold fruit sometimes displays as a negative value.

The results of the regression reaffirmed the initial predictions which assume prices fall as each season continues. Market retail starts higher than all other domestic sales, but is only able to retain 60% of its initial price tag over the course of a season. However, wholesale markets start at about the same price as regional retailers, but drop lower than any other market by week 50 (the hypothetical end of the season). At the end of week 50, wholesale markets are predicted to retain only 41.7% of their original price. Here lies the problem that current sales companies face. Toward the end of each season, wholesale markets are leaned upon by sellers to receive more fruit than they may be able to process or resell. According to the market supply and demand model, these buyers will require a much lower price in order to purchase such a large volume.

The progression of wholesale markets purchasing can be seen in figure 5.

Figure 5 - Percentage of Fruit Sold to Each Market by Day



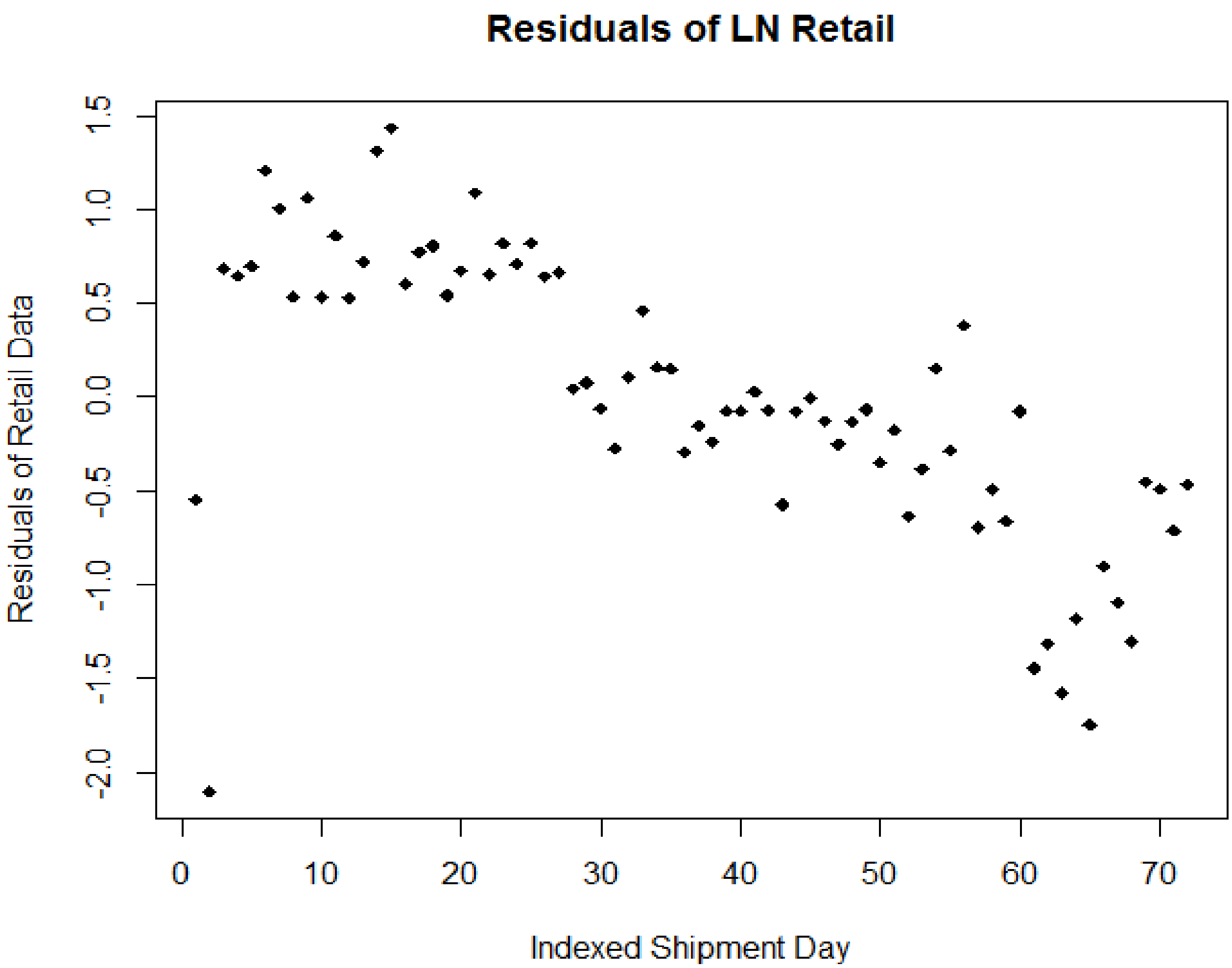
Each of the dots marks the specific percentage of fruit that goes to a specific market for each indexed shipment day. The data for this chart is aggregated from the crop years of 2011-2014. Day 0 of indexed shipment days marks the first day of continues shipment for each season. If the first 10 days prior to day 0 are negated, then a fairly clear preference can be seen towards retail market buyers, and wholesale buyers purchase more and more fruit as the season continues.

