FACTORS ASSOCIATED WITH PRICE RESPONSIVENESS OF CONCORD GRAPE GROWERS IN NEW YORK STATE

A Thesis

Presented to the Faculty of the Graduate School

of Cornell University

in Partial Fulfillment of the Requirements for the Degree of

Master of Science

by

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December 2021

ABSTRACT

New York State is the second-largest producer of Concord grapes in the US, and economic activities related to Concord grapes have a significant impact on the state. In recent years, there has been a shrinkage of vineyards and land producing Concord grapes, which is acknowledged as the response to the long-last declining prices and shift of consumer preferences. In this study, we surveyed individual Concord grape growers in New York and collected thirty usable responses, which were used to examine factors that are associated with Concord grape growers' supply response to price changes. We employ t-tests to compare the characteristics that differentiate responsive growers and non-responsive growers. In addition, we adopt the logit model to estimate growers' responses to different levels of price changes. Based on a study that estimates the supply elasticity of California wine grapes, we utilize a two-stage least squares (2SLS) model to estimate the price supply elasticity of the New York Concord grape growers. We find that Concord grape supply is elastic to price changes in the long run. Lastly, using the estimated supply elasticity and the data from the grower survey, we estimate growers' acreage and production response to price changes. These findings shed light on the drivers of growers' production decisions, and can help the industry understand the challenges Concord grape growers are facing.

BIOGRAPHICAL SKETCH

Jialiang Sun was born in 1997 in Tianjin, China. She grew up in her hometown Tianjin and went to Nankai University for undergraduate studies. Majoring in Economics, she received her Bachelor of Science degree in July 2019. She is a Master of Science candidate in Applied Economics and Management at Cornell University. After graduation, Jialiang will work as a product analyst at Adobe.

This document is dedicated to all Cornell graduate students.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to those who helped and supported me. First and foremost, I am sincerely grateful to my advisor Dr. Miguel Gómez, for his constant support and guidance throughout my master's studies and in all the time of my thesis research. I am also grateful to Dr. Calum Turvey for his willingness to serve on my committee and feedback on my thesis. I would like to thank my committee member, Dr. Jie Li, for providing survey data, and all her guidance and assistance, as well as many encouragements during the research and writing process. I would also like to express my appreciation to Dr. Leslie Verteramo for his help with the initial survey design, and the support and feedback for improving my thesis. Their help and encouragement are highly important to me.

Last but not least, I would like to express my deepest thanks to my family members and friends who are always there to support me with lots of love. My parents and my brother always believe in me and give me all the support for me to have a great time while studying abroad. Their encouragements were the most valuable for me while I was struggling with classes at first. My boyfriend has accompanied me all the time through the pandemic, I could not imagine living under pandemic without his company. Last, I want to thank my friends who helped and supported me through my master's studies.

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CHAPTER 1

INTRODUCTION

Concord is an aromatic grape variety that is the major source to produce grape juice, grape jellies, and jams in the US. As the fourth largest produced grape variety in the US (Alston and Sambucci, 2019), Concord grapes have a significant impact on the country's economy. The five major states growing Concord grapes are Washington, New York, Pennsylvania, Michigan, and Ohio. Among these states, Washington is the country's leading producer, followed by New York and Pennsylvania. In 2017, Washington produced 176,000 tons of Concord grapes, followed by New York, which produced 125,000 tons of Concord grapes. Noticeably, the Lake Erie Region, which crosses New York, Pennsylvania, and Ohio states, is the largest and oldest Concord grape-growing region in the country, producing more than 190,000 tons in 2017, more than Washington.

In the most recent decade, the Concord grape industry has seen a substantial price variability: as high as 292 dollars per ton in 2012, and as low as 207 dollars per ton in 2014. In response to low prices, there has been a decline in bearing acreage and production after 2014. Starting from 2015, the land planted to Concord grapes fell around 20 percent in Washington and Michigan, and 10 percent in the Lake Erie Region, including New York, Pennsylvania, and Ohio (Martin, 2019). Concord grape prices grew steadily and reached 222 dollars per ton in 2017. Figure 1 displays the trend of Concord grape production and prices over the past twenty years in the United States.

New York is the second-largest producer of Concord grapes in the US. Con-

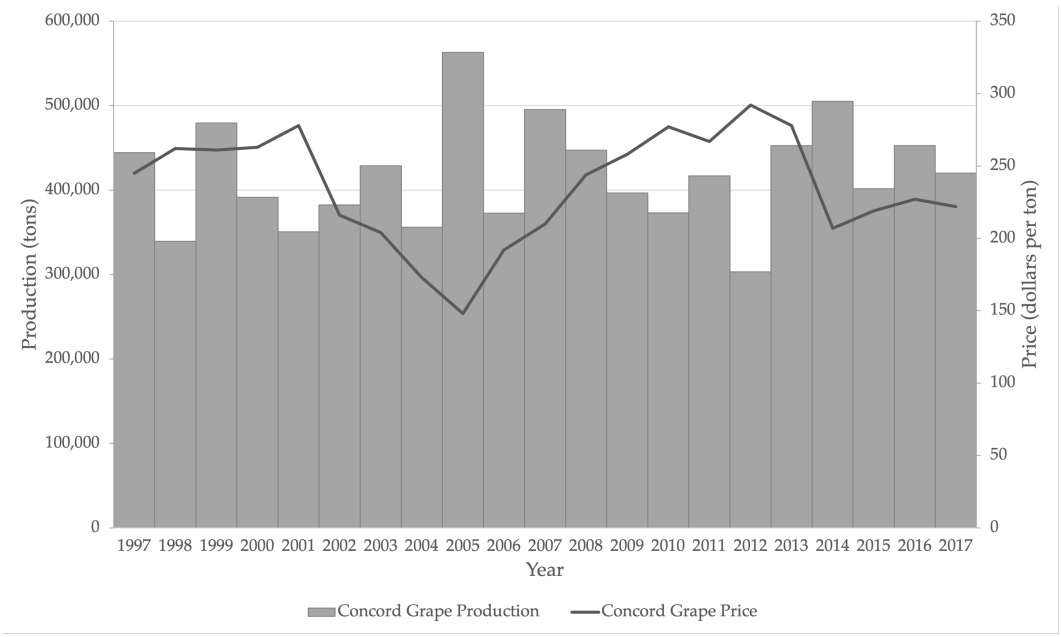

Figure 1: United States Concord grape production and prices (1997-2017)

cord grapes constitute 80 percent of the total grape production in New York[1], and most of the harvested fruit is made to produce juice. It is estimated that in New York, grape-related production activities such as growing, processing, and wine-making support nearly 2,000 jobs and contribute 340 million dollars in total economic impact to the state's economy[2]. In recent years, New York's Concord grape growers are facing not only challenges from declining prices resulting from oversupply and unpredictable weather but also declining consumer preferences for carbohydrate-rich drinks. These market challenges have already caused a decline in the supply of Concord grapes.

This study aims to investigate how growers would adjust their production decisions in response to price changes. This is relevant for businesses depending on Concord grape production and policymakers interested in supporting

[1]Cornell projects support Concord grape growers in New York

[2]Department of Agriculture and Markets and New York Wine and Grape Foundation Launch New Social Media Campaign to Promote Concord Grape Industry

this important sector of the state's rural economy. To our knowledge, no studies to date have collected primary data from Concord grape growers in New York to assess supply response to price changes. We designed and conducted a survey among Concord grape growers to study how growers would respond to price changes. Additionally, we leverage secondary data to estimate the long-run price elasticity of supply. We combine the price elasticity estimates with the results from the grower survey to simulate, in the context of the sample growers participating in the survey, how the acreage of Concord grapes may change in response to changes in prices.

