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Relationship Between the California Drought and Almond Demand

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This is to certify that the doctoral study by

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has been found to be complete and satisfactory in all respects,
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2017

Abstract

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MBA, Western Governor's University, 2014

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Doctoral Study Submitted in Partial Fulfillment

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Abstract

Areas of California's Central Valley are sinking at rates up to 1 foot per year due to subsidence caused, in part, by the state's years-long drought, challenging growers to locate additional water sources for their crops. Supply and demand theory guided this correlational study. The purpose of the study was to examine the financial impact of drought on almond demand. This study included annualized historical almond industry data for the United States ($N = 97$), downloaded from a United States Department of Agriculture database. The results of multiple linear regression analysis indicated that the model was capable of predicting almond demand, $F(3,92) = 483.579$, $p < .001$, $R^2 = .940$. Both supply and price were statistically significant in the final model, with supply ($p < .001$) accounting for a higher contribution to the model than price ($p = .015$). Fine effect's contribution ($p = .267$) to the model was not statistically significant. The results of this study could enable almond industry leaders to increase profit margins through market predictability understanding and mitigate fiscal risks associated with variable labor and groundwater pumping costs. The implications for positive social change include the potential to restore employment opportunities, stabilize migratory worker prospects, and reduce water utilization to preserve natural resources.

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Dedication

If I could save time in a bottle
the first thing that I'd like to do
is to save every day
'til eternity passes away
just to spend them with you

~ Jim Croce (1972)

My father taught me to appreciate music. My mother taught me to be strong. The Navy taught me to see the world as a whole. You taught me to live.

This work is dedicated to you…my beautiful wife, Peggy. I wish I could give back the many days, evenings, nights, and weekends that slipped away while freeing these pages from my mind. I thank you from the deepest part of my soul for urging me to be better, pushing me through the difficult parts, and just being there when I needed to decompress.

Without you behind me, I would not have started this journey. Without you beside me, I would not have continued. Without you in front of me, I would not have had anyone to cheer me through the finish. Thank you!

Acknowledgments

A single conversation with a wise man is better than ten years of study

~ Chinese proverb

The completion of this study was made possible through constant interaction with my committee chair, Dr. Edward Walker. I must acknowledge his unwavering support and encouragement that enabled me to work through difficult times when I could not do it on my own. I would also like to acknowledge Dr. Erik Shefsky, Proposal Second Committee Member, Dr. James Glenn, Study Second Committee Member, and Dr. Scott Burrus, URR. Their insight and advice facilitated significant growth in the scholarly quality of this study.

Finally, I would like to acknowledge Mr. Joseph Poio, my high school music teacher. When he placed me as the drum major of the high school band more than 30 years ago, he unknowingly set me on this path. He taught me that great things could be accomplished through belief in oneself.

I cannot convey how tightly I held to Joe's every word, but the following example should suffice. Those who were not part of the band will not understand this reference, but it will be incredibly clear for those who were. Joe, "Airplane." Everyone else, "Bad joke." Thank you, Joe!

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Section 1: Foundation of the Study

If California were a country, it would rank as the ninth largest agricultural economy in the world (Monllor & Murphy, 2017). Considering the almond industry is the leading export of California (Klinge, 2016), the economic impact of the industry is significant. However, conversations regarding lifting the water consumption exemption from agriculture have begun because of the combination of information regarding water utilization for almond production and the results of some drought models projecting more intense drought effects in the future (Berg & Hall, 2017; Le, El-Askary, Allali, & Struppa, 2017; Trinh, Ishida, Kavvas, Ercan, & Carr, 2017). Lifting the exemption could be devastating to the almond industry, as well as other agricultural markets, and subsequently to the economy of California.

The purpose of this study was to examine the relationship between the California drought and the California almond industry. Understanding this relationship and the potential impacts of the relationship may influence the decisions of almond industry leaders. Enhancing leader understanding could result in positive economic and social change.

Background of the Problem

California continues to suffer the effects of the most severe drought in more than 1,200 years (Griffin & Anchukaitis, 2014). According to the California Department of Water Resources (2016), the 2016 state water storage levels were at 71% of historical averages and 51% of total capacity. However, despite having one of the largest water footprints (Arabi, Alizadeh, Rajaee, Jam, & Niknia, 2012) of California exports, farmers in California’s Central Valley expanded almond production by 187% to 1,870,000,000 lb (848,217.73 t) between 2003 and 2013 (Almond Board of California, 2013).

The rise in production volume was the result of a significant increase in acres (hectares) devoted to almonds. According to the United States Department of Agriculture, almond acreage increased by 213% to approximately 890,000 ac (360,170 ha) between 1995 and 2015 (United States Department of Agriculture National Agricultural Statistics Service, 2015). The increase appears to have been a response to the 75% price increase between 2008 and 2012 (United States Department of Agriculture National Agricultural Statistics Service, 2013). However, the entirety of the report detailed significant periods of price reduction and only a 4% increase in price per pound between 1995 and 2012 (United States Department of Agriculture National Agricultural Statistics Service, 2013). Growers appeared to be discounting the historical data and the impact the drought may have on the industry.

The lack of apparent grower attention toward historical trends may have been the result of a lack of available information. Due to the short timeframe since the official end of the California drought, studies correlating the effect of the drought and the projected financial impact to almond growers were nonexistent. The lack of available literature ostensibly required California growers to make long-term economic decisions without data to support or refute the decision.

The results of this study may contribute to the available literature through the introduction of an environmental variable into existing supply and demand models, thereby including potential effects of the environment. The primary goal of this study was to examine demand projections of the almond commodity market before and after the inclusion of an environmentally related variable. The focus of the study was to provide California growers a foundation for economic decisions regarding the fiscal viability of planting almond groves.

Problem Statement

Exacerbated by being California's hottest and driest year ever measured, 2014 extended the state's most extreme drought in recorded history, leading to extreme water shortages throughout the state (Mann & Gleick, 2015). Because of the significant water shortages, California's Central Valley farmers fallowed 450,000 ac (182,109 ha) of farmland, experienced $447,000,000 in increased costs to pump groundwater, and realized decreased revenues of approximately $800,000,000 (Keppen & Dutcher, 2015). The general business problem is a minimal understanding of environmental impacts on the financial viability of certain crop types. The specific business problem is some California almond business leaders do not know the relationship between fines for excessive water utilization, almond supply, almond market price, and almond demand.

Purpose Statement

The purpose of this quantitative correlation study was to examine the relationship between fines for excessive water utilization, almond supply, almond market price, and almond demand. The independent variables were (a) California imposed fines for excessive water utilization, (b) almond supply, and (c) almond market price. The dependent variable was almond demand. The target population consisted of almond business leaders in California. The target population was appropriate for this study because the California job market lost approximately 10,100 seasonal jobs in 2015 as a direct result of environmental impacts (Howitt, MacEwan, Medellin-Azuara, Lund, & Sumner, 2015a). The implications for social change included the restoration of employment opportunities, stabilization of migratory worker prospects, and reduction of water utilization to preserve natural resources.

Nature of the Study

Quantitative research is a means by which researchers employ mathematical analysis of numerical data to examine and explain phenomena (Yilmaz, 2013). Although social data are more generally associated with qualitative research, integration measures enable the use of social data in a quantitative manner (Babones, 2015). I used the quantitative method for this study because of the need to examine the mathematical relationships among variables. The qualitative method was not appropriate for this study because qualitative researchers explore social phenomena through the exploration of social experiences (Leavy, 2014). The mixed-method approach was not appropriate for this study because it includes both quantitative and qualitative methods within the same study (Venkatesh, Brown, & Bala, 2013). The qualitative aspect nullified the applicability of mixed-method research as a viable methodology option for this study.

To determine the design of this study, I examined three quantitative designs for applicability: correlation, experimental, and quas-iexperimental. Correlation often refers to a model developed by Pearson as a means of studying the relationships between variables (Tuğran, Kocak, Mirtagioğlu, Yiğit, & Mendes, 2015). Researchers employ the experimental design to study the effect of an independent variable on a dependent variable through the measurement of the independent variable (Watson, 2015). The primary use for the quasi-experimental design is in social science or psychological research for trend identification (Lu et al., 2014) and exploration of groups of nonrandomized participants (D'Onofrio, Class, Lahey, & Larsson, 2014). Because I intended to examine the relationships between variables, I used a correlational design for this study.

Research Question

The research question for this study was as follows: What is the relationship between fines for excessive water utilization, almond supply, almond market price, and almond demand?

Hypotheses

Null Hypothesis (H_0): There is no statistically significant relationship between fines for excessive water utilization, almond supply, almond market price, and almond demand.

Alternative Hypothesis (H_1): There is a statistically significant relationship between fines for excessive water utilization, almond supply, almond market price, and almond demand.

Theoretical Framework

One of the critical success factors for commodity related businesses is the ability to forecast changes in a given market (Misra & Goswami, 2015). The theoretical framework for this study and one method of economic forecasting was the theory of supply and demand. As the seminal framer of the supply and demand economic model

(Ness & Chebrolu, 2013), Marshall (1920) developed the theory as a means of explaining the effect of supply and demand on price. In its simplest form, the theory has three foundational concepts: (a) Price will decrease if supply increases and demand remains constant or if demand decreases while supply remains constant, (b) price will increase if supply decreases and demand remains constant or if demand increases while supply remains constant, and (c) a state of equilibrium exists if both supply and demand remain the same or change similarly (Marshall, 1920). This theoretical framework was expected to apply to this study because the theory of supply and demand dictates that the combination of the independent variables can reasonably predict almond demand.

Operational Definitions

The following were terms and definitions used throughout this study. The inclusion of the definitions facilitated a consistent level of understanding throughout the study.

Grower: An almond grower is a business leader who owns and operates one or more almond groves (Farrar, Baur, & Elliott, 2016).

Migratory: Workers who move from location to location, often across state and national borders, in search of employment based on agricultural needs are migratory (Weiler, Levkoe, & Young, 2016).

Seasonal: Workers who establish a residence in a single location and work for agricultural entities at various times throughout the year are seasonal (Quandt et al., 2016).

Assumptions, Limitations, and Delimitations

Assumptions

Assumptions are critical aspects of all social research (Chatterji, 2016) because they delineate statements that appear to be true in the research without direct verification. Two areas of assumption for this study were linear demand and price factors. Using a linear function to calculate demand is a means of presenting flexible demand (Botterud et al., 2013). Therefore, I assumed that a wholesale linear demand curve was representative of consumer demand. Shifts in the demand curve are the result of significant external factors influencing supply or price (Chatterjee, 2016). Because California almost entirely supplies the domestic almond market, external factors equally affecting all suppliers of the almond industry were assumed.