As previously discussed, the increase in wholesale market sales is caused by two factors, both the market supply and demand theory, and Akerlof's theory of peaches and lemons. Towards the tail end of any given season, retail markets have purchased all they are interested in purchasing, and as a result the retail market will only purchase fruit if the price is signifigantly lower. At the same time, the quality of cherries being produced starts to decline as a result of being the last fruit off the tree, or by being held in storage for too long. Both being the last picked fruit, and nearing the edge of the shelf of a cherry lower any price premium the fruit may have previously demanded. In general, the wholesale market demands less premium fruit than retail or regional markets, and as a result purchases more of the late-season cherries than other markets.

The pricing model is arguably the biggest factor that leads to irregularities of market share throughout a cherry season. To look closer at the price differences, the natural log of each day for each market was taken. The residuals of each market for price and volume of fruit shipped were then plotted against each other. Because some days in the data set were recorded as having no sales, the log of these days resulted in a negative infinity calculation; these observations were removed from the dataset. By calculating these values from the natural log (ln) of each data set, the data can be seen in percent changes and elasticities. A change in the natural log of *x* almost directly relates to a percentage change in the same variable.

Looking at the wholesale market, towards the beginning of the season the selling firm is charging too little, whereas at the end of the season they are charging too much. However, the distribution of retail pricing lands in nearly a straight line suggesting that there may be a steady pricing model.

Figure 6 - Residuals for Retail Data



The residuals of this data set are the differences between predicted and actual values, and if each of the residuals were to land at approxiamately zero then the result would be that the retail pricing does not change from day to day. However, the spread of values for the retail data set was much smaller than the spread seen for the wholesale and regional data sets. Residuals for the retail data, as seen in figure 6, landed between 1.5 and -2, however regional residuals were spread from 2 to approxiamtely -6 (seen in figure 7), andresiduals for the wholesale data ranged from 2 to -8 (seen in figure 8).