Our results suggest that growers who are responsive to price decreases tend to sell more grapes through more volatile cash markets, which makes them more vulnerable to unfavorable market conditions. In addition, our analysis shows that the Concord grape supply is elastic in the long run. Lastly, our estimation of growers' acreage and production response to price changes indicates that the impact of price changes is asymmetric, so the supply response is much larger when price drops in comparison to when price increases.

Our study contributes to the literature on supply response to price changes in the grape sector. The results could inform decisions for the design of price strategies affecting Concord grape growers and other interventions to support the supply of the Concord grape market in New York. The remainder of the thesis is structured as follows: Chapter 2 summarizes the relevant literature; Chapter 3 describes the methodology; Chapter 4 describes the summarized statistics; Chapter 5 presents and analyzes the results; Chapter 6 discusses and concludes the thesis.

CHAPTER 2

LITERATURE REVIEW

2.1 Concord Grape Production and Demand

The Lake Erie Region is the largest and oldest Concord grape-growing region in the world. A considerable number of vineyards in this region have more than a century of history in growing Concord grapes. Around two decades ago, the yield of Concord grapes averaged only three tons per acre. Nowadays, the yield of Concord grapes is about six tons per acre, because of the continuing research and the adoption of new production technologies (Gashler, 2018). However, along with the increasing yield, Concord grapes have experienced oversupply in recent years, which has led to lower grower prices and challenges for producers. In New York alone, Concord grape's bearing acreage declined by 15 percent from 2012 to 2017, and 202 vineyards exited the market during this period[1].

In addition to the oversupply problem, the market has also experienced a declining demand for Concord grapes due to shifts in consumer preferences. In recent years, the consumer interest in healthy food (e.g., foods with low sugar content and added fiber) has been growing fast (Bimbo et al., 2017). Grape juice is often considered an unhealthy beverage option because of the high sugar content of the naturally grown product (Wojtanik, 2018). Nevertheless, consumers prefer grape juice that is produced with 100% fresh grapes over juice concentrate (Priyadarshini and Priyadarshini, 2018). Scientific research has revealed

[1]According to USDA National Agricultural Statistics Service, 1235 vineyards had in total 36919 acres of land bearing grapes in 2012 across New York, while in 2017, only 1033 vineyards remained in the market with 31464 acres of bearing land.

a great number of benefits that grape juice provides, such as improving memory function among adults with mild cognitive impairment and reducing the blood pressure of hypertensive adults (Lamport et al., 2016). Researchers also show that the plant nutrients or polyphenols present in Concord grape juice might aid in slowing down the body's absorption of naturally occurring sugars in the juice, implying that 100% grape juice is distinctively different from sugar-sweetened juice (Moser, 2016). Despite these benefits, Concord grape juice is still facing challenges in demand. One reason might be the lack of marketing efforts emphasizing the health benefits associated with Concord grape juice.

2.2 Supply Elasticity in the Grape Market

In agricultural supply response research, the Nerlove model has been widely adopted to examine supply response to price changes (Askari et al., 1976). Nerlove proposed that growers' planting decisions are based on the expectations of future prices (Nerlove and Addison, 1958). Growers constantly revise their price expectations based on the actual received prices and thus their expected price is a weighted moving average of past prices (Nerlove, 1956). The Nerlove model has been used and modified by many researchers to examine different types of crops. Askari and Cummings (1977) found that some literature analyzing perennial tree crops involved current prices at the harvest time and past received prices, because post-planting shifts in prices may also have a significant impact on the harvest in addition to planting decisions. Since supply shifts might also be associated with demand changes, and the expected price reflects the intersection of anticipated supply and anticipated demand, there might be endogeneity issues of the expected price (Roberts and Schlenker,

2013). Researchers have discussed the endogeneity issue associated with expected price (Choi and Helmberger, 1993a), in which inventory is usually used to address possible endogeneity issues in estimation.

In terms of the grape market, researchers have studied the supply response of wine grapes. Volpe et al. (2010) estimated a simultaneous system of equations for California's four major wine grape-growing regions and eight of the most widely grown varieties. The study found that California wine grape supply is price inelastic. Alston et al. (2013) used a simulation model to compute the region-specific elasticity of California wine grapes. They found that the elasticity becomes larger when a longer time for price adjustment is allowed. Overall, evidence from the literature shows the wine grape price elasticity of supply is generally inelastic, meaning that the bearing acreage, as well as production, changes modestly in response to price changes.

2.3 Growers' price response

The price elasticity of supply reflects the response of suppliers with respect to market price changes. Knowledge about the individual decision-making processes of a grower is also important to policymakers. A study in the Pakistan context analyzed a farm household survey among rice growers from Punjab to assess the scope of the local price support policy. The results show that rice growers are not responsive to price changes, and they are more willing to respond to increased fertilizer application (Farooq et al., 2001). Another study in Pakistan studied wheat growers' response to price changes and found growers are indeed making planting decisions in response to price levels. The results

also show that education plays a significant role in farm profitability (Junaid et al., 2014). In terms of grape growers, Sumner et al. (2001) studied the bearing areas of California wine grapes and claimed that growers are more likely to decrease production when a long-lasting price collapse is projected. Centinari et al. (2016) surveyed 39 Pennsylvania wine grape growers and found that the major issues limiting production and profitability are disease control, frost injury, and labor availability. Since individual-level analysis of growers' response usually needs primary data collection through surveys, research on grower response to prices and how prices affect planting decisions is scarce. In particular, to our knowledge, no previous study has surveyed Concord grape growers in the US to understand how price changes affect their production decisions.

To fill this gap in the literature, this study developed and implemented a survey among New York Concord grape growers to examine the relationship between price changes and the acreage allocated to this commodity. In addition, we estimate the supply elasticity for New York Concord grapes to combine it with survey results and simulate the changes in production and total acreage planted to Concord grapes at different levels of price changes.

CHAPTER 3

METHODOLOGY

3.1 Data Collection

Two datasets were compiled in this study. The first dataset involves a study aiming to understand Concord grape growers' responsiveness to the market price changes, and the second one consists of market data to estimate the supply elasticity of Concord grape in New York in the long run.

Specifically, a mobile-friendly online survey questionnaire was designed on the Qualtric survey platform. The survey questionnaire was then sent to survey experts and Concord grape extension specialists for validation. It was later distributed to New York Concord grape growers from September 2020 to March 2021. To reach more growers and increase the response rate, the survey questionnaire was distributed through the growers' email list provided by Cornell grape extension associates and through the weekly newsletter sent by New York Grape and Wine Foundation. In the end, thirty usable responses were collected. The survey questionnaire asked growers' information about their vineyards, the yields and received prices in the last three years, and growers' opinions on the current market conditions. In addition, growers were asked to indicate their production decisions under different market conditions. Growers were also asked to provide their social-demographic information. The complete survey questionnaire is included in the Appendix.