Limitations

Limitations are areas of possible weakness within the study that may require additional research for validation (Albert, Dean, & Baron, 2016). The limitations of this study included commodity, variety of commodity, and geographic area. The commodity included in this study was the almond. However, the dataset provided by the National Agricultural Statistics Survey (2016) does not differentiate between varietals. Limitations of this study were the combination of all almond varietals into a single annual production value and the production values of only the United States. As a result of the inclusion of only almonds, combination of almond varietals, and geographic constraints, the findings of this study may not be generalizable for other commodities, specific varietals, or other geographic regions.

Delimitations

Delimitations develop the boundaries of the study by defining the research inclusions and exclusions (Souleles, 2016). The delimitations for this study included the commodity, geographic area, and data set. The only commodity included in this study was the almond. Although various regions throughout the world grow almonds (Lin et al., 2016), the geographic delimitation of this study was the United States. As such, the dataset for this study contained data only for the United States almond market.

Significance of the Study

Contribution to Business Practice

Because almond trees require at least 4 years to mature and become productive (Gradzie & Martínez-Gómez, 2013), California growers must seriously consider the future of the almond market when making crop-planting decisions. The results of this study could provide a foundation for a model that almond growers and agricultural business leaders can use to understand the relationship between the environment and the almond commodity market. The results of this study could also contribute to effective business practices by enabling almond growers and agricultural business leaders to stabilize or increase profit margins by decreasing groundwater utilization and associated variable pumping costs, minimizing the risk of receiving fines for excessive water utilization, and predicting market demand fluctuations based on environmental impacts.

Implications for Social Change

Partially explained by the reduction of agricultural job availability and days of employment, and as compared to 2011, four agriculturally dependent counties in

California's San Joaquin Valley (Kings, Madera, Merced, and Tulare) experienced a 2014 average median household income reduction of 7% (Zelezny et al., 2015). As a direct effect of the drought, California realized an elimination of approximately 10,100 seasonal jobs in 2015 (Howitt, MacEwan, Medellin-Azuara, Lund, & Sumner, 2015a). Increasing the accuracy by which growers predict the future needs of the almond industry can enable growers to reverse or attenuate the losses and establish job creation strategies. One result of these strategies could be a stabilization of the migratory and seasonal workforces.

The agricultural job market is critically dependent on water availability. As a reflection of the estimated 4,000,000,000,000 gal (15,141,647,136,000 kg wt.) per year of water supply loss since 2011 (Weiler, 2014), groundwater level recession has exceeded 200 ft (60.96 m) in some areas of California (Nelson, 2012). Some models indicate that continued water demand above natural replenishment cycles could trigger a disruption in the flow of water from the Colorado River Basin (Castle et al., 2014), one of the sources of water for California and six other states. Water, required for both animal and plant life, is a building block for social development (Setegn & Donoso, 2015). Therefore, minimizing water usage is not only critical to continued social development in California but potentially for enhancing societal stability beyond the regional benefit from this study.

A Review of the Professional and Academic Literature

To establish the foundation for this study, I conducted an extensive literature review. The specific goal of this review was to locate the nexus between the theoretical framework (theory of supply and demand) and the almond agricultural market. Walden University Library database sources, including ABI/INFORM Collection, Business Source Complete, National Bureau of Economic Research, ProQuest Central, and SAGE Stats, contained scholarly research papers and journal articles. Other internet data sources included in the literature search were CrossRef.org and Google Scholar. Databases from the California Department of Water Resources, United Nations Statistics Division, and United States Department of Agriculture contained statistical and historical data.

A review of the above sources was conducted using the following search terms and keywords: *Alfred Marshall, California almond, California drought, demand, drought, Marshallian supply and demand, Marshallian demand, Marshallian supply, supply and demand*, and *theory of supply and demand*. The search revealed 85 relevant sources. The relevant sources include 77 (90.59%) peer reviewed and government sources, and 74 (87.06%) sources published during or after 2014. The topic organization of the relevant sources is theory of supply and demand, California almond industry, drought, and California government. The result of the categorization of the relevant sources was a collection of sources that met the goal of the review, which was subsequently documented and synthesized in the literature review.

Purpose and Variables

The purpose of this study was to quantitatively examine the relationship, or lack thereof, between the independent variables and dependent variable using Marshall's (1920) theory of supply and demand. Marshall's theory, applied in its most basic form, states that the combination of the independent variables will reasonably predict the dependent variable. Therefore, if the combination of the independent variables reasonably predicts the dependent variable, a statistically significant relationship will exist between the variables (alternative hypothesis). However, if the combination of the independent variables does not reasonably predict the dependent variable, a statistically significant relationship will not exist between the variables (null hypothesis).

Theory of Supply and Demand

Although previously documented by several economists before him (Ginzburg, 2015), Marshall is often referred to as the father of supply and demand diagrams (Humphrey, 1992). The purpose of his diagrams was to present a graphical representation of the effects of supply and demand on price (Marshall, 1920). One of the diagrams, as published in the third edition of Marshall's book, Figure 1 depicts the supply and demand curves as related to rent (Marshall, 1895).

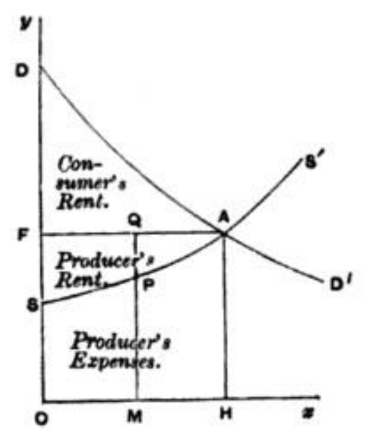

Figure 1. Marshallian supply and demand diagram. Adapted from *Principles of Economics* (3rd ed.) (p. 503), by A. Marshall, 1895, London, England: Macmillan and Co. Copyright 1895 by Macmillan and Co.

Although he did not specifically state as such, Marshall (1920) repeatedly intimated that supply is a specified volume of a product or service. As depicted in Figure

1, the product or service is rent and graphically presented as $\overline{SS'}$. In Marshall's model, aggregated supply is always presented as flat or increasing across the horizontal plane and can be drawn either linearly or as a curve (Jordan, 2014).

The supply curve is the result of defining supply as a function of price (Kim et al., 2016). Marshall (1920) defined the total supply function as $y = \varphi(x)$. This definition includes all supply curve points depicted by $\overline{SS'}$. Therefore, a singular instance of the supply function that focuses on a single supply curve would be defined as $y = f(x)$ (Marshall, 1920) where y is price and x is supply quantity. The linear supply curve, derived from the function and presented in slope intercept form, is defined as $P = P_{\text{int}} + bQ_{\text{s}}$ where P is price, P_{int} is the price (y axis) at the zero quantity (x axis) intercept, b is the positive slope derived from $\Delta P/\Delta Q_{\text{s}}$, and Q_{s} is the quantity supplied.

The demand curve, represented in Figure 1 by $\overline{DD'}$, is similar to the supply curve because the curve is also defined as $y = f(x)$ as the curve defines demanded quantity as a function of price (Marshall, 1920). Another similarity between the supply curve and demand curve functions is that the demand curve can be drawn either linearly or as a curve. However, the demand curve is distinctly different because it is presented with a downward slope across the horizontal plane (Dwyer, Phan, Jago, Bailey, & Marshall, 2016). The linear demand curve, derived from the function and presented in slope intercept form, is defined as $P = P_{\text{int}} - bQ_{\text{d}}$ where P is price, P_{int} is the price (y axis) at the zero quantity (x axis) intercept, b is the negative slope derived from $\Delta P/\Delta Q_{\text{d}}$, and Q_{d} is the quantity demanded.

The reason for the negative slope is that the definition of demand centers on individual or societal desire to obtain a product or service at a specified price (Lloret, Abarle, Panaleon, Valdez, & Vinluan, 2015; Marshall, 1920). The focal point of the definition is that price dictates individual or societal demand. Therefore, assuming all other variables remain unchanged, demand for the product or service would decrease as price increases (Marshall, 1920). Conversely, as the price for the product or service decreases, demand for the product or service increases (Vivekananthan, Mishra, Ledwich, & Li, 2014). The cyclical pressure of market price and market demand on one another continues in an attempt to establish a desired state where pressures equalize, and the market reaches a state of equilibrium.

Equilibrium and Elasticity

One of the theoretical concepts of market supply and demand is that the market will reach a state of equilibrium when demand equals available supply (Krause, Börries, & Bornholdt, 2015). Equilibrium is a state at which price remains constant because one of two conditions exist: both supply and demand remain constant or both supply and demand change similarly (Marshall, 1920). In Figure 1, equilibrium is represented by $\overline{SS'} \cap \overline{DD'}$ (point A). This, however, assumes supply and demand are all variables and are dependent on the other variables. An aspect missing in the base equilibrium state is an instance where ratios amongst multiple variables are not required to remain constant to maintain equilibrium (Truong & Luc, 2015). If variables are dependent on one another, but the ratio between the prices of the items is not, one of the variables can change without affecting the state of equilibrium.

Artificially established equilibrium may exist despite current variable changes if market expectations include future variable adjustments (Krause et al., 2015). Artificial equilibrium is one example of elasticity. Elasticity is the result of an economic equation that quantifies the change in output as it relates to input (Balk, Färe, & Karagiannis, 2015). The elasticity of a market is a measure of the resilience of the market to change (Roberts & Schlenker, 2013). If the elasticity of a market is extremely low, minor changes in variables can produce significant changes making it difficult to identify periods of equilibrium (Bas, Mayer, & Thoenig, 2017). Conversely, extremely high elasticity can allow major changes in the market to have only nominal effects on other variables.

One type of elasticity is demand elasticity, which is the measure of the impacts that changes in other economic variables have on demand. Demand elasticity is a primary key to economic forecasting (Javan & Zahran, 2015). There are three types of demand elasticity: cross, income, and price (Waheed, 2015). Of particular interest to this study is price elasticity of demand.

Price elasticity of demand quantifies the measure of demand responsiveness to market changes in price (Sabatelli, 2016). This responsiveness is cardinal to calculating demand as a function of price (Coglianese, Davis, Kilian, & Stock, 2016). It is, therefore, a critical aspect to predicting market demand (Selvaraj, Srivastava, & Karan, 2015). Marshall (1920) defined the equation for price elasticity of demand, referring to Figure 2, as $(P'R/OM) \div (PR/PM)$. The equation identified the percent of change in quantity demanded divided by the percent of change in price or $\Delta Q_{\mathrm{d}}/\Delta P$.