Figure 7 - Residuals for Regional Data

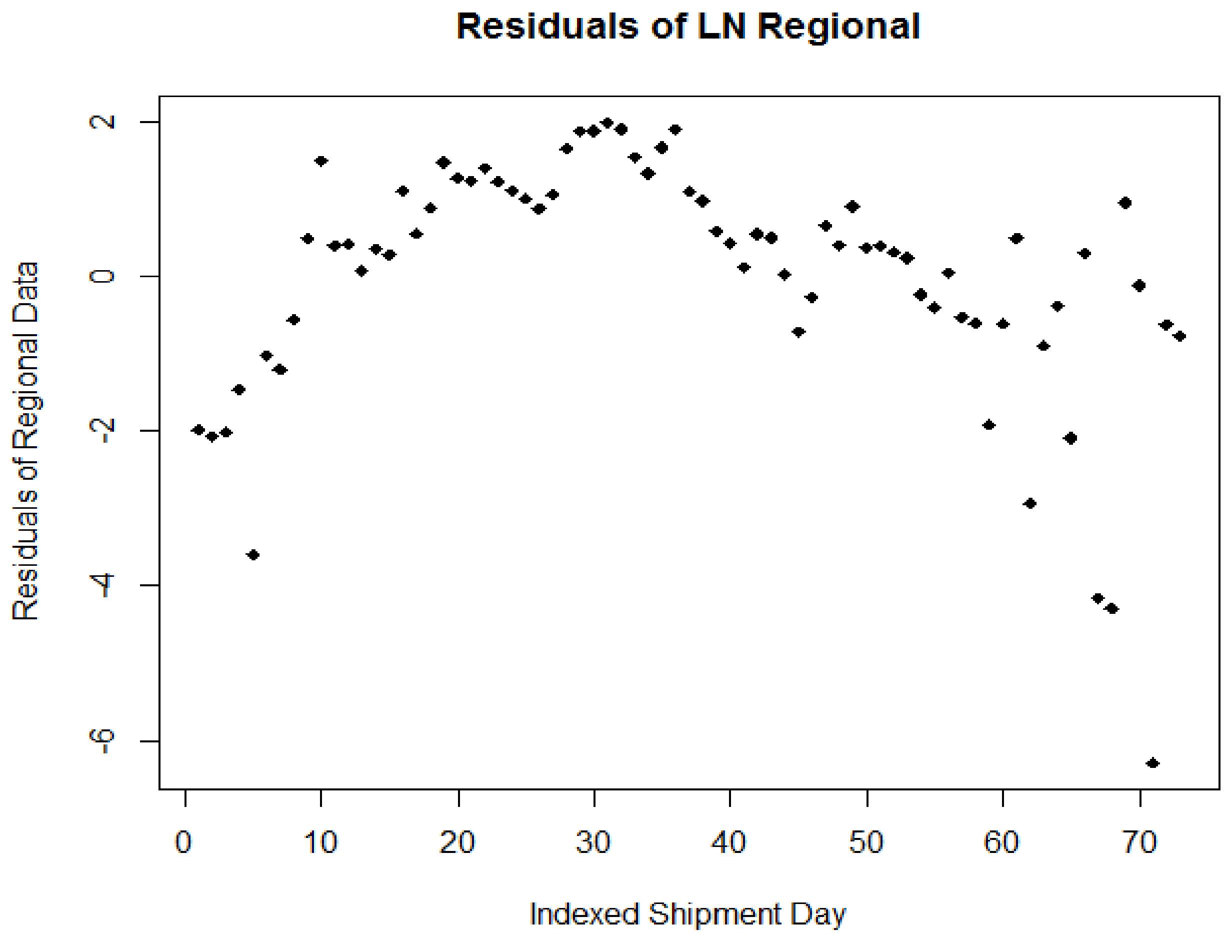