In addition, the second dataset with regard to Concord grape production, price, and climate measurements over the period 1989-2017 in New York was

compiled from various sources. Specifically, the annual production data (in tons) and annual price data (in dollars per ton) were collected from New York State Agricultural Statistics Annual Bulletin from the National Agricultural Statistics Service (NASS) website. The climate data was collected from National Oceanic and Atmospheric Association (NOAA). In this study, we use the New York monthly county-level data, including (1) the absolute value of precipitation from May to September, in inches, (2) the minimum temperature during June, in degrees Fahrenheit. In New York, Concord grapes typically bloom in June and harvest in September, during which precipitation plays an important role in determining the yield on that year. Temperature is crucial to the bloom season. Lower temperatures might delay the bloom date, resulting in poor fruit development. Therefore, the minimum temperature data was collected as an additional measurement of the weather condition in the bloom season.

3.2 The Econometric Model

3.2.1 Production decisions under various price conditions

In order to study growers' production decisions (supply responses) under various market price conditions, we asked growers whether they would change production in response to various market price increases (i.e., 5%, 10%, 20% and 30% increases) and decreases (i.e., 5%, 10%, 20% and 30% decreases). The reason for such hypothetical settings is that we want to examine how growers would respond rationally to projected price changes, instead of random fluctuations. For instance, growers were asked whether they would increase production if

the market price for Concord grapes increases by 5 percent and the production cost remains constant. If their answer is yes, they are categorized as responsive growers to a 5 percent price change; if their answer is no, they are categorized as non-responsive growers to a 5 percent price change. They would then be asked the question again but presented with a greater price change than 5 percent (e.g., 10% price change). We first use a simple t-test to compare the surveyed characteristics between responsive growers and non-responsive growers. In addition, we employ logit models to examine growers' characteristics that may be associated with growers' price responsiveness. Specifically, for the price increases, the model specification is:

$$\begin{aligned} Response\_increase_i = \beta_0 + \beta_1 concord\_land\_percent_i + \beta_2 year\_from\_plant_i \\ + \beta_3 grape\_sell\_through\_coop_i + \varepsilon \end{aligned} \tag{1}$$

The dependent variable $Response\_increase_i$ represents the response of grower i to price increases. The variable equals 1 when growers indicated that they would increase production in response to a certain price increase in the next five years, and 0 otherwise. In the logit regression models, we consider two price change scenarios: 10 percent increase and 30 percent increase. The control variables in this model are collected from the survey as well. The variable $concord\_land\_percent_i$ measures the percentage of land dedicated to Concord grapes of grower i, where a higher number means the grower may depend more on Concord grapes to generate income. The variable $year\_from\_plant_i$ measures the number of years since the vineyard has planted Concord grapes for grower i. The variable $grape\_sell\_through\_coop_i$ measures the percentage of grapes that grower i sells through cooperatives.

With regard to logit models measuring growers' responsiveness to price de-

creases, the dependent variable $Response\_decrease_i$ is defined as 1 if grower i would decrease production when price decreases by a certain percent, and defined as 0 otherwise. Furthermore, the same set of control variables are included in these logit regressions. The model specification is shown in the following Equation 2:

$$\begin{aligned} Response\_decrease_i = \beta_0 + \beta_1 concord\_land\_percent_i + \beta_2 year\_from\_plant_i \\ + \beta_3 grape\_sell\_through\_coop_i + \varepsilon \end{aligned} \tag{2}$$

3.2.2 Supply elasticity simulation

To estimate the supply elasticity, we assume that Concord grape growers maximize their incomes through producing decisions. Following Volpe et al. (2010), this study uses a 2SLS model to estimate the own-price elasticity of supply of Concord grapes. Specifically, the model specification is presented in Equation 3:

$$\ln production_t = \beta_0 + \beta_1 \ln eprice_t + \beta_2 \ln prcp_t + \beta_3 \ln tmp_t + \varepsilon \tag{3}$$

The variable $\ln production_t$ is the log form of the production measured in tons in year t; $\ln eprice_t$ is the log form of the expected received price in year t, calculated by taking the moving average of prices in year $t-4$, $t-3$, $t-2$, and $t-1$. We use nominal prices here because growers usually make their decisions according to the actual prices they received. Additionally, it takes three to four years for Concord grapes to ripen, therefore the prices growers observe when they plant grapes are usually lagged. Repeated estimations as well as existing research (Volpe et al., 2010) have shown moving average prices have more power than naive lagged prices. The variable $\ln prcp_t$ is the log form of the absolute value

of precipitation from May to September in year t, measured by inches; $\ln tmp_t$ is the log form of the minimum temperature during June in year t, measured by Fahrenheit.

To account for the endogeneity issue of the expected price, two instrumental variables are selected and included in the first stage estimation. The selection of instrumental variables are primarily built on the previous study by Volpe et al. (2010). The model specification is presented in Equation 4:

$$\ln price_t = \beta_0 + \beta_1 \ln production_t + \beta_2 \ln gdp_t + \beta_3 t + \varepsilon \tag{4}$$

where the variable $\ln price_t$ is the log form of the nominal price growers received in year t; $\ln production_t$ is the log form of the production in year t; $\ln gdp_t$ is the log form of the per capita GDP in year t as a proxy for income level. Since the Concord grape market is relatively competitive, we assume that the price is largely determined by the production (Fuller and Alston, 2012). Given that production can be seen as independent every year (Volpe et al., 2010), it is reasonable to include same-year production as an instrumental variable. Income level may have an impact on the nominal prices because the grape market can be affected by the overall economy (Choi and Helmberger, 1993b). The time variable t accounts for unobserved factors that are correlated with time.

CHAPTER 4

DATA DESCRIPTION

4.1 New York State Concord Grape Growers

There are three sections in the survey. The first section asked growers their basic information and their production-related operations, as well as their income sources. The second section presented growers various scenarios when the market price increases or decreases by a certain percent and asked whether growers would react to the certain price changes. The third section asked questions regarding growers' confidence level in the market as well as the minimum price at which they would otherwise consider stopping producing.

We received 59 responses to the survey distributed. After filtering out responses that skipped important questions or put random answers, 30 complete responses were picked in this study for analysis. The descriptive statistics are presented in Table 1.

Table 1: Descriptive statistics

Variable	Description		Mean	Std	Min	Max
age	age of the growers		62.040	9.195	38	79
year_from_plant	number of years since the first Concord grapevine was planted		102.667	28.158	50	161
year_from_start	number of years since the growers started to operate the vineyard		36.900	16.865	6	69
concord_acre	acres of land under Concord grape production		89.500	89.408	4	350
concord_acre_rent	acres of rented land under Concord grape production		21.283	38.897	0	150
concord_land_percent	percentage of land under Concord grape production (%)		42.320	29.384	5	100
grow_other_variety	=1 if a grower grows other grape varieties, 0 if a grower only grows Concord		0.900	0.310	0	1
income_from_grape_percent	percentage of total household income from grape production		65	30.405	4	100
income_from_concord_percent	percentage of total grape production income from Concord grape production		42.720	31.914	5	100
grape_sell_through_coop	percentage of grape production sell through coops		53.800	38.558	0	100
grape_sell_through_cash_market	percentage of grape production sell through cash market		30.467	35.045	0	100
yield	tons per acre	2017	7.329	1.275	5.500	11.200
		2018	6.970	1.295	5	10
		2019	7.607	2.316	2	12
price	received price, dollars per ton	2017	237.074	33.283	165	300
		2018	245.111	29.216	196	300
		2019	267.704	33.764	210	340
price_stop_production	the minimum price that growers would seriously consider stopping producing Concord grapes (0 if will never stop)		148.833	107.367	0	300

In our sample, the average age of growers is 62.040. Growers have been operating their vineyards for 36.900 years on average. The vineyards have an average of 102.667 years of history producing Concord grapes. Regarding the usage of the land, growers have an average of 89.500 acres of land dedicated to Concord grape production. In comparison to the average farm size of 259 acres in New York State[1], Concord grape vineyards in our sample are relatively small. The average rented land for Concord grape production is 21.283 acres, which takes up around 23 percent of total land. On average, 42.320 percent of the total land is used to grow Concord grapes, suggesting that less than half of the land is dedicated to Concord grapes and growers tend to grow more other crops on their land. In addition to producing Concord grapes, 90 percent of growers in our sample grow other grape varieties, which is reasonable because

[1]New York's Agricultural Districts

growers can make their income more diverse and reliable by growing more than one grape variety.