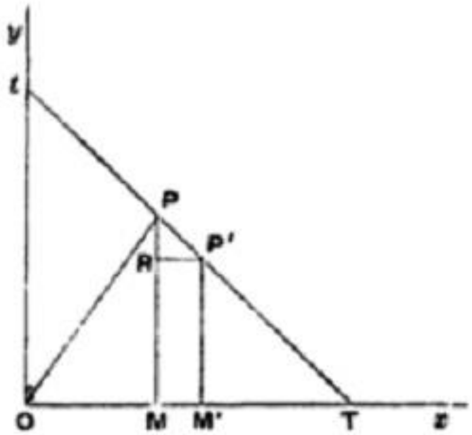

Figure 2. Marshallian price elasticity of demand diagram. Adapted from *Principles of Economics* (3rd ed.) (p. 792), by A. Marshall, 1895, London, England: Macmillan and Co. Copyright 1895 by Macmillan and Co.

Curve Shift

When variables change beyond the pressure exerted by the market's elasticity, the supply and/or demand curve(s) will shift. A demand curve or supply curve shift, therefore, occurs when the commodity's demand or supply does not move along the specific curve (Knittel & Pindyck, 2016) but rather generates a new curve as a result of the change. A sudden and significant change to a curve's variable is called a shock. Shocks can cause a shift in either or both curves simultaneously (Daly & Hobijn, 2014).

Regardless of the type, normal or shock, shifts in the demand curve are generally brought on by either consumer or market changes. Demand curve shifts attributable to market conditions are lower cost direct substitute availability (Schwartz, Silberberg, Casey, Paukner, & Suomi, 2016) and future market speculation (Carter, Rausser, & Smith, 2016). Shifts based on the individual consumer include changes in available income (Carvalho & Rezai, 2015) and consumer preference due to product uncertainty such as the outbreaks of mad cow (Bovine Spongiform Encephalopathy) or foot/hoof and mouth (Aphthae Epizooticae) disease (Oladosu, Rose, & Lee, 2013). Another consumer-based shift is when the total number of possible consumers changes (Michaillat & Saez, 2015), but this specific change is only in relation to aggregate demand.

Figure 3 illustrates demand curve shifts which indicate a change in demand for a product at a given price. Represented by a shift from $\overline{DD'}$ to $\overline{dd'}$ in Figure 3, a shift to the right represents an increase in demand (Kim, Jeong, & Jung, 2014). Conversely, a curve shift to the left indicates a decrease in demand (Vivekananthan et al., 2014), represented by the shift from $\overline{dd'}$ to $\overline{DD'}$.

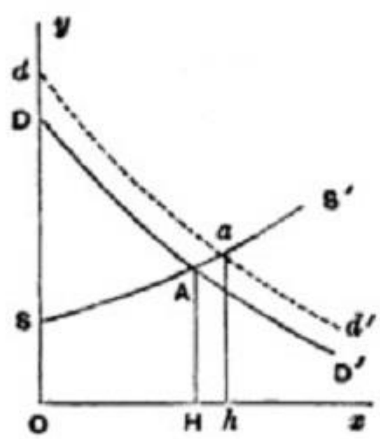

Figure 3. Marshallian demand curve diagram. Adapted from *Principles of Economics* (3rd ed.) (p. 520), by A. Marshall, 1895, London, England: Macmillan and Co. Copyright 1895 by Macmillan and Co.

Shifts in the supply curve are predominantly the result of changes in input costs (Beaudry, Green, & Sand, 2016), such as production costs, taxes, subsidies, or anticipated consumer perception of the product or service. Figure 4 illustrates supply curve shifts, which indicate a change in the volume at which a supplier is willing to sell a product at a specific price. A shift of the supply curve to the left results in a lower supplier output to reach equilibrium (Du & Lin, 2015)., represented by the shift from $\overline{SS'}$ to $\overline{ss'}$ in Figure 4. However, a shift to the right results in a greater supply to reach market equilibrium (Du & Lin, 2015), represented by the a shift from $\overline{ss'}$ to $\overline{SS'}$ in Figure 4.

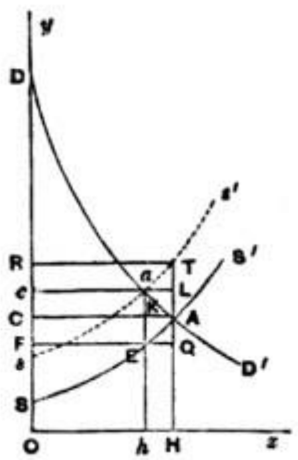

Figure 4. Marshallian supply curve diagram. Adapted from *Principles of Economics* (3rd ed.) (p. 524), by A. Marshall, 1895, London, England: Macmillan and Co. Copyright 1895 by Macmillan and Co.

A tax imposed on a product or service will increase the price of the product or service to allow the supplier to maintain profit margins (Marshall, 1920). The shift from $\overline{SS'}$ to $\overline{ss'}$ in Figure 4 represents the effect of the tax. The result is a price increase for quantity H from $H \cap C$ to $H \cap R$ in the amount of $\overline{aE}$. When the shift is caused by taxation, the shift is the result of a specified amount (tax) levied across the entire market (Marshall, 1920). The shift caused by short term taxation, of most interest to this study, has a much greater impact on demand than long term taxation because consumer demand adjusts over time to the tax induced price increase (Keane, 2015).

Contrasting Theory

As previously discussed, Marshall's (1920) theory of supply and demand was, and often is, considered an economic pillar. However, not all economists have historically agreed with his methods. Two particular economists, Kaldor and Hicks, developed theories that contrasted with that of Marshall.

Kaldor. Kaldor (1934) approached the supply curve from the perspective of the individual firm as a prerequisite to developing the supply curve for the aggregate of the entire industry, which is contrary to a single curve for an industry as defined by Marshall (1920). A key facet of Kaldor's theory, pointing to the industry's aggregate, is the positive impact of exports on an economy (Padhi, 2015; Ribeiro, McCombie, & Lima, 2017). The economic impact of exports may have been of interest to this study because, as evidenced by being the provider of more than 80% of the world's almonds, the California almond industry is heavily dependent on almond exports (Larsen, Horney, & Macon, 2014). However, the position of the individual firm within Kaldor's theory negates the applicability of his theory for this study because the data for this study are inclusive of the almond industry as a whole.

Hicks. The differentiating aspects of Hicksian demand theory are consumer utility and compensation assumptions (Hicks, 1934). In his demand equation, Hicks (1939) assumed consumers of a group of products have sufficient wealth to purchase the group of products and that the consumer has a defined level of utility for the group of products. Marshall (1920) quantified the relationship between a commodity's price and its demand while assuming all other variables, including utility and compensation, remain constant.

The approaches of Marshall and Hicks are clearly different. Still, Hicksian demand $D^{h} = f(p)$ and Marshallian demand $y = f(x)$ equations both satisfy the Law of Demand under specific circumstances and linear examination (Amir, Erickson, & Jin, 2017). However, because of the requirement of an indeterminate and subsequently assumed consumer utility, “Hicksian demands are not typically used in empirical demand analysis” (Jadidzadeh & Serletis, 2016, p. 6). This theory, therefore, is also inappropriate for this study.

Almond Demand and Supply

Consumers throughout the world are increasingly using plant-based substitutes for milk. Although global almond-based product demand has significantly increased primarily due to marketing campaigns focused on the nutritional benefits of almonds (Brittain, Kremen, Garber, & Kelin, 2014; Deliwe & Knott, 2015), other uses also explain the increase. In areas where traditional mammal milk is regionally too costly or unavailable (Mäkinen, Wanhalinna, Zannini, & Arendt, 2015), almond milk is more affordable and available. Almond milk is also an alternative for those who are lactose intolerant (Bernat, Cháfer, Rodriguez-Garcia, Chiralt, & González-Martínez, 2015) or have celiac disease (Jnawali, Kumar, & Tanwar, 2016). The significant increase in almond production reflects the increase of almond-based product demand.

Since the introduction of almonds production into the United States’ agricultural repertoire, production has risen significantly. Government records of almonds as a commodity began in 1919 with approximately 9,000,000 lb (4,082,331 kg) of almonds produced (National Agricultural Statistics Survey, 2016). That volume, however, pales in comparison to the 396,832,000 lb (179,999,997 kg) produced in 1983 (Food and Agriculture Organization of the United Nations Statistics Division, 2013) and the 2,014,000,000,000 lb (913,535,033,180 kg) produced in 2011 (National Agricultural Statistics Survey, 2016).

Until 1963, the National Agricultural Statistics Survey (2016) reported total production with the almond in the shell (unshelled). In a fundamental shift in reporting, the United States Department of Agriculture (USDA) began recording the total production weight of the almond industry in shelled (out of the shell) pounds in 1977 (National Agricultural Statistics Survey, 2016). However, total almond production was recorded unshelled and shelled between 1964 and 1976 (National Agricultural Statistics Survey, 2016).

The shift in recording method enabled the report to include the overall weight of production as well as the edible portion of the overall weight. Almond processing must occur to determine the edible portion. The processing of almonds begins with hulling and shelling the almonds (Aktas et al., 2015). Removing the hull and shell of the almond exposes the edible part of the almond (Maestri et al., 2015). Extracting the meat of the almond allows inspectors to determine the quality and reporting status of the almond.

Drought

A common misconception is that a drought is a period of little to no rainfall. In fact, a drought is the combination of sustained periods of little to no precipitation that accumulate to cause an imbalance that is hydrological and meteorological in nature (Deo, Byun, Adamowski, & Begum, 2015). This definition is, however, a broad definition that generalizes the four types of drought into a single phenomenon.

The four types of drought are meteorological, hydrological, agricultural, and socioeconomic (Deo, Byun, Adamowski, & Begum, 2015). A meteorological drought is a significant reduction in precipitation across an entire region (Hatmoko, Radhika, Raharja, Tollenaar, & Vernimmen, 2015). As a cyclical phenomenon, an extended meteorological drought can advance to the other types of droughts (Deo, Byun, Adamowski, & Begum, 2015). An agricultural drought, one marked by significant reductions in moisture contained within the soil (Luo et al., 2017), can be the result of an extended meteorological drought.

A hydrological drought is another potential result of a meteorological drought (Deo, Byun, Adamowski, & Begum, 2015). A hydrological drought is a lack of groundwater and water below the surface (Van Loon, 2015). Hydrological droughts can have extended areas of impact beyond the areas of reduced precipitation (Van Loon, 2015). A socioeconomic drought, one of the least studied types of droughts, refers to the social, economic, and environmental impacts of the drought based on the inability of the supply to meet the demand of water (Huang, Huang, Leng, & Liu, 2016). Based on the reduction of annual precipitation, lack of available ground and subterranean water, and area of impact, the California drought meets the conditions for three of the four drought classifications.