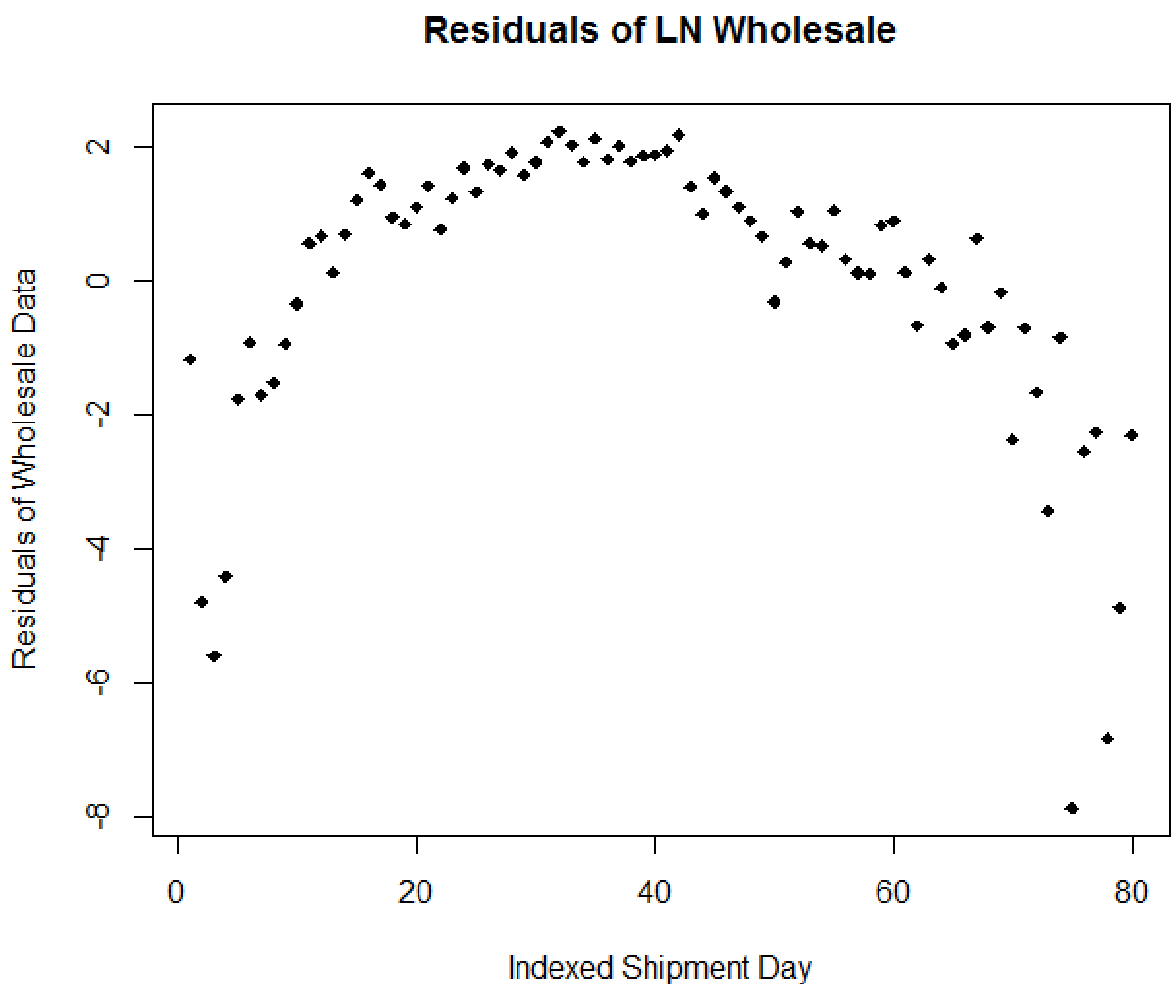