Regarding the income, on average, 65 percent of growers' household income is from grape production, and among which, 42.720 percent is from Concord grape production. The statistics suggest that grape production is the major income source for growers in our sample. Concord grape production takes up almost half of the income from grape production and accounts for around 30 percent of the total household income. Therefore growers in our sample are largely influenced by the Concord grape market. As for selling outlets, on average 53.800 percent of grape production is sold through cooperatives, and 30.467 percent of grape production is sold on cash markets. The survey also asked growers to report the yield and price over the past three years, and the reported yield and price data are comparable to the market data we observed. Yields during the three years were stable. The average yield in the market was around 6 tons per acre, and most growers reported yields from 5 to 10 tons per acre; the market price was on average 226 dollars per ton, and the prices reported by growers were around 200 to 300 dollars per ton.

In the survey, we asked growers to indicate the minimum market price that will make them seriously consider stopping producing Concord grapes. Nine growers stated that they would never consider stopping producing Concord grapes. The average response was 148.833 dollars per ton, which is considerably lower than the average market price they received over the past three years. Such a lower value indicates that Concord grape growers are generally reluctant to switch to other crops once they have established Concord vineyards.

Additionally, we asked how confident they are about the market conditions

in the next three years, the results are summarized in Table 2. In our sample, 25 growers answered this question. Seven growers were not positive about the market conditions in the next three years. The remaining 72 percent of growers (i.e., 18 growers) indicated they were confident about the market to some extent, among which specifically, seven of them reported very strong confidence in the market conditions in the next three years. In general, the result shows that most growers in our sample are confident about the market.

Table 2: Growers' confidence in the market

How likely do you feel the market for Concord grape will improve in the next three years?	**Frequency**	**Percent (%)**	**Cumulative Percent (%)**
Very Unlikely	1	4	4
Somewhat Unlikely	6	24	28
Somewhat Likely	11	44	72
Very Likely	7	28	100

The second section of the survey asked about growers' responses to market price changes. The results are summarized in Table 3. This table shows the number of growers (or the frequency) who stated that they would decrease or increase production in the case of a price decrease or increase of Concord grapes, respectively.

Table 3: Frequency of growers' responses to price changes

Price Changes (%)	Frequency	Cumulative Frequency	Percentage(%)
Price Increase			
5	4	4	13.333
10	3	7	23.333
20	5	12	40
30	3	15	50
Price Decrease			
5	5	5	16.667
10	6	11	36.667
20	5	20	66.667
30	2	22	73.333

The results show that four growers would increase production when the price increases by 5 percent. When the price increases by 10 percent, additional three growers would respond to the price increase, so a total number of seven growers are responsive to a 10 percent price increase. Under 20 percent price increase, a total of twelve growers would respond to the price increase. For a 30 percent price increase, fifteen growers would increase production.

When the price decreases by 5 percent, five growers stated that they would decrease production in response. When the price decreases by 10 percent, additional six growers would respond to the price decrease, so a total number of eleven growers are responsive to the price decrease. For a 20 percent price decrease, a total of twenty growers would decrease production. Twenty-two growers are responsive to a 30 percent price decrease.

The results suggest that more growers are responsive to price decreases relative to the same magnitude of price increases. A bar graph is generated to visualize the comparison in more detail to show the percentage of growers who would change their production decisions when the market price changes.

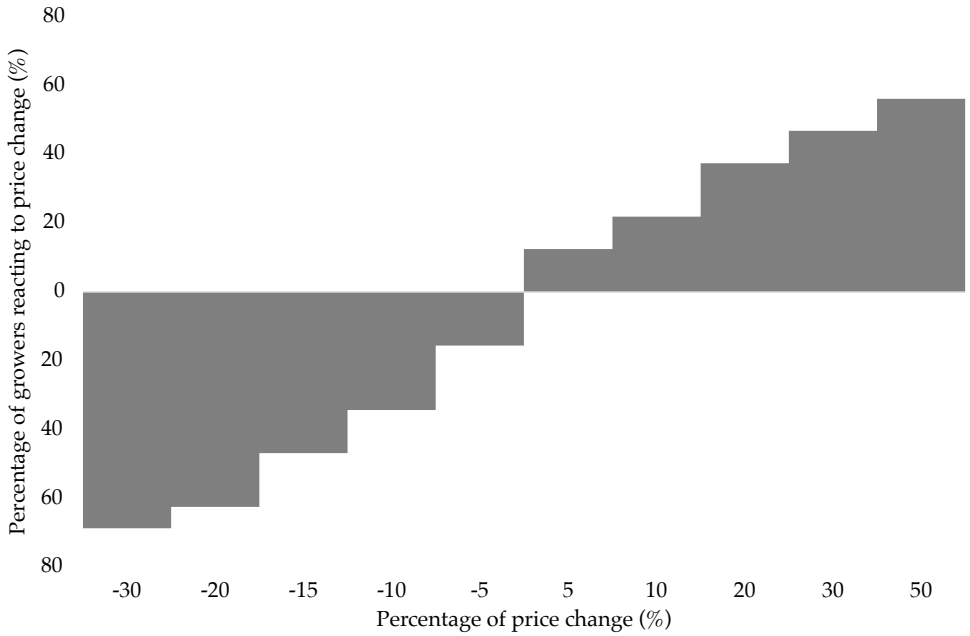

Figure 2: Growers' responses to market price changes

In Figure 2, the horizontal axis shows the percentage of price changes, where positive numbers represent price increases and negative numbers denote price decreases. On the vertical axis, numbers above 0 are the accumulative percentage of growers who are willing to increase their production when the price increases, and the numbers below 0 are the accumulative percentage of growers who would decrease their production in response to price decreases. The figure indicates that growers are more responsive to negative changes in the price than positive changes in the price of the same magnitude. This asymmetric response to price changes is expected because the negative change in price is bounded to 100%, whereas the positive change in price is in theory unbounded.

4.2 New York State Concord Grape Supply

To estimate the supply elasticity for Concord grapes in New York, we collected data on production, growers' received prices, and weather from 1989 to 2017. Even though inflation remains an issue, the market does not show an increasing nominal price. The nominal price started at 273 dollars per ton in 1989, went through the all-time low at 169 dollars per ton in 2005, and reached the all-time high at 315 dollars per ton in 2012. We computed the real price by discounting the nominal price on a prime rate (2%) to the base year 1989. In Figure 3, a declining trend of real prices is observed over the years. It appears that Concord grape growers were facing difficulties making more profits over the years because of the declining received prices and increasing input prices (land and farm labor)[2].