Government Mandates

Due to the statewide effects of the continued drought, California began implementing significant measures to govern water utilization. In May of 2013, California Governor Edmund G. Brown Jr. acknowledged the significance of the effect of the drought on agriculture and ordered the California Department of Water Resources and the State Water Resources Control Board to process water transfer requests more expeditiously (Cal. Exec. Order No. B-21-13, May 20, 2013). At the time of the order, state projections for area-specific water deliveries were between 20% and 35% of requested amounts (Cal. Exec. Order No. B-21-13, May 20, 2013). The order eased the ability of California farmers to transfer excess water to farmers in need.

As the drought continued, the Governor continued intervention methods. In 2014, the Governor established (Cal. Proclamation No. 1-17-14, January 7, 2014) and later extended through the remainder of 2014 (Cal. Proclamation No. 4-25-14, April 25, 2014) a state of emergency because of the drought. In addition to reducing nonessential water usage by eliminating state-sponsored landscaping projects, restricting the use of potable water at recreational, commercial, and sports facilities, and prohibiting Homeowners Associations from implementing fines for owner water reduction measures, the proclamations again increased the speed at which the California Department of Water Resources and the State Water Resources Control Board would process water transfer requests (Cal. Proclamation No. 1-17-14, January 7, 2014; Cal. Proclamation No. 4-25-14, April 25, 2014). The Governor's proclamations established a foundation for governing water utilization.

While previous proclamations established and extended a drought-induced state of emergency, some of the provisions contained within the proclamations were set to expire at the end of 2014. The Governor extended two provisions contained within the proclamations through May 31, 2016 (Cal. Exec. Order No. B-28-14, December 22, 2014). Specifically, the Governor extended provisions that suspended some environmental reviews by state agencies where local agencies were sufficient (Cal. Proclamation No. 4-25-14, April 25, 2014) and some state regulations that restricted the ability of state agencies to directly combat the impacts of the drought (Cal. Proclamation No. 1-17-14, January 7, 2014)

In 2015, after four years of continued drought conditions, it became apparent that drastic measures were required to mitigate drought effects. The Governor, for the first time in the history of California, ordered a 25% reduction in potable water utilization throughout the state, a prohibition on potable water use in irrigation, the development of enforcement procedures to combat water waste, and the investment of state funds into new technology for water conservation (Cal. Exec. Order No. B-29-15, April 1, 2015). Additionally, the Governor acknowledged the potential of a continued drought through and after 2016 (Cal. Exec. Order No. B-29-15, April 1, 2015).

Although not as sweeping as his previous order, the Governor continued to use his executive powers to guide Californian through the drought. In May 2016, the Governor ordered the California Department of Water Resources to begin preparing recommendations for potable water reductions through 2017, the State Water Board to convert short-term prohibitions on water waste to permanent prohibitions, an increase in drought planning, and a reduced threshold for agricultural water plan development from 25,000 ac (10,117.14 ha) to 10,000 ac (4,046.86 ha) (Cal. Exec. Order No. B-37-16, May 9, 2016).

In April of 2017, the Governor issued Executive Order B-40-17. The order, issued in response to the significant precipitation increase in the early months of 2017, lifted the state of emergency for the majority of California (Cal. Exec. Order No. B-40-17, April 7, 2017). Fresno, Kings, Tulare, and Tuolumne counties, all situated in the Central Valley, were exempted from the order due to continued drought effects and reduced water availability (Cal. Exec. Order No. B-40-17, April 7, 2017). As of June, this was the Governor's most recent mandate regarding water utilization. The exemption of these counties seemed to indicate a cautious approach to mandate reversal in the highly agricultural areas of the Central Valley and an acknowledgment of the significant impact of the drought.

Authority, Enforcement, and Penalties

The legislation established for the governing of water within the State of California is the California Water Code. The California Water Resources Control Board is the body with authority to establish policies and procedures deemed necessary to fulfill the powers granted within the California Water Code (Cal. Water Code § 1058, 2015). As a method of deterrence, the California Water Resources Control Board has the authority to fine any person or entity that violates policies adopted by the California Water Resources Control Board to a maximum of $500.00 per day (Cal. Water Code § 1058, 2015; Cal. Water Code § 1846, 2015). The California Water Resources Control Board may enforce the $500.00 per day assessment or request enforcement by the Attorney General (Cal. Water Code § 1846, 2015).

If a person or entity does not comply with a California Water Resources Control Board issued cease and desist order, the California Water Resources Control Board may request the Attorney General utilize the superior court to intercede (Cal. Water Code § 1845, 2014). The penalty for not complying with a cease and desist order is $10,000.00 per day if this occurs while under a drought-induced state of emergency (Cal. Water Code § 1845, 2014). The combined penalty potential could be significant for small and large organizations alike.

Literature Focus

The focus of this quantitative study was agricultural market demand based on the insertion of the effects of environmental fines into supply and demand equations. Comparable studies were either incredibly difficult to locate or not existent. Several consistent groups of literature themes were, however, present.

Roberts and Schlenker (2009) conducted a study of the world's supply and demand of four food staples (corn, rice, soybeans, and wheat) to analyze the effect of environmental shocks on the supply of those products. The commodity aggregation method was total caloric content (Roberts & Schlenker, 2009). Their innovative approach, using yield shocks to the elasticity of supply, enabled the isolation of supply curve changes from the effects of demand curve variance (Roberts & Schlenker, 2009) and later to examine the effects of renewable fuel legislation on commodity prices (Roberts & Schlenker, 2013).

This perspective exposed an expansion point for researchers by providing an alternate platform. Wright (2014a) analyzed the caloric content of grain production to examine causes for grain price changes and later (2014b) leaned on the Roberts and Schlenker (2009, 2013) perspective to evaluate the effects of biofuels on world grain and stock prices. Other researchers have conducted topically similar studies of the relationships between agriculture and various industries such as oil (Baumeister & Kilian, 2014; Dillon & Barrett, 2015), biofuel legislation (Korting & Just, 2017; Wright, Larson, Lark, & Gibbs, 2017; Zhou & Babcock, 2017), and bioenergy (Waldenström et al., 2016; Wesseler & Drabik, 2016) .

The other major body of associated literature related to the effect of the drought on agriculture. One of the predominantly cited series of work was a series of studies conducted by the University of California as a report to the California Department of Agriculture. University researchers conducted a series of broad economic impact studies based on the continued drought (Howitt, MacEwan, Medellin-Azuara, Lund, & Sumner, 2014; Howitt, MacEwan, Medellin-Azuara, Lund, & Sumner, 2015a; Medellín-Azuara, MacEwan, Howitt, Sumner, & Lund, 2017). Additional dominant areas of study included the effects of drought on food security (Rodriguez, Horowitz, Espinoza, Aguilera, & de la Torre, 2015; Sá et al., 2017; Stahl et al., 2016), water management (Murti et al., 2016; Rey, Holman, & Knox, 2017; Urquijo & De Stefano, 2015), and drought risk assessment (Cheng et al., 2016; Feng, Trnka, Hayes, & Zhang, 2017; Skakun, Kussul, Shelestov, & Kussul, 2015).

Literature Synthesis for Variable Measurement

The independent variables included in this study were almond supply, almond market price, and California imposed fines for excessive water utilization. The data downloaded from the United States Department of Agriculture National Agricultural Statistics Service included almond supply and almond market datum. Data from the California Water Board and the California Almond Board were the basis for the values of the final independent variable (fine effect). The dependent variable for this study was almond demand.

Almond market supply. The almond market supply variable was predefined because the data for the variable was historical data. However, almond production (almond supply) weight data were recorded using imperial measurements. The researcher converted the historical data to metric values using the National Institute of Standards and Technology equation (United States Department of Commerce, 2016)

$$W_{\mathrm{t}} = W_{\mathrm{r}} * W_{\mathrm{cmt}} = W_{\mathrm{r}} * 0.9071847$$

where W_{t} was the converted weight value in metric tons (United States Department of Commerce, 2016), W_{r} was the reported weight value in imperial tons (National Agricultural Statistics Survey, 2016), and W_{cmt} was the value to convert one U.S. ton to one metric ton (United States Department of Commerce, 2016).

Due to the 1973 change in recording methods of almond production from unshelled to shelled (National Agricultural Statistics Survey, 2016), I converted weight values from imperial to metric values and converted production values between 1919 and 1963 from unshelled to shelled. The conversion was calculated using a researcher adaptation of the National Institute of Standards and Technology equation (United States Department of Commerce, 2016) that included a researcher defined variable for the variance between unshelled and shelled weights as a part of the equation

$$W_{\mathrm{t}} = \frac{W_{\mathrm{r}} * W_{\mathrm{cmt}}}{A_{\mathrm{D}}} = \frac{W_{\mathrm{r}} * 0.9071847}{\left(\frac{\frac{U_{1964}}{S_{1964}} + \frac{U_{1965}}{S_{1965}} + \cdots + \frac{U_{1975}}{S_{1975}} + \frac{U_{1976}}{S_{1976}}}{13}\right)}$$

where W_{t} was the converted and calculated weight value in metric tons, W_{r} was the reported weight value in tons (National Agricultural Statistics Survey, 2016), W_{cmt} was the value to convert one U.S. ton to one metric ton (United States Department of Commerce, 2016), A_{D} was the average percent difference between the converted unshelled and shelled production weight values between 1964 and 1976, U_{19XX} was the converted unshelled production weight for the given year, and S_{19XX} was the converted production shelled weight for the given year.

Almond market price. The variable for almond market price, just as the almond market supply variable, was predefined because of the historical nature of the data. The reported commodity market prices were in imperial units (National Agricultural Statistics Survey, 2016). Therefore, I recalculated the value for market price. The recalculation, conducted after converting supply weights to metric tons, resulted in "price per metric ton" instead of "price per ton." The researcher defined equation for the recalculation was

$$P_{\mathrm{t}} = \frac{P_{\mathrm{rt}}}{W_{\mathrm{t}}}$$

where P_t was the calculated price per metric ton, P_{rt} was the total market value reported in U.S. dollars (National Agricultural Statistics Survey, 2016), and W_t was the previously converted weight value in metric tons.

Market fine effect. Because agriculture was exempt from water reduction mandates, data for fine assessment to agricultural entities did not exist. Therefore, the data was generated using various sets of information and scenarios. The California Water Resources Control Board has the authority to fine either a person or entity (Cal. Water Code § 1058, 2015; Cal. Water Code § 1846, 2015). According to the Almond Board of California, approximately 6,800 almond farms (Almond Board of California, 2015) deliver to 95 suppliers/exporters (Almond Board of California, 2016).