Figure 8 - Residuals for Wholesale Data



The residuals for the wholesale and regional markets prove troublesome because they show that the pricing for each market was inconsistent, and did not necessarily reflect on previous days prices or volume. Plotting the residuals of each market's data set also demonstrates that a linear model approach does not correctly capture the pricing model as was expected.

Knowing the prices for each market were inconsistent, its important to see each markets prices in relation to each other. Because regional sales account for a smaller portion of the sales than retail or wholesale markets, regional sales were negated for this portion of analysis.

Theoretically, the retail market should have a nearly standard mark-up on price in relation to the wholesale market. The mark up would be a result of higher quality fruit that is packed specifically to a customers needs. If a standard mark existed it would be seen when plotting the natural log of wholesale prices against the natural log of retail prices.

Figure 9 - Natural Log of Wholesale Prices against the Natural Log of Retail Prices

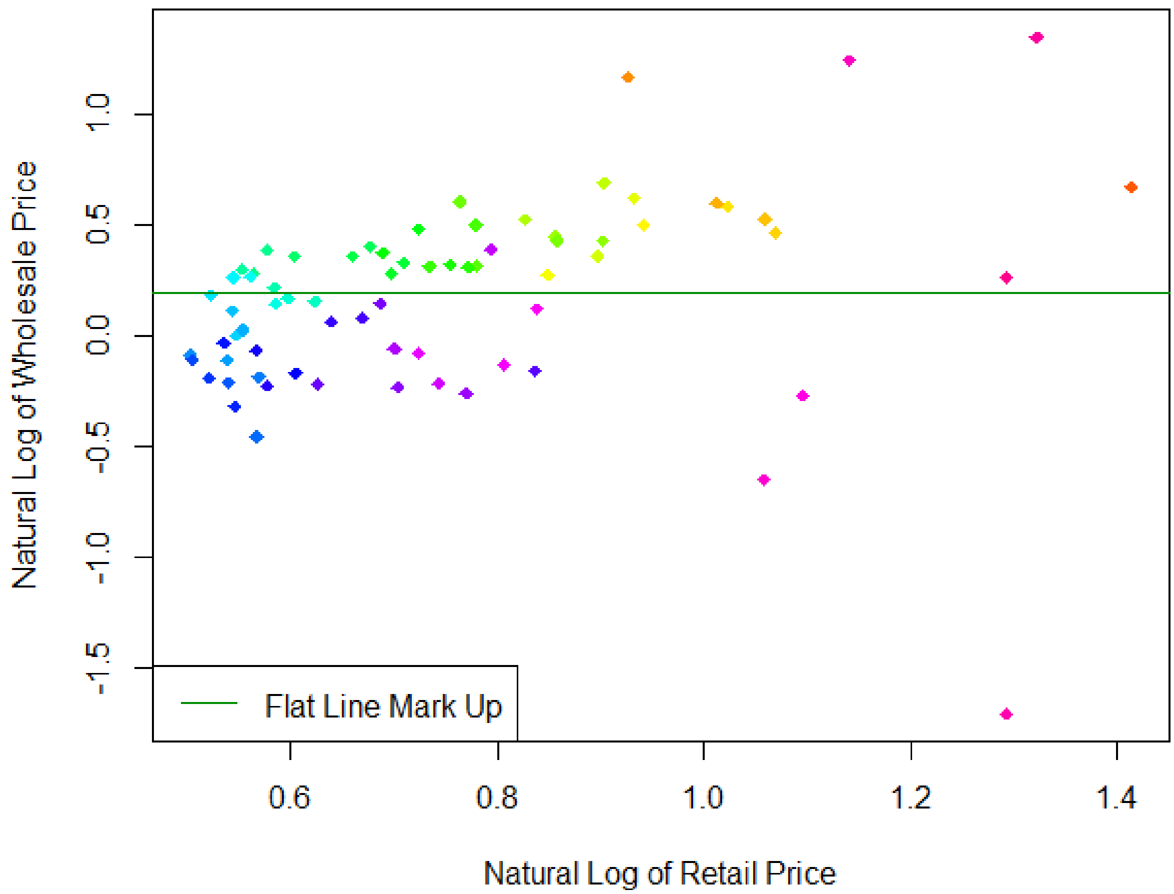


Figure 9 shows the regression of natural logs of both retail and wholesale prices. To illustrate when each observation occurs, the first sales of a season are seen in dark blue, and the final sales are seen in dark red. If there was a constant mark up of .2/.6, then all points would fall along the green line illustrated. However, the trend of the data shows that mark ups for retail sales are much lower in the beginning of the season than at the end of the season.

The mark-up for each day aggregated from all years of observations can be found by dividing the retail price by the wholesale price for the same day. Within this calculation, the only shipment days looked at were from the first day of continuous shipment until the 60th day of shipment for each season. The narrower window eliminates null data points caused by days where there were not shipments to both retail and wholesale markets.