Figure 3: Concord grape prices in New York (1989-2017)

[2]Concord costs: The quest to keep juice grapes profitable

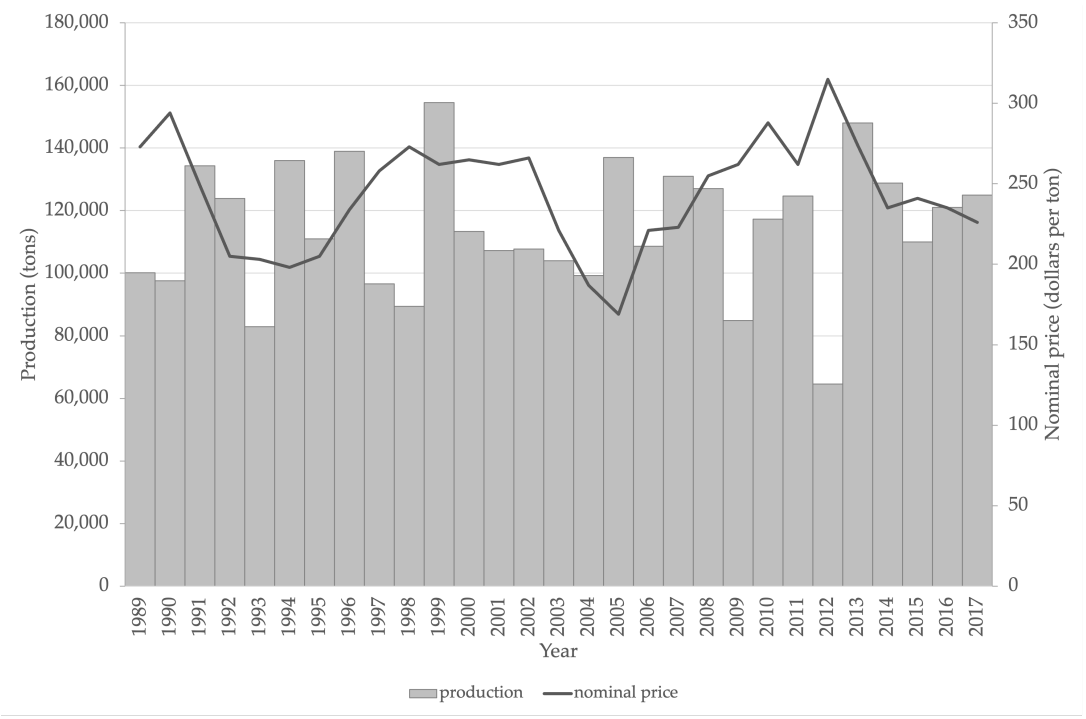

Figure 4: Concord grape production and prices in New York (1989-2017)

Regarding production, Figure 4 shows that the production level fluctuated over the years. The production reached to the highest with 154,500 tons produced in 1999 and reached to the lowest in 2012 when production dropped to 64,600 tons.

We obtained the monthly weather data from the National Oceanic and Atmospheric Administration (NOAA). NOAA provides monthly county-level weather data, and we collected the minimum temperature data in Fahrenheit in June and the absolute value of precipitation in inches from May to September in 105 stations in New York. For the minimum temperature, we calculated the average of all individual stations to generate the variable as a proxy of the temperature during bloom seasons. For precipitation, we first computed the summed total precipitation in each station over the period of May to September

and took the average across all stations to indicate the precipitation condition from bloom to harvest. From Table 4, we observe the wettest year in 2011 with 25.097 inches of rainfall, and the driest year in 1995 with only 12.332 inches of rainfall. In terms of the temperature during the bloom season, the recorded highest minimum temperature was in 2005 with a temperature of 59.019 degrees. The recorded lowest minimum temperature was in 1992 with a temperature of 51.667 degrees.

Table 4: Annual weather variables for New York (1989-2017)

Year	Average Total Precipitation from May to September (inches)	Average Minimum Temperature in June (°F)
1989	24.464	56.820
1990	21.335	55.123
1991	15.406	55.070
1992	21.486	51.667
1993	14.187	53.491
1994	19.052	56.302
1995	12.332	55.605
1996	21.913	57.410
1997	16.892	54.745
1998	18.815	55.790
1999	17.275	55.730
2000	21.895	55.207
2001	15.434	55.278
2002	19.635	55.031
2003	23.686	54.302
2004	24.407	52.940
2005	15.198	59.019
2006	23.686	56.292
2007	14.702	54.343
2008	19.241	57.765
2009	22.114	54.118
2010	18.572	56.919
2011	25.097	56.106
2012	17.657	54.565
2013	21.470	54.478
2014	18.886	54.136
2015	20.124	53.536
2016	14.299	51.937
2017	20.365	53.877

CHAPTER 5

RESULTS

5.1 Concord Grape Growers' Decision Making Estimation

In the survey, growers were asked to report their production decisions under a series of market price changes. According to their responses, we measure their responsiveness to market price changes. In the survey, we asked the grower to report their production decisions for a series of prices changes: 5%, 10%, 20% and 30% price increases and price decreases. We therefore divide growers into two groups based on their responses to the 30 percent price increase and decrease. A 30 percent market price change could be considered as a very significant change in the market price. Growers who are reluctant to make any changes to the production are therefore categorized as non-responsive growers (denoted as Group 0). The rest are then responsive growers (denoted as Group 1). By comparing the characteristics of responsive growers and non-responsive growers, we can have a better understanding of the characteristics that differentiate them. Therefore, we carry out a t-test to compare the characteristics of growers who are responsive to price changes and growers who are not responsive.

Table 5: T-test results for 30 percent price increase

Variable		Mean		t-statistic	p-value
		Group 0	Group 1		
age		64.214	59.273	1.357	0.906
year_from_plant		100.333	105.000	-0.448	0.329
year_from_start		37.067	36.733	0.053	0.521
concord_acre		60.333	118.667	-1.861**	0.037
concord_acre_rent		14.967	27.600	-0.886	0.191
concord_land_percent		28.552	56.088	-3.254***	0.001
grow_other_variety		0.857	0.933	-0.658	0.259
income_from_grape_percent		65.083	64.929	0.013	0.505
income_from_concord_percent		24.727	56.857	-2.845***	0.005
grape_sell_through_coop		42.400	65.200	-1.668*	0.053
grape_sell_through_cash_market		31.133	29.800	0.102	0.540
yield	2017	7.264	7.395	-0.293	0.386
	2018	6.736	7.205	-1.049	0.152
	2019	7.521	7.694	-0.212	0.417
price	2017	248.472	225.676	2.093	0.978
	2018	254.741	234.482	2.003	0.973
	2019	276.447	258.961	1.532	0.932
confidence_score		2.071	1.818	0.741	0.767
price_stop_production		107.000	190.667	-2.284**	0.015

***: p<0.01, **: p<0.05, *: p<0.1
Group 0: growers who would not increase production in response to a 30% price increase
Group 1: growers who would increase production in response to a 30% price increase

Table 5 presents the results of the t-test that compares the characteristics between responsive growers and non-responsive growers when facing price increases. In our sample, fifteen growers reported that they would increase their production when the price increases by 30 percent, and the rest reported not. The t-test result (t=-1.861, p=0.037) suggests that responsive growers have significantly larger acreages of land dedicated to Concord grape production rel-

ative to non-responsive growers. The acreages of rented land are not significantly different based on the t-test results, although responsive growers have more rented land on average. In addition, the t-test results (t=-3.254, p=0.001) indicate that responsive growers have a significantly larger proportion of land growing Concord grapes. The reason might be that growers who are more dependent on growing Concord grapes can make more profits when the market price increases relative to those who are less dependent on Concord grapes. This would incentivize growers with more land growing Concord grapes to increase production when the market price increases.