The total effect of fines for excessive water utilization will vary depending on the number of growers fined, the number of days fined, and the level of fine application. For example, the market impact will be lower if one grower were fined one day at the lower level than if all growers were fined 30 days at the upper level. The equation must include the total amount of the fines to determine the overall market effect of the fine. The researcher developed equation for total fine was

$$F_t = F_L(D_{f1} * G_{f1}) + F_U(D_{f2} * G_{f2}) = \$500(D_{f1} * G_{f1}) + \$10{,}000(D_{f2} * G_{f2})$$

where F_t was the total amount fined across the almond market for the market year, F_L and F_U were the lower and upper fine amounts respectively (Cal. Water Code § 1845, 2014; Cal. Water Code § 1058, 2015; Cal. Water Code § 1846, 2015), D_f was the number of days fined at each level, and G_f was the number of growers fined at each level.

With F_t defined, the following researcher developed equation was used to determine the market effect of fines for excessive water utilization based on Marshall's (1920) taxation supply curve shift as the market will likely react to potential fines similar to if the fines were a tax. The equation identified the impact of the fines across the entire market based on a percentage of the individual grower aggregate fines as the fines relate to total market output.

$$F_e = F_p \frac{F_t}{W_t}$$

where F_e was the overall fine effect on the market, F_p was percent of growers fined, F_t was the total fine amount across the market, and W_t was the previously converted weight value in metric tons.

Almond market demand and elasticity. The data to calculate demand and price elasticity of demand were available in the historical data set. However, I was required to calculate both because the data did not specifically provide either. The researcher calculated both by segments of time defined by historical price fluctuations. Marshall's (1920) price elasticity of demand equation was used to calculate the resistance to change for each segment

$$\eta = \Delta Q_d / \Delta P_t$$

where η was the price elasticity of demand (Marshall, 1920), Q_d was the demand quantity (previously converted weight value in metric tons), and P_t was the previously converted price per metric ton.

Demand for each time segment was calculated with and without the inclusion of fines for excessive water utilization. The separate calculations allowed the inclusion of the fines in the examination of the relationships, or lack thereof, between variables. Unaltered (without fine inclusion) almond demand was calculated using Marshall's (1920) linear demand equation

$$Q_{\mathrm{d}} = \frac{P_{\mathrm{t}} - P_{\mathrm{int}}}{b} = \frac{P_{\mathrm{t}} - P_{\mathrm{int}}}{\frac{\Delta P_{\mathrm{t}}}{\Delta Q_{\mathrm{d}}}}$$

where Q_d was the quantity demanded (Marshall, 1920), P_t was the previously converted price per metric ton, P_{int} was the price (y axis) at the zero quantity (x axis) intercept (previously converted to price per metric ton), and b was the negative slope.

Almond demand that included the effect of the fine was calculated using a researcher adaptation of Marshall's (1920) linear demand equation that included F_e as part of the equation

$$Q_{\mathrm{d}} = \frac{\mathrm{F_e} + P_{\mathrm{t}} - P_{\mathrm{int}}}{b} = \frac{\mathrm{F_e} + P_{\mathrm{t}} - P_{\mathrm{int}}}{\frac{\Delta P_{\mathrm{t}}}{\Delta Q_{\mathrm{d}}}}$$

where Q_d was the quantity demanded (Marshall, 1920), F_e was the fine effect, P_t was the previously converted price per metric ton, P_{int} was the price (y axis) at the zero quantity (x axis) intercept (previously converted to price per metric ton), and b was the negative slope.

Transition

Section 1 introduced the business problem identified as the foundation for this study and the purpose for examining the potential relationships between fines for excessive water utilization, almond supply, almond market price, and almond demand. Because of the need to examine the relationships or lack thereof, the method and design recommended for this study were quantitative correlation using Marshall's theory of supply and demand as the theoretical framework.

The Literature Review aided my identification of alternative frameworks. Economic theories such as those developed by Kaldor and Hicks were possible frameworks, but the data source and differing perspectives eliminated them as viable for this study. Marshall's theory, however, was appropriate because the data source for this study included data that precisely mapped to the variables required for calculation.

The results of the Literature Review more firmly established the need to examine the relationship between the almond market and potential fines for excessive water utilization. The legislation regarding water reduction requirements exempted agriculture but did not indefinitely exempt agriculture. Almond growers must prepare for the potential of water reductions in agriculture to prevent paying the substantial fines, considering the definite authority of the California Water Resources Control Board to exact fines and the rate at which the fines accumulate and increase. Although an individual or single entity is the recipient of the fine, the potential for market demand impact is significant.

Section 2 more deeply addresses the nature of this research project. Section 2 also explains the researcher's role in the study, data gathering processes, and the methodology employed in data analysis. Section 3 documents the data analysis results, provides practical business application, and identifies areas of positive social change based on the results of this study.

Section 2: The Project

Section 2 includes the purpose statement, an explanation of the researcher's role in this study, a description of study's participants, and a discussion of the study's design and method. Additionally, Section 2 includes the population and sample size rationale, ethical research considerations, description of the data collection technique, and discussions of instrumentation, data analysis, and study validity. The combination of these areas provides the foundation for the data analysis reported in Section 3.

Purpose Statement

The purpose of this quantitative correlation study was to examine the relationship between fines for excessive water utilization, almond supply, almond market price, and almond demand. The independent variables were (a) California imposed fines for excessive water utilization, (b) almond supply, and (c) almond market price. The dependent variable was almond demand. The target population consisted of almond business leaders in California. The target population was appropriate for this study because the California job market lost approximately 10,100 seasonal jobs in 2015 as a direct result of environmental impacts (Howitt, MacEwan, Medellin-Azuara, Lund, & Sumner, 2015a). The implications for social change included the restoration of employment opportunities, stabilization of migratory worker prospects, and reduction of water utilization to preserve natural resources.

Role of the Researcher

A critical aspect of the integrity of research is the ability of the researcher to remain objective and unbiased throughout the process (Kozica et al., 2015). For this study, my roles were to collect, organize, and analyze the data. The data for this study consisted of publicly available historical government data regarding almond industry production. I had no personal affiliation with the almond industry or the USDA. No ethical or interest conflicts existed for this study.

Participants

Participants are individuals or groups of individuals (Gardner, Fraser, MacLennan, & Treweek, 2016) selected to provide input for or take part in a study (Middleton et al., 2015) based on predefined measures that represent designated attributes of a larger population (Ko, LaToza, & Burnett, 2013). The dataset for this study consisted solely of publicly available government archival data. Therefore, this study required no participants.

Research Method and Design

Research Method

The purpose of this quantitative study was to examine the relationships between fines for excessive water utilization, almond supply, almond market price, and almond demand. The specific focus was the impact of the fines on demand through almond supply and market price. The quantitative method enables researchers to identify and examine relationships between variables (Ansell, Freudenberger, Munro, & Gibbons, 2016) through the statistical analysis of mathematical data (Nankar et al., 2016). The use of mathematical data allows researchers to include large data sets, thereby potentially increasing the accuracy of the results of the analysis (Adeyolanu & Ogunkunle, 2016).

Two methodologies not selected for this study were mixed methods and qualitative. Mixed methods research employs both quantitative and qualitative analysis within the same study (Mayoh & Onwuegbuzie, 2015). Qualitative research is a method by which researchers attempt to understand a phenomenon by gathering and analyzing background, social, and/or experience information from participants (Berger, 2015), often through structured or semistructured participant interviews (Gioia, Corley, & Hamilton, 2013). Because of the need to analyze only mathematical data, as opposed to narrative data provided by participants or both mathematical and narrative data, the mixed methods and qualitative research methodologies were not appropriate for this study.

Research Design

Researchers use the correlational design when studying the mathematical relationships, or lack thereof, between variables (Bettany-Saltikov & Whittaker, 2013; Bozkurt et al., 2012; Yaghoubi & Habibinejad, 2015). The focus of this quantitative study was to examine the relationships between the three independent variables and the dependent variable. Therefore, the appropriate design for this study was the correlational design.

The experimental design employs variable manipulation to examine the effect of one variable on another randomized variable through comparison of effects in treated and control groups (Curtis et al., 2015). Studies that are quasi-experimental may also use treated and control groups, but group membership is not randomized (Riemersma, VanSantvoort, Janssens, Hosman, & VanDoesum, 2015). Although experimental and quasi-experimental designs are strong quantitative study designs, neither were suitable for this study. The lack of suitability was because of the aforementioned variable randomization in the experimental design and treated/control groups in the quasi-experimental design.

Population and Sampling

The data for this study were historical data archived by the USDA National Agricultural Statistics Service. The dataset included, but was not limited to, data on almond production and price between 1919 and 2015 inclusive. The total data set consisted of 97 annual data points for production and price.

G*Power 3.1.9.2 (Faul, Erdfelder, Buchner, & Lang, 2009) is an application that can be used to identify a minimum sample size for research (Capielo, Delgado-Romero, & Stewart, 2015; Fulton & Cashwell, 2015; Sánchez, Rosenthal, Tansey, Frain, & Bezyak, 2016). As displayed in Figure 5, the G*Power application was configured to use three predictors, error probability α = 0.05, and an effect size f^2 = 0.1. The minimum sample size, calculated by G*Power configured as described, was 88. The dataset sample size (97) exceeded the minimum sample size and was, therefore, appropriate.

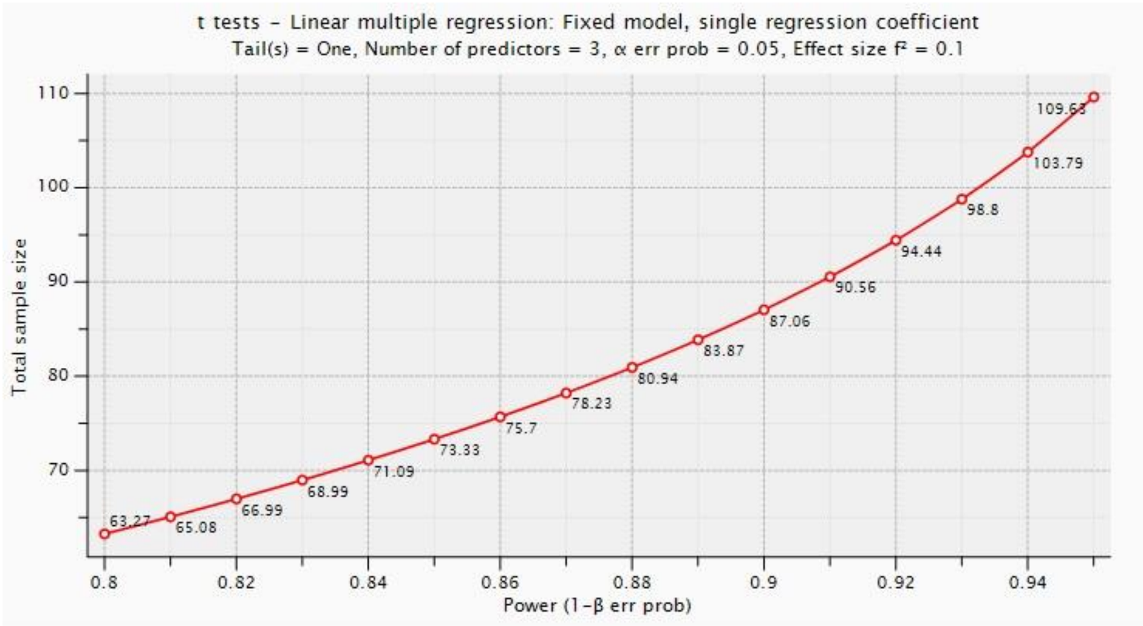

*Figure 5***.** G*Power (Version 3.1) [Computer software] multiple regression power analysis and sample size calculation result.