Figure 10 - Retail Markup for Days 0-60

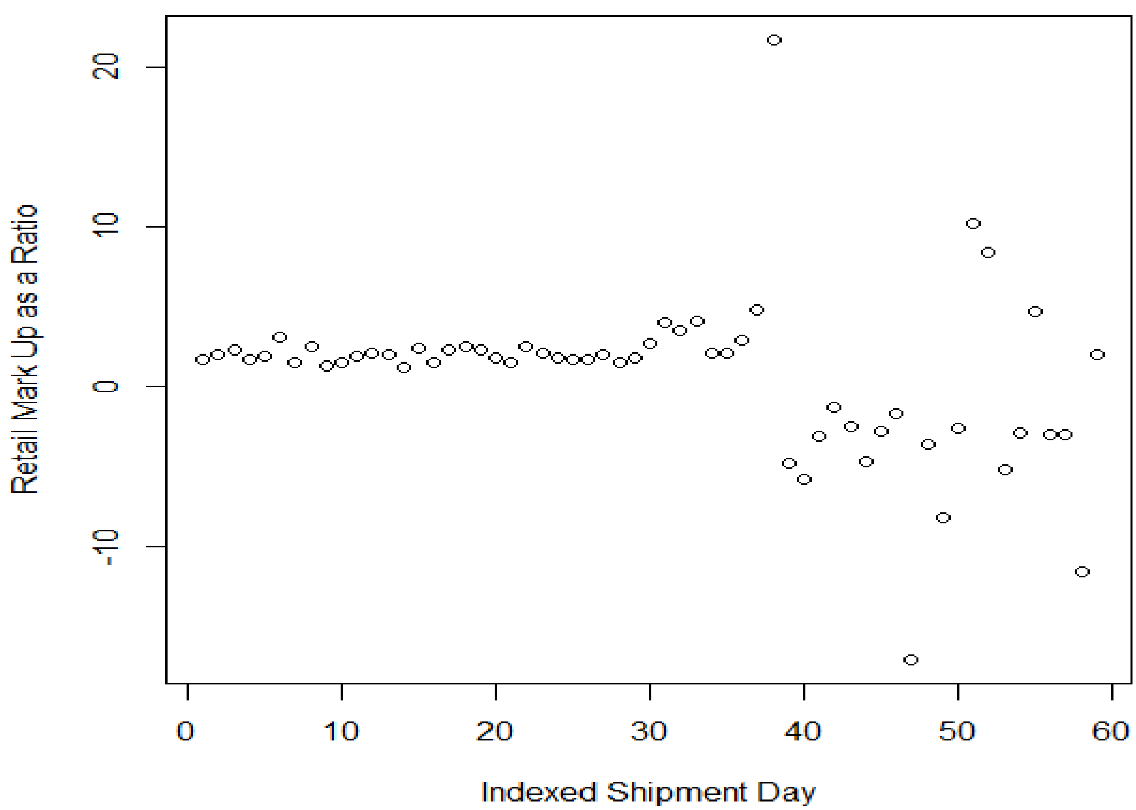
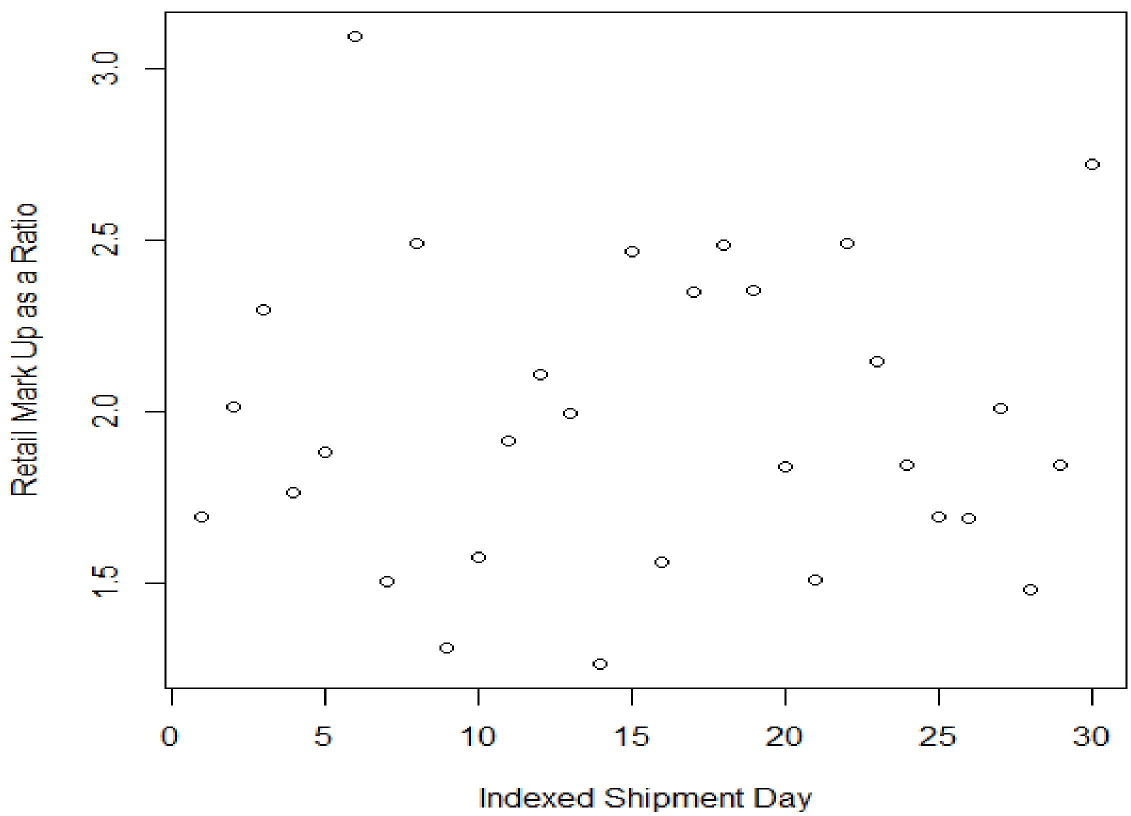