The results show that there are no significant differences between responsive and non-responsive growers in terms of their age. The number of years of growing Concord grapes is also not significantly different. There are slightly more responsive growers who plant other grape varieties compared to non-responsive growers, but the difference is not statistically significant. The t-test results show that growers in the two groups are not statistically different in terms of the proportion of household income from grape production, but the t-test results indicate that responsive growers have a significantly larger proportion of income generated from Concord grape production (t=-2.845, p=0.005). As for the selling outlets, the t-test results indicate that responsive growers sell much more grapes through cooperatives relative to non-responsive growers (t=-1.668, p=0.053). However, the t-test results show that both types of growers do not differ significantly on the proportion of grapes sold through cash markets. In terms of yields and prices in the past three years, growers in the two groups are not significantly different.

Although the t-test results indicate no statistically significant difference

between growers' reported confidence level in future market conditions, responsive growers have a significantly higher minimum price (i.e., the market price they consider stopping producing) than non-responsive growers (t=-2.284, p=0.015). This implies that responsive growers generally have much higher bottom lines about market prices, and they are generally more responsive to the changes in the market conditions.

Table 6: T-test results for 30 percent price decrease

Variable		Mean		t-statistic	p-value
		Group 0	Group 1		
age		65.286	60.778	1.106	0.860
year_from_plant		118.750	96.818	1.979	0.971
year_from_start		41.375	35.273	0.873	0.805
concord_acre		108.625	82.545	0.700	0.755
concord_acre_rent		19.563	21.909	-0.144	0.443
concord_land_percent		49.745	39.620	0.915	0.816
grow_other_variety		0.857	0.909	-0.380	0.353
income_from_grape_percent		68.333	64.000	0.301	0.617
income_from_concord_percent		54.400	39.800	0.912	0.814
grape_sell_through_coop		62.625	50.591	0.750	0.770
grape_sell_through_cash_market		14.000	36.455	-1.593*	0.061
	2017	6.841	7.507	-1.356*	0.093
yield	2018	6.721	7.061	-0.665	0.256
	2019	6.426	8.037	-1.853**	0.037
	2017	250.000	232.374	1.375	0.910
price	2018	263.875	238.288	2.421	0.989
	2019	298.750	256.414	3.924	0.999
confidence_score		2.143	1.889	0.670	0.745
price_stop_production		68.750	177.955	-2.723***	0.006

***: p<0.01, **: p<0.05, *: p<0.1
Group 0: growers who would not decrease production in response to a 30% price decrease
Group 1: growers who would decrease production in response to a 30% price decrease

When given the scenario of 30 percent market price decreases, twenty-two growers would decrease their production, and the other eight growers would remain at the same production level. We separate growers into two groups, where growers in Group 0 are not responsive to the price decrease, and those in Group 1 are responsive to the price decrease. Table 6 summarizes the results of the t-test that compares the characteristics between growers in the two groups.

In terms of the selling outlets, the t-test result (t=-1.593, p=0.061) shows that responsive growers sell a significantly larger percentage of grapes through cash markets compared to non-responsive growers. In contrast, the shares of grapes sell through cooperatives are smaller for responsive growers, but the difference is not significant. The reason might be that the price on cash markets is more volatile, therefore growers who are more dependent on cash markets are more sensitive to price changes.

The t-test results indicate that the yields are significantly higher for responsive growers in 2017 (t=-1.356, p=0.093) and 2019 (t=-1.853, p=0.037). In 2018, the average yield for responsive growers was slightly higher than non-responsive growers, but the difference is not significant. These results imply that responsive growers have on average higher yields of production, and they seem to care more about producing Concord grapes, which is also reflected by their willingness to adjust their production based on changes in market conditions. For the prices received in the past, the result does not imply significant differences. In terms of confidence in the market, the result shows there are no significant differences between growers in the two groups. However, the t-test result (t=-2.723, p=0.006) suggests that responsive growers have significantly higher bottom lines for market prices, similar to the results for the price increase.

Compared with non-responsive growers, responsive growers generally are younger and have shorter years of experience operating the vineyards, and the number of years that their vineyards have been growing Concord grapes is also shorter, but those differences are not statistically significant based on the t-test results. As for land usage, responsive growers are not significantly different from non-responsive growers. Regarding the income sources, although non-responsive growers have a larger proportion of income derived from grape production on average, the t-test result does not indicate a significant difference.

To summarize, growers who are responsive to price increases have larger acreages of land under Concord grape production and a significantly higher proportion of income derived from Concord grape production. Growers who are responsive to price decreases are not statistically different from non-responsive growers with regard to land usage and income sources. Regarding selling outlets, growers who are responsive to price increases tend to sell more grapes through cooperatives, while growers responsive to price decreases sell more grapes through cash markets. As for yields and prices, there are no significant differences between growers when facing price increases. However, when the price decreases, responsive growers have significantly higher yields of production relative to non-responsive growers. Lastly, for both price increases and price decreases, responsive growers tend to have higher bottom lines about the market prices.

To further understand the important characteristics that are associated with growers' price responsiveness, three explanatory variables are included in the logit models. The results for the price increase models are shown in Table 7. The dependent variable in Column 1 is a binary variable that equals 1 if grow-

ers would respond to a 10 percent price increase, 0 otherwise. Similarly, the dependent variable in Column 2 is a binary variable that equals 1 if growers would respond to a 30 percent price increase, 0 otherwise.

Table 7: Regression results of logit models for price increases

Variable	**Coefficient**	
	y_10_increase	***y_30_increase***
concord_land_percent	0.039	0.053**
	(0.027)	(0.022)
year_from_plant	0.069**	-0.011
	(0.032)	(0.021)
grape_sell_through_coop	0.042*	0.010
	(0.022)	(0.013)
constant	-13.461***	-1.625
	(4.771)	(2.432)
N	30	30
Log Likelihood	-8.113	-15.602
Pseudo R-Squared	0.502	0.250

***: p<0.01, **: p<0.05, *: p<0.1 , standard error in parentheses

Column 1 presents the regression results for the 10 percent price increase model. The results suggest that the coefficient for *year_from_plant* is significantly positive. That implies if a grower operates a vineyard with a longer history of growing Concord grapes, the grower will be more likely to increase production in response to a 10 percent price increase. The variable *grape_sell_through_coop* has a significantly positive coefficient. When a grower sells more grapes through cooperatives, he/she will be more likely to increase production when the price increases by 10 percent. Growers work with cooperatives under payment schedules and production agreements. The prices that growers get from cooperatives are usually pre-fixed based on historical prices

and the market outlook. If it is believed that the price will increase in the future, cooperatives will be very likely to raise their prices as well (Jermolowicz, 1999). Growers who sell more grapes through cooperatives will maximize their profits by producing more in response to the price increase. The coefficient for *concord_land_percent* is not statistically significant in this model specification.