The nonprobabilistic sampling method employed in this study was the consecutive sampling method. I used this method because it includes all available data points instead of a subset of data (Holmes, LaHurd, Wasson, McClarin, & Dabney, 2015). Probabilistic sampling methods were not appropriate for this study because the data set did not identify individuals, and probabilistic methods require a means of differentiating between population members (Luo, 2016).

Ethical Research

Protecting individual privacy during all phases of research is critical when researchers study an individual or groups of individuals (Busher & James, 2015). Academic institutions often establish governance, such as an Institutional Review Board, to protect study participants (Sedenberg, Chuang, & Mulligan, 2016). When using publicly available archival information as the data source for a study, individual privacy must remain an ethical priority (Abonyi, Hackett, & Dyck, 2016).

Although I used archival data that are public domain, the data set did not include any individual data. Quantities and values contained in the data set were aggregate numbers for the entire United States. Subsequently, no ethical concerns pertained to the data included in this study.

The lack of individual participation precluded the need for informed consent, participant withdrawal procedures, participatory incentives, and individual/organizational anonymization. Still, I included a copy of my Certificate of Completion of the "Protecting Human Research Participants" course provided by the National Institutes of Health Office of Extramural Research in Appendix A. Although the data for this study was publicly available, I will store a copy of the data set on an encrypted universal serial bus (USB) device in a safe for 5 years.

Instrumentation

The data collection instrument for this study was the USDA National Agricultural Statistics Service and the California Water Code. Neither surveys nor interviews were necessary. Table 1 details the study's variable names, types, and units of measure.

Table 1

Study Variables, Types, and Measures

Variable	Type	Measure
Almond demand	Dependent	Metric tons
Almond price	Independent	U.S. Dollar per metric ton
Almond supply	Independent	Metric tons
Fines for excessive water utilization	Independent	U.S. Dollar

The measure for almond demand (dependent variable; DV) and almond supply (IV) was metric tons, per the internationally accepted (Frezza, Maddio, Pelosi, & Selleri, 2015; Pavese & Charki, 2016; van Remortel, 2016) International System of Units (Bureau International des Poids et Mesures, 2014). I downloaded the annual data for these variables and almond price from the USDA National Agricultural Statistics Service. The measure for almond price (independent variable; IV) was U.S. dollar per metric ton. The measure for fines for excessive water utilization (IV) was United States dollars. I calculated these data from the California Water Code.

The USDA National Agricultural Statistics Service is a complete source of publicly available agricultural data and was, therefore, the appropriate data source for this study. No concerns regarding data reliability and validity were evident because the data consist solely of government archival data from the regulating agency (Fleischhacker, Evenson, Sharkey, Pitts, & Rodriguez, 2013). The raw data were available from the USDA National Agricultural Statistics Service website. Additionally, the compiled raw data are available in Tables B1, B2, and B3 (see Appendix B).

Data Collection Technique

I downloaded data for this study from the National Agricultural Statistics Service provided by the USDA. After the Walden University Institutional Review Board approved this study (IRB Approval Number 08-25-17-0577058), I downloaded the data to an encrypted hard drive partition. I stored the data in a password protected Microsoft Excel spreadsheet.

Data Analysis

The research question for this study was as follows: What is the relationship between fines for excessive water utilization, almond supply, almond market price, and almond demand?

H_0: There is no statistically significant relationship between fines for excessive water utilization, almond supply, almond market price, and almond demand.

H_1: There is a statistically significant relationship between fines for excessive water utilization, almond supply, almond market price, and almond demand.

The purpose of this study was to examine the relationships between the predictor variables (fines for excessive water utilization, almond supply, and almond market price) and the response variable (almond demand). The quantitative statistical analysis method for this study was multiple linear regression. This analysis method was appropriate for this study because multiple linear regression can analyze the correlations between multiple predictor variables and a dependent variable (Mahmoud, Saad, & El Shaer, 2014; Miozzo, Pulvermüller, & Hauk, 2014; Nimon & Oswald, 2013) as dictated by the research question.

I considered three additional methods for suitability to this study: simple correlation, path analysis, and analysis of variance. Simple correlation analysis is limited to two variables (Nagar, Mishra, & Vijay, 2015). Path analysis is employed to determine causality among variables (Zhang, 2015). Analysis of variance (ANOVA) is a method used to identify differences between the influence of two or more IVs on the DV (Zębala & Kowalczyk, 2014). Therefore, I did not use any of the additional methods.

Data cleaning is the act of reducing the potential effects of invalid or missing data on a study by locating the data and performing some corrective action (Li et al., 2015). The data used in this study were a complete historical set of annual data downloaded from the National Agricultural Statistics Service. Therefore, the need for locating invalid and/or missing data was not a concern.

However, I needed to test the multiple linear regression assumptions before conducting data analysis. The assumptions associated with multiple linear regression are auto-correlation, homoscedasticity, linearity, multicollinearity, normality (Žmuk, 2015), and outliers (Altman & Krzywinski, 2016). The Durbin-Watson test was used to identify instances of auto-correlation (Boozer Jr., Staples, Keith Lowe, & Landry III, 2016) and, with variance inflation factor, multicollinearity (Shaw, Phinn, Tilbrook, & Steven, 2015). A scatter plot was used to check for outliers, homoscedasticity, and linearity (Shaw et al., 2015). The Shapiro-Wilk test was used to check for data normality (Dasyam, Pal, Rao, & Bhattacharyya, 2015). If assumption violations occur, bootstrapping is a mechanism employed to combat the potential effects of said violations (Welker & Carré, 2014).

In addition to analyzing assumption test results for violations, I needed to interpret inferential results of data analysis. The inferential result that was of particular interest to this study was significance level (*p*). The significance level is a numerical value the researcher employs to determine whether to reject a null hypothesis (Szucs & Ioannidis, 2017). However, the false rejection of a true null hypothesis is a concerning statistical probability when using multiple hypotheses (Streiner, 2015). A false rejection due to multiplicity was not a concern because this study had a single hypothesis. Therefore, this study relied on statistical significance values where if $p < 0.05$, the null hypothesis would be rejected, and if $p > 0.05$, the null hypothesis would not be rejected (Glickman, Rao, & Schultz, 2014; Motulsky, 2014).

I used SPSS Statistics for Windows (SPSS) version 23 by IBM (IBM Corp., 2015) as the statistical analysis platform for this study despite the potential applicability of other software packages that were either proprietary (i.e., Number Cruncher Statistical System, Stata, and Statistical Analysis System) or freeware (i.e., ADaMSoft, Octave, and PSPP). SPSS is capable of conducting multiple regression analysis (James et al., 2015), correlation analysis (Bechard, Cacodcar, King, & Lewis, 2016), and the necessary assumption tests previously noted (IBM Corp., 2015). SPSS was, therefore, applicable to this study. Additionally, I recommended SPSS over other software packages due to prior use of and familiarity with SPSS.

Study Validity

Internal validity is one of the primary concerns for studies attempting to discern causality and experimental studies. As this study was correlational and neither experimental in nature nor focused on causality, threats to internal validity were not applicable. However, threats to the statistical validity of the conclusions were a significant concern. The two threats to statistical conclusion validity are Type I errors and Type II errors (Akobeng, 2016). A Type I error causes a true null hypothesis to be rejected (Glickman et al., 2014) where a Type II error causes a false null hypothesis not to be rejected (Mittal, Singh, & Patel, 2016). As displayed in Figure 5, this study's probability for Type I error (α) and Type II error (β) was 0.05 and 0.2 respectively. Researchers traditionally consider these values acceptable (Mittal et al., 2016).

The data for this study represented the complete collection of data. Assuming $\alpha = 0.05$ and f^2 (effect size) = 0.1, the sample size for this study of 97 exceeded the minimum sample size of 88. However, the results of this study may not be generalizable beyond the delimitations of this study because a larger population with the same characteristics (almond growers within the United States) does not exist.

Transition and Summary

The driving force for this study was the continuous increase of almond acreage in California during an extreme drought. The objective of this study was to examine almond industry demand with a focus on one potential drought impact on demand: fines for excessive water utilization. Section 2 included the justification for the use of publicly available data and defined sample size, an explanation of data instrumentation and manipulation, and a discussion of data analysis and study validity. Section 3 includes an analysis of the data, the applicability of the study's results to professional practices, and the implications for positive social change.

Section 3: Application to Professional Practice and Implications for Change

Introduction

The purpose of this quantitative correlational study was to examine the relationship between fines for excessive water utilization, almond supply, almond market price, and almond demand. The IVs were excessive water utilization, almond supply, and almond market price. The DV was almond demand. Based on statistical analysis, a significant relationship existed between the IVs and the DV. Therefore, I rejected the null hypothesis and accepted the alternative hypothesis.

Presentation of the Findings

In this section, I discuss assumption testing, present descriptive statistics and statistical analysis results, and provide a findings discussion and concluding summary. To mitigate the potential impacts of assumption violations, I used 2,000 samples for Bootstrapping. When applicable, I reported the 95% bootstrapping confidence intervals.

Assumption Testing

Before conducting assumption testing, I converted the annual raw data as described in Section 1 and calculated elasticity and demand curves for the demand segments without including fine effect (IV). I documented the converted data, demand segments, elasticity, and initial demand curves in Appendix C. While calculating the demand curves, I identified a significant data outlier that exemplified the recent volatility of the almond market. The 2013 data indicated a large increase in both production and price that, when included in the demand calculation, resulted in a positive demand curve. This result violated Marshall’s (1920) theory of supply and demand requirement of a negative demand curve. Based on this result, I excluded the 2013 data point from further calculations. The remaining 96 annual data points exceeded the previously identified minimum of 88 data points.