Figure 10 displays the multiplier for days zero through sixty of the crop years 2011-2014. Each days multiplier is seen on the x-axis; multipliers for this data ranged from roughly -15 to slightly over 20 times the price paid in the retail market opposed to the wholesale market. Day 37 was omitted from this chart as it was an outlier that saw an average multiplier upwards of 600. The remaining data shows two things: after approxiamately day 30 there seems to be no consistent markup for retail fruit, and in some cases wholesale fruit was sold at a higher price premium than retail fruit.

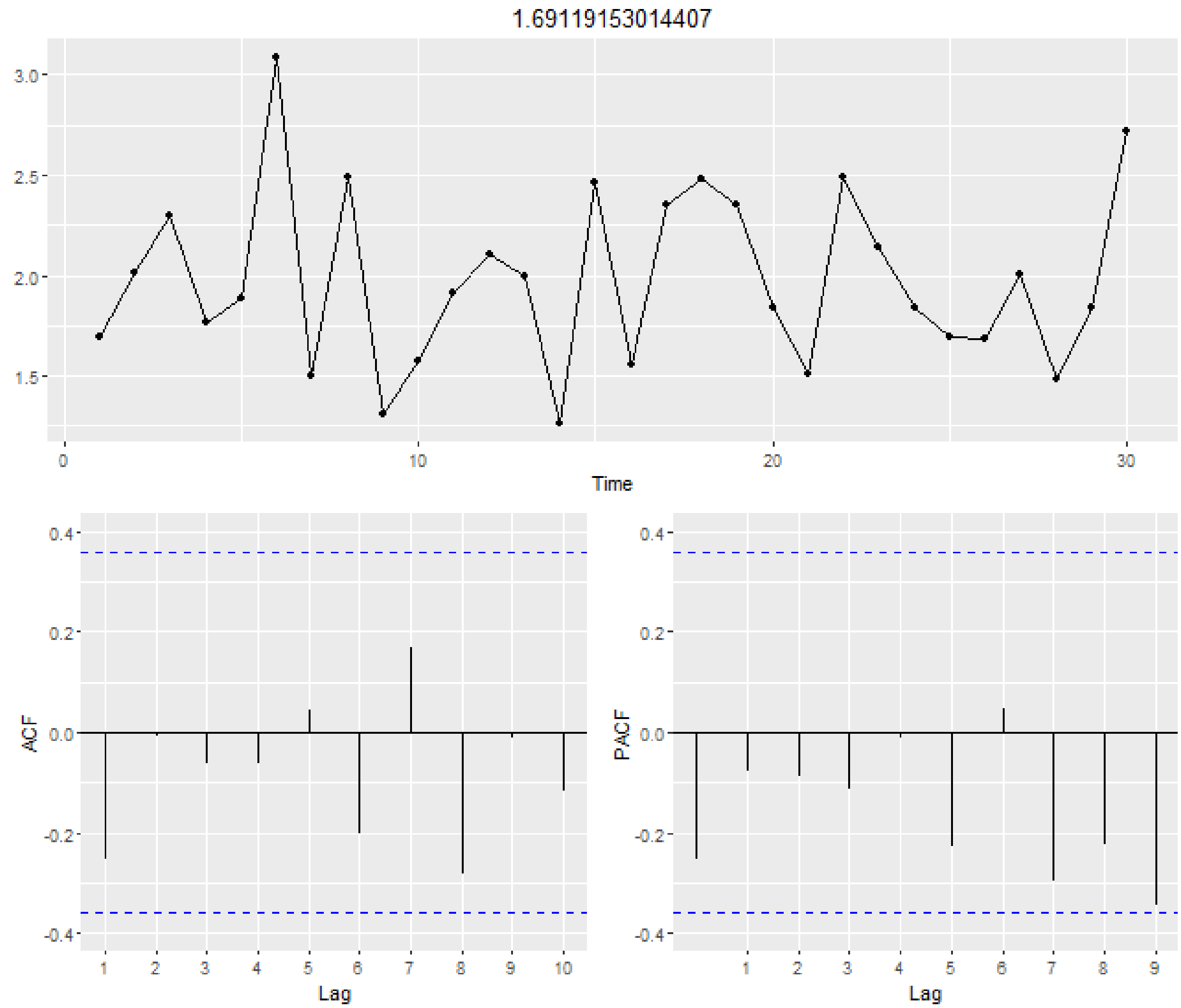
Figure 11 - Retail Markup for Days 0-30



Wide uncertainty regarding the price mark up at the end of the season can be explained both by liquidation of remaining cherries by the supplier, and a lack of a solid pricing model that predefines a set mark up. However, when looking at only the first thirty days, as seen in figure 11, of consistent shipping during a season a new story can be seen. The markup for retail fruit can be seen as anywhere from $1.30 for retail-sold fruit for every $1 of wholesale-sold fruit, to $3 for retail-sold fruit for every $1 of wholesale-sold fruit.

To further the evidence found in the previous chart about random pricing, an auto-correlation function was used. The data used for the auto-correlation also omitted the outlier variable of day 37.

Figure 12 - Auto-Correlation of Days 1-30



At the top of figure 12 the raw relation is seen showing the mark-up for each day. The bottom shows both the auto-correlation function and a partial auto-correlation function displaying price changes over a series of days (lags). Although the observations never leave the blue confidence intervals, they do flip from being positive to negative. Within the auto-correlation this flip across the zero line says that if a sale was made at a high mark up, then it will be at a negative mark up a certain number of lags (days) later. If there was a constant mark up across all fruit sold then there would be no deviation from the zero line.

Conclusions

Within the Washington State cherry crop there are discrepancies in the pricing structure that limit sales firms from maximizing their profit. The root of the issue was thought to be that wholesale markets were not being charged enough, and that wholesale sales were undercutting the traditional business to retail markets.

For the crop years 2011-2014 there seems to be no consistent pricing strategy to charge more for retail fruit over wholesale fruit. The pricing discrepancies can be seen in the first half of the season, and then become amplified when there is a consolidation of inventory at the end of a season.

To help eliminate sporadic price changes, a flat mark up, or relatively consistent mark up, should be implemented. A constant mark-up on fruit sold to the retail market would help to eliminate the retail market waiting days for the price to drop before purchasing more fruit. By implementing such a pricing structure firms should expect to see more consistent purchases from all markets rather than each market waiting until the price falls to purchase their fruit. A constant mark up would also further define the roles of each market to the supplier in the sense that a specific percentage of all fruit may be sent to each market specifically rather than a fairly random distribution of fruit across the season.

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