Column 2 describes the results for the 30 percent price increase model. The variable *concord_land_percent* has a significantly positive coefficient. The result indicates that if a grower has a larger proportion of land under Concord grape production, he/she will be more likely to increase production when the price increases by 30 percent because the grower can benefit more from the operations in response to price increases. The coefficients of *year_from_plant* and *grape_sell_through_coop* are not statistically significant in the *y_30_increase* model.

Table 8: Regression results of logit models for price decreases

Variable	**Coefficient**	
	y_10_decrease	***y_30_decrease***
concord_land_percent	0.008	-0.001
	(0.169)	(0.018)
year_from_plant	-0.015	-0.033*
	(0.015)	(0.169)
grape_sell_through_coop	-0.011	-0.011
	(0.011)	(0.014)
constant	1.207	5.174***
	(1.606)	(1.899)
N	30	30
Log Likelihood	-18.720	-15.115
Pseudo R-Squared	0.051	0.131

***: p<0.01, **: p<0.05, *: p<0.1 , standard error in parentheses

Table 8 presents the regression results of logit models for price decreases. Column 1 shows the results of the 10 percent price decrease model. The coefficients for all three explanatory variables are not statistically significant. Column 2 presents the results of the 30 percent price decrease model. The coefficient of *year_from_plant* is significant and negative. That means if a grower operates a vineyard with a longer history of growing Concord grapes, he/she will be less likely to make changes to the production. Therefore the grower is less responsive to the change in market conditions. The coefficients of *concord_land_percent* and *grape_sell_through_coop* are not statistically significant in this model specification.

5.2 Concord Grape Supply Elasticity Simulation

Table 9 presents the results of the 2SLS model that estimates the supply elasticity for Concord grapes in the focal regions. The dependent variable for the first stage ln(*price*) is the log form of the nominal price. The dependent variable for the second stage ln(*production*) is the log form of the production. Column 1 includes the expected price as the explanatory variable in the second stage regression, and Column 2 includes other control variables (in addition to the expected price).

Table 9: Concord grape supply elasticity estimation

Variable	M1	M2
First Stage Regression		
ln(*price*)		
ln(*production*)	-0.213*	-0.213*
	(0.110)	(0.110)
ln(*gdp*)	-0.824	-0.824
	(0.901)	(0.901)
t	0.015	0.015
	(0.013)	(0.013)
constant	16.605*	16.605*
	(9.948)	(9.948)
Second Stage Regression		
ln(*production*)		
ln(*eprice*)	1.311	2.228**
	(1.040)	(1.067)
ln(*prcp*)		0.070
		(0.147)
ln(*tmp*)		3.231***
		(0.830)
constant	4.447	-13.746
	(5.691)	(7.685)
N	25	25
F-Statistic	1.587	7.802
Adj. R-Squared	0.008	0.140

***: p<0.01, **: p<0.05, *: p<0.1, standard error in parentheses

The first stage regression results indicate a negative and significant impact of production on nominal prices. That means higher production leads to lower prices. This finding is consistent with expectations that price is negatively related to output in a competitive market. The result is also observed in the market data presented in the figures, as it is evident that price moves in the opposite

direction of total output. The coefficient of GDP is not statistically different from zero, and the coefficient for the time trend t is positive but statistically insignificant.

In the second stage regression, Column 1 shows that the coefficient for ln($eprice$) is positive but not significant. The direction is as expected since production should increase as the price of Concord grapes increases. One possible explanation for the lack of significance could be the absence of related variables which leads to omitted variable bias. Volpe et al. (2010) included weather data to isolate the impact of weather variations. Following Volpe et al. (2010), we add two variables to control the impact of weather during the harvest and bloom seasons when the concord grape vines are particularly sensitive. The results are shown in Column 2.

After controlling the weather's impact, we obtain a significantly positive coefficient for the variable ln($eprice$). The findings suggest that a 1 percent increase in the expected price leads to a 2.228 percent increase in the production of Concord grapes. Usually, the supply of perennial crops like grapes is price inelastic as there are time lags between planting and harvest (Volpe et al., 2010; Alston et al., 2013), and growers often work with contracts that give them less flexibility over the amount of production. However, our results suggest the Concord grape supply is elastic with respect to prices. The dependent variable here is the production, which takes into considerations both the land allocated to produce grapes and the yield of production. Recent technology improvements have reduced the production costs and enhanced the yield of Concord grapes to around six tons per acre (Gashler, 2018). Crops that adopt cost-reducing technologies and have higher yields per acre often exhibit a flatter supply curve, and the

elasticity is also larger (Keeney and Hertel, 2009). Moreover, the expected price considers lagged prices for the past four years instead of the current price, so the estimated elasticity is a long-term elasticity, which is usually larger. This result is also consistent with the fact that the bearing acreage of Concord grapes has diminished in recent years, and a considerable number of vineyards have already exited the market in response to low prices.

As for the other explanatory variables, precipitation has a positive but statistically insignificant coefficient in Column 2. Although the coefficient is statistically insignificant, this finding is in line with expectations since higher precipitation benefits the harvest and can help increase production. For the minimum temperature, Column 2 exhibits a statistically significant and positive coefficient, implying that a higher minimum temperature during the bloom season would promote the growth of grapevines and increase production. This is reasonable as warmer years usually have earlier bloom dates and longer periods before harvest, and that is good for grapes to ripen and nurture.

Using the estimated supply elasticity, combined with the analysis from the survey, we can simulate the changes in land allocated to Concord grapes and production for the different price change scenarios. Table 10 presents results showing the changes in acreage and production in response to different levels of price changes.

Table 10: Acreage and production changes of growers from the survey

Price Changes (%)	Net Acreage Changes (acres)	Acreage after Changes (acres)	Production after Changes (tons)
Price Increase			
5	40.812	2725.812	19907.513
10	142.842	2827.842	20652.673
20	489.744	3174.744	23186.214
30	918.270	3603.270	26315.882
Price Decrease			
5	-51.015	2633.985	19236.870
10	-224.466	2460.534	17970.099
20	-816.240	1868.760	13648.177
30	-1346.796	1338.204	9773.350

The supply elasticity suggests that the production changes by 2.228 percent in response to a 1 percent price change. We assume the yield is unchanged, therefore the percentage change of acreage is the same as the percentage change in production. Given the supply elasticity, we can estimate growers' acreage and production response to price changes. In our sample, the total acreage of land under Concord grape production is 2,685 acres for all the thirty growers, and the average yield is 7.333 tons per acre.

From the survey, we know that when the price increases by 5 percent, 13.333 percent of growers would increase production. Given the supply elasticity, 40.812 acres of land will be increased to produce Concord grapes. The total acreage will therefore be 2725.812 acres and the production will be 19,907.501 tons. When the price increases by 10 percent, 23.333 percent of growers will increase the acreage planted Concord grapes. The increased land will be 142.842 acres, so the total acreage will be 2,827.842 acres and the production will be 20,652.673 tons. For a 20 percent price increase, growers will expand 489.744

acres of land to produce Concord grapes, and that will lead to a total of 23,186.214 tons of Concord grape production. When the price increases by 30 percent, 918.270 acres of land will be increased and a total of 26,315.882 tons of Concord grapes will be produced.