After calculating demand without fine effect, I calculated fine effect and demand including fine effect. Because the number of farms was not provided in the data but was required to calculate fine effect, I used the following equation for calculating the value for each year

$$N_{\mathrm{f}} = \frac{W_{\mathrm{t}}}{\left(\frac{W_{\mathrm{t2015}}}{F_{2015}}\right)} = \frac{W_{\mathrm{t}}}{\left(\frac{861{,}825.47}{6{,}800}\right)} = \frac{W_{\mathrm{t}}}{127}$$

where N_{f} was the total number of farms for the given year, W_{t} was the previously converted weight value in metric tons, W_{t2015} was the previously converted weight value in metric tons for 2015, and F_{2015} was the number of farms in 2015 (Almond Board of California, 2015).

To calculate the growers fined for the upper and lower fine amount, I used 40% of the calculated number of farms for the year. I selected this value because the Almond Board of California (2015) stated that approximately 60% of farms used water reducing irrigation methods in 2015. I interpreted this statement to imply that, for this study, 40% of almond growers were at greater risk of receiving fines for excessive water consumption. To calculate the total fine, I elected to use 30 days at the lower fine level and 1 day at the upper fine level to reflect the first point at which the upper level could legally be imposed.

Using the modified demand equation discussed in Section 1, I calculated the modified demand curve, fine effect included, for each time segment. With all necessary variables calculated, I evaluated the data for assumptions of auto-correlation, homoscedasticity, linearity, multicollinearity, normality, and outliers. I used 2,000 samples for bootstrapping to combat any influence of assumption violations.

Normality. I evaluated the data for violations of normality by reviewing the result of the Shapiro-Wilk test of normality. A test result of $p < \alpha$ violates the assumption of normality (Hanusz, Tarasinska, & Zielinski, 2016). I determined the assumption of normality violated based on the test result of $p = .000$ for demand. Additionally, the initial Normal P-P Probability Plot of Regression Standardized Residual supported this result and determination. Based on this result, I transformed all variables using SPSS LG10, which can be used to normalize data (Ay et al., 2010). The updated Shapiro-Wilk test results for demand increased slightly to $p = .004$. However, based on the propensity of the data points displayed on the updated Normal P-P Plot of Regression Standardized Residual (Figure 6) to remain on or near the upward and left to right trending diagonal line indicated normality (Casson & Farmer, 2014), I determined the assumption of normality was not significantly violated.

Auto-correlation. I evaluated the data for violations of the assumption of auto-correlation by reviewing the result of the Durbin-Watson test. A test result of approximately 2, on a scale from 0 to 4, indicates a lack of significant auto-correlation (Mwizarubi, Singh, Mnzava, & Prusty, 2016). I determined that no violation of the assumption of auto-correlation occurred because the result was $d = 1.994$ (Table 2).

Table 2

Model Summary

Model	R	R^2	Adjusted R^2	Std. Error of the estimate	Durbin-Watson
1	.970	.940	.938	.20446	1.994

Outliers, homoscedasticity, and linearity. I evaluated the data for violations of the assumptions of outliers, homoscedasticity, and linearity by reviewing the Normal Probability P-P Plot of Regression Standardized Residual (Figure 6) and the scatterplot of the standardized residuals (Figure 7). The evaluation indicated no major violations of the assumptions of outliers, homoscedasticity, and linearity because of the patternless dispersion of scatterplot data points (Casson & Farmer, 2014).

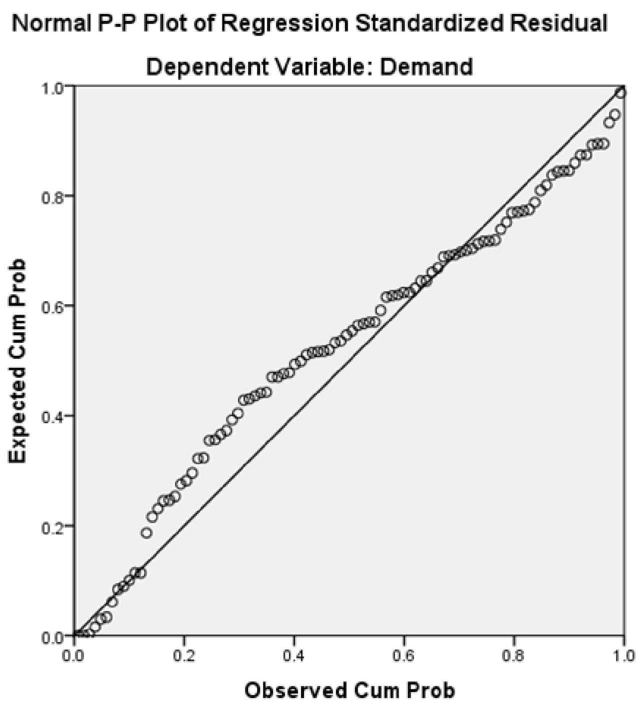

Figure 6. Normal probability plot (P-P) of the regression standardized residuals.

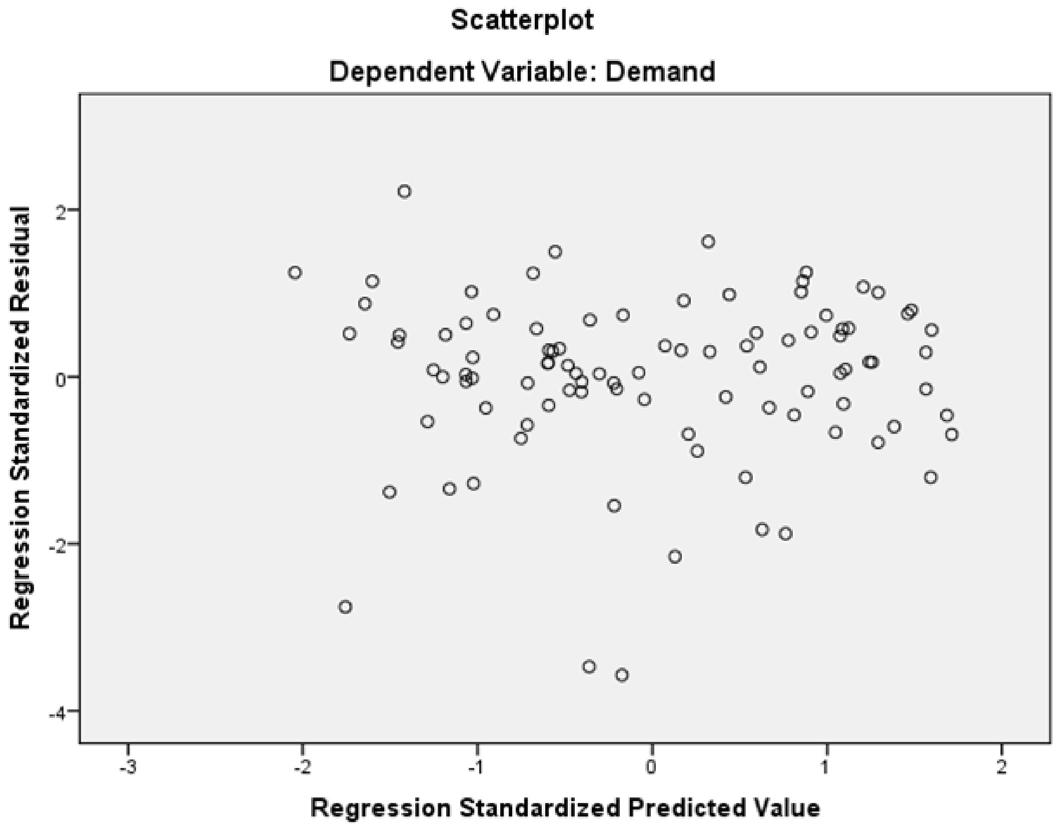

Figure 7. Scatterplot of the standardized residuals.

Multicollinearity. I evaluated the data for the assumption of multicollinearity by reviewing the variance inflation factor (VIF) and correlation coefficients for the IVs (Table 3). The VIF values were less than 10, which was an indicator that the data do not include significant multicollinearity problems (Asumadu-Sarkodie & Owusu, 2017). The bivariate coefficients of the predictor variables were small for fine effect and medium for the combination of price and supply. The medium correlation coefficient between price and supply (-.873) was not unexpected because a central premise of the theory of supply and demand is that price is a function of supply and demand (Marshall, 1920). Therefore, I concluded that the assumption of multicollinearity was not violated.

Table 3

Correlation Coefficients and VIF Values for Predictor Variables

Variable	Fine effect	Price	Supply	VIF
Fine effect	1.000	-.202	.287	1.101
Price	-.202	1.000	-.873	4.238
Supply	.287	-.873	1.000	4.429

Descriptive Statistics

The initial data download included 97 data points. I eliminated the data point for 2013 because inclusion of this data point violated Marshall's (1920) theory of supply and demand requirement of a negative demand curve. The remaining 96 data points exceeded the minimum requirement of 88 data points. Table 4 contains the descriptive statistics for the study variables.

Table 4

Means and Standard Deviations for Quantitative Study Variables

Variable	*M*	*SD*	Bootstrapped 95% CI (*M*)
Demand	4.707	.823	[4.540,4.871]
Fine effect	1.499	.009	[1.498,1.501]
Price	3.154	.323	[3.090,3.221]
Supply	4.716	.733	[4.565,4.875]

Note. $n = 96$

Inferential Results

Standard multiple linear regression, $\alpha = .05$, was used to examine the efficacy of fine effect, price, and supply in predicting demand. The IVs were fine effect, price, and supply. The DV was demand. The null hypothesis was that fine effect, price, and supply would not significantly predict demand. The alternative hypothesis was that fine effect, price, and supply would significantly predict demand. Preliminary analyses were conducted to assess whether the assumptions of auto-correlation, homoscedasticity, linearity, multicollinearity, normality, and outliers were met; no major violations were noted. The model as a whole was able to significantly predict demand, $F(3,92) = 483.579$, $p < .001$, $R^2 = .940$. The R^2 (.940) value indicated that approximately 94% of variations in demand was accounted for by the linear combination of the predictor variables (fine effect, prices, and supply). In the final model (see table 5), supply and price were statistically significant with supply ($t = 20.011$, $p < .001$) accounting for a higher contribution to the model than price ($t = -2.468$, $p = .015$). Fine effect did not explain any significant variation in demand ($t = -1.117$, $p = .267$). The final predictive equation was as follows:

Demand = 3.912 + 1.204 (supply) - .329 (price) – 2.563 (fine effect).