For a 5 percent price decrease, 16.667 percent of growers will reduce the area planted Concord grapes. Using the price elasticity of supply estimated above, this translates into a reduction of 51.015 acres of land. Therefore, the acreage planted Concord grapes will decrease to 2,633.985 acres and the production will drop to 19,236.870 tons. For a 10 percent price decrease, 224.466 acres of land will be decreased. When the price decreases by 20 percent, growers will pull 816.240 acres of land planted Concord grapes, so the production will decrease to 13,648.177 tons. When the price decreases by 30 percent, 1,347.769 acres will be reduced in response, which accounts for over half of the total acreage of land.

From the results above, we can observe that the supply response to price changes is non-linear. This is because larger price changes lead to more growers changing the land allocated to Concord grapes. In addition, the results suggest that the impact of price changes is asymmetric. That is, supply response is larger in magnitude when prices drop in comparison to when prices increase. Given that the market price is volatile, policymakers may consider implementing price supports or promoting contract farming to provide stability and reduce production risks. The gain in benefits will give growers incentives for more sustainable production, and that could help the entire industry.

CHAPTER 6

CONCLUSION

6.1 Discussion

This study provides an individual-level estimation of factors that are associated with growers' price responsiveness and their production decisions. Given the recent declining production and bearing acreage in the Concord grape market, and the fact that grape growers are experiencing hardship making profits, the findings of this study explore approaches to help protect growers' profitability and make them more robust to market fluctuations.

Our analysis suggests that growers are more sensitive to price decreases than price increases. Therefore, more price supports should be provided to growers when price decreases are projected. Our results indicate that growers responsive to price increases are more dependent on Concord grape production and have more income from Concord grapes. Growers who are more reliant on Concord grape production could obtain more benefits from a upward market however they are also more vulnerable to a downward market. Another implication is that growers responsive to price increases sell more grapes through cooperatives, while growers responsive to price decreases sell more grapes through cash markets. Cash markets are more volatile, and growers' wealth is directly related to the market changes. Encouraging collaborations with cooperatives will help growers to tackle unfavorable market decreases, which can assist the stability of vineyards' operations.

In addition to individual-level examinations, we also analyze the supply

elasticity in the Concord grape market. Our results show that the Concord grape market in New York is relatively elastic to the expected price in the long run. Using the survey data and the estimated supply elasticity, we estimate the growers' acreage and production response to the price changes. The results suggest that the production decreases in response to price declines will create significant financial challenges to growers, especially when the magnitude of price decrease is large.

These results add to the current body of literature and suggest that the establishment of price supports and the help of diverse selling outlets are needed to provide growers with more sustainable profitability.

6.2 Limitations

There are several limitations of this study and future research prospects regarding the topic. First, individual-level estimation should take considerations of broader topics such as technology utilization and more specific planting operations so that more flexible approaches can be developed to tackle market changes. Additionally, larger reach to Concord grape growers across the country will be helpful to understand growers in a more comprehensive way. Regarding the supply elasticity estimation, more explorations could be conducted to help overcome the endogeneity issue of expected price, and the analysis of other potentially important factors will also be appreciated.

APPENDIX

SURVEY INSTRUMENT

The purpose of the project is to generate knowledge of the Concord grape market to help growers add value to their products and become more profitable.

Your participation is voluntary and your answers will be completely confidential. The results of our analyses will be shared only in a consolidated form, which will not identify individuals or specific wineries.

1. Do you grow concord grapes?

   O Yes

   O No

2. In what year did you start operating your farm?

   .....

3. In what year were the first Concord grape vines planted in your farm?

   .....

4. How many acres of land do you have under Concord grape production (including owned and rented land)?

   .....

5. How many acres of land are rented for Concord grape production? Put 0 if you do not rent any land for Concord production.

   .....

6. In addition to Concord grapes, do you grow any other grape varieties?

   O Yes

   O No

7. Approximately, what percentage of your total production land (owned and rented) is used to grow Concord grapes?

   .....

   All questions related to production and prices refer to your Concord grape production.

8. Over the past five years (2015-2019), your average cost of production per acre has:

   O been stable

   O increased, by how much .....

   O increased, by how much .....

   O Not applicable (if you have not started production in the past 5 years)

   O costs have varied largely from year to year

9. What was your average yield (in tons per acre) over the past three years?

   In 2019 .....

   In 2018 .....

   In 2017 .....

10. What was your price per ton (in dollars per ton) over the past three years?

    In 2019 .....

    In 2018 .....

    In 2017 .....

11. Approximately, what percentage of your total household income comes from grape production?

    .....

12. Approximately, what percentage of your total grape production income comes from Concord grapes?

    .....

13. How many cooperatives do you belong to?

    O none

    O one

    O two or more

14. What percentage of your grapes sell through (total must add up to 100).

    Co-ops .....

    Cash markets .....

    Others .....

    Total .....

    The following questions refer to an increase in price.

15. Over the next five years, if Concord grape prices increase by 5% and production costs remain constant, I would

    O increase production (plant more Concord grape vines on my land or rent additional land)

    O remain with the same production level

    O decrease production

16. Over the next five years, if Concord grape prices increase by 10% and production costs remain constant, I would

    O increase production (plant more Concord grape vines on my land or rent additional land)

    O remain with the same production level

    O decrease production

17. Over the next five years, if Concord grape prices increase by 20% and production costs remain constant, I would

    O increase production (plant more Concord grape vines on my land or rent additional land)

O remain with the same production level

O decrease production

18. Over the next five years, if Concord grape prices increase by 30% and production costs remain constant, I would

    O increase production (plant more Concord grape vines on my land or rent additional land)

    O remain with the same production level

    O decrease production

19. Over the next five years, if Concord grape prices increase by 50% and production costs remain constant, I would

    O increase production (plant more Concord grape vines on my land or rent additional land)

    O remain with the same production level

    O decrease production

The following questions refer to a decrease in price.

20. Over the next five years, if Concord grape prices decrease by 5% and production costs remain constant, I would

    O increase production (plant more Concord grape vines on my land or rent additional land)

    O remain with the same production level

    O decrease production

21. Over the next five years, if Concord grape prices decrease by 10% and production costs remain constant, I would

    O increase production (plant more Concord grape vines on my land or rent additional land)

O remain with the same production level

O decrease production

22. Over the next five years, if Concord grape prices decrease by 15% and production costs remain constant, I would

    O increase production (plant more Concord grape vines on my land or rent additional land)

    O remain with the same production level

    O decrease production

23. Over the next five years, if Concord grape prices decrease by 20% and production costs remain constant, I would

    O increase production (plant more Concord grape vines on my land or rent additional land)

    O remain with the same production level

    O decrease production

24. Over the next five years, if Concord grape prices decrease by 30% and production costs remain constant, I would

    O increase production (plant more Concord grape vines on my land or rent additional land)

    O remain with the same production level

    O decrease production

25. For the next 5 years, at what price ($ per ton), would you seriously consider stop producing Concord grapes? Write 0 if would never consider stopping Concord grape production.

    .....

26. How likely do you feel the market for Concord grapes will improve in the next three years?

O Very likely

O Somewhat likely

O Somewhat unlikely

O Very unlikely

27. What is your age?

.....

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