Supply. The positive slope for supply (1.204) as a predictor of demand indicated a 1.204 increase in demand for each additional one-unit increase in supply. Therefore, demand tends to increase as supply increases. The squared semipartial coefficient (sr^2) that estimated demand's variance uniquely predictable by supply was .2591, indicating that 25.91% of the variance in demand is uniquely accounted for by supply when price and fine effect are controlled.

Price. The negative slope for price (-.329) as a predictor of demand indicated a .329 decrease in demand for each additional one-unit increase in price. Therefore, demand tends to decrease as price increases. The squared semipartial coefficient (sr^2) that estimated demand's variance uniquely predictable by price was -.0039, indicating that 0.39% of the variance in demand is uniquely accounted for by price when supply and fine effect are controlled.

Table 5

Regression Analysis Summary for Predicator Variables

Variable	*B*	*SE B*	β	*t*	*p*	*B* 95% Bootstrap CI
Supply	1.204	.060	1.072	20.011	.000	[1.108,1.314]
Price	-.329	.133	-.129	-2.468	.015	[-.559,-.126]
Fine effect	-2.563	2.295	0.030	-1.117	.267	[-8.967,7.215]

Note. $n = 96$

Analysis summary. The purpose of this study was to examine the efficacy of fine effect, price, and supply in predicting demand. I used standard multiple linear regression to examine the ability of fine effect, price, and supply to predict the value of demand. Assumptions surrounding the multiple regression were assessed with no serious violations, but 2,000 samples for bootstrapping were calculated to combat any influence of assumption violations. As a whole, the model was capable of significantly predicting demand, $F(3,92) = 483.579$, $p < .001$, $R^2 = .940$. Both supply and price provided useful predictive information about demand. The conclusion from this analysis is that price and supply are significantly associated with demand while the contribution of fine effect is not statistically significant.

Theoretical conversation on findings. The results of this study supported and extended Marshall's (1920) theory of supply and demand. The findings that an increase in demand will likely occur if supply increases without a price increase and demand will likely decrease if price increases without an increase in supply supported the theory's central concepts that were discussed in Section 1. The findings of this study quantified the linear relationship between the variables presented by Marshall as related to the almond market.

Although the findings for fine effect were statistically insignificant, the insertion of fine effect as a variable caused a left shift in the demand curve for all demand segments. The left shift in demand indicated a decrease in demand when fine effect was included in the equation. The direct impact of fine effect was low, but the overall impact was realized because of the elasticity and subsequent volatility of the almond market. Therefore, the findings of this study extend Marshall's theory through the insertion of an environmental variable as a predictor.

Applications to Professional Practice

This quantitative research was conducted to examine the relationships between variables in supply and demand theory in an effort to expand the knowledge base for California almond business leaders. The results of this study should encourage business leaders to consider the effect of the environment when making business decisions. Specifically, areas to consider for the almond industry include the costs associated with groundwater pumping, impact of fines for excessive water utilization, and market fluctuations based on environmental variables.

Despite the inability of groundwater to serve as a long term sustainable solution (Scanlon et al., 2012), California farmers significantly increased the use of groundwater as a source of irrigation to account for water shortages during the drought (Seager et al., 2015). The increase in groundwater use has resulted in higher water pumping costs because of the well depth required to reach the water (Famiglietti, 2014). Considering that some models predict future droughts will provide conditions never before experienced (Cook, Ault, & Smerdon, 2015), California farmers must identify water reduction measures that will minimize the need for increasing well depth to reach lowering groundwater depths. Limiting the dependency on groundwater as a source of irrigation may reduce and stabilize irrigation costs, thereby reducing variable costs and increasing profit margins.

Although a protracted drought could reduce profit margins because of increased costs in groundwater pumping, the potential of California lifting the water reduction exemption from agriculture should be of greater concern. The results of this study indicated a statistically insignificant correlation between demand and fine effect, but the impact was evident because of the left shift in segment demand curves. Business leaders should, as previously discussed, identify mechanisms to reduce the water used for irrigation to minimize the risk of receiving fines for excessive water utilization.

In addition to implementing risk mitigation measures, business leaders should become more proactive by understanding the predictive nature of the market. The results of this study provided an equation that business leaders can use to predict market fluctuations based on industry knowledge. Although Marshall developed the theory of supply and demand as a means of explaining the relationship between the variables (Marshall, 1920) and therefore does not provide precise predictive qualities, it does provide a method for business leaders to predict market trends. The combination of understanding Marshall's theory and employing the quantitative results of this study should increase the accuracy by which the business leader predicts the future of the almond market.

Implications for Social Change

The results of this study not only extend the knowledge base by which business leaders can stabilize or increase profit margins, but the results also provide a platform by which business leaders can highlight their focus on social responsibility. The increase in groundwater use by agriculture negatively impacts society because agricultural and urban areas must compete for a lowering water table (Medellín-Azuara et al., 2015). Reducing agriculture's dependency on groundwater mitigates the potential for reduced water availability from the Colorado River Basin (Castle et al., 2014), thereby ensuring continued regional societal stability.

Additionally, the results of this study could enable business leaders to establish job creation strategies as a byproduct of profit margin stabilization. The strategies could restore the job opportunities lost as a result of the drought. Restoring the job opportunities could reverse the household income reductions and stabilize the migratory and seasonal workforce, thereby reducing the jobless rate and ensuring predictability in labor costs.

Recommendations for Action

In the coming decades, some models predict increasing California temperatures (Cheng et al., 2016) and drought severity (Cook et al., 2015). In the next 30 years, the global agricultural industry must expand production by up to 70% to meet population projections (Lehnhoff et al., 2017). Because of the integral connection between societal stability and agricultural production (von Uexkull, Croicu, Fjelde, & Buhaug, 2016) and agricultures critical dependence on water availability, sustainable agricultural water use practices must become a priority (Chartzoulakis & Bertaki, 2015). Based on the results of my research, I recommend that California lawmakers work in conjunction with almond industry leaders and professional organizations to establish incentives and legislation to encourage the development and implementation of water reducing irrigation methods. The purpose of this recommendation is to potentially decrease the societal impact of future droughts.

Recommendations for Further Research

As discussed in Section 1, this study's inherent limitations were a single commodity, variety combination, and geographic area. The dataset for this study included all varieties of almonds as a single commodity and only that of the United States. To expand on these limitations, future researchers could apply the model to individual almond varietals and other agricultural commodities as well as enlarge the study to the global market. Applying the model to individual almond varietals and household agricultural staples such as beef, poultry, and dairy could illuminate the broader implications of environmental variables on supply and demand. Expanding the focus to the global almond market could expand the model from microeconomic to macroeconomic by altering the perspective to include the effects of environmental variables on global imports and exports.

A recommendation for future research that I find particularly interesting is the cumulative impact of the potential fines for excessive water utilization. This study analyzed the impact on a per segment basis. It did not, however, reduce or increase future variables based on cumulative impacts. For example, if demand significantly decreases or increases during a particular segment, what would be the impact on the next segment? Research in this area could provide greater insight into the impact of the fines over time.

Another area of potential future research could include qualitative variables. The consumer's opinion of a product is a qualitative variable in supply and demand theory (Teh, Hayashi, Latner, & Mueller, 2016) not considered in this study. Therefore, future qualitative or mixed methods research could include this variable in the model. Depending on the strength and direction of consumer opinion, this variable may enhance or suppress the effects of the environmental variable. The mixed methods research could also expand to additional products and the global market as previously described.

Reflections

When I decided to conduct this particular study, I was driving to work and noticed the almond fields being flooded for irrigation although California was in the midst of an extreme drought. My initial perception was that flooding was the preferred method of irrigation. I later found that a majority of almond growers (approximately 60%) have proactively reduced water consumption through the installation of alternative irrigation methods. The voluntary reduction is commendable and gives hope to those concerned about natural resources. The act of researching this topic altered my perception of almond growers as a group significantly.

Another of my preconceptions revolved around the available literature. I assumed, incorrectly, that forecasting for specific markets included the potential for changes to external impactors like fines and taxes. The body of literature regarding supply and demand was substantial. However, I was not able to locate any research that considered the potential of California lifting the water reduction exemption from agriculture. The difficulty in locating research material served as a driving force for the completion of this study and spawned a desire to extend my abilities as a researcher.

Conclusion

The purpose of this study was to examine almond supply, almond price, and California imposed fines for excessive water utilization as linear predictors for almond demand. The focus of the research question was whether a statistically significant relationship existed between the predictors and almond demand. To answer the research question, I used multiple regression analysis to quantitatively correlate the impact of each predictor on almond demand and develop a linear model for predicting almond demand. Based on the results of my research, a statistically significant correlation between the predictor variables and almond demand existed. The ability of the model, $F(3,92) = 483.579$, $p < .001$, $R2 = .940$, to predict almond demand combined with the recommendation for incentivised and legislated water reducing irrigation development should encourage business leaders to implement business practice changes that focus on market predictability and groundwater pumping cost reduction thereby minimizing the risk of receiving fines for excessive water utilization. These changes should enable continued positive social change efforts through the development of job creation strategies, stabilization of seasonal and migratory worker prospects, and reduced natural resource utilization.

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Appendix A: National Institutes of Health Certificate of Completion

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Wayne Lacy** successfully completed the NIH Web-based training course "Protecting Human Research Participants".

Date of completion: 09/12/2015.

Certification Number: 1850172.

Appendix B: Compiled Raw Data

Table B1

Almond Production and Price Raw Data (National Agricultural Statistics Survey, 2016): 1919 – 1976

Year	Production[a]	Price[b]	Farm value[c]
1919	7,900	$440	$3,476
1920	6,000	$360	$2,160
1921	6,200	$320	$1,984
1922	9,000	$290	$2,610
1923	11,000	$260	$2,860
1924	8,000	$300	$2,400
1925	7,500	$400	$3,000
1926	16,000	$300	$4,800
1927	12,000	$320	$3,840
1928	14,000	$340	$4,760
1929	4,700	$480	$2,256
1930	13,500	$200	$2,700
1931	14,800	$176	$2,605
1932	14,000	$165	$2,310
1933	12,900	$186	$2,399
1934	12,000	$180	$2,160
1935	12,700	$280	$3,556
1936	10,700	$402	$4,301
1937	24,600	$275	$6,765
1938	18,400	$258	$4,747
1939	28,700	$209	$5,998
1940	15,000	$324	$4,860
1941	9,500	$704	$6,688
1942	31,500	$442	$13,923
1943	20,500	$732	$15,006
1944	31,700	$744	$23,585
1945	32,000	$720	$23,040
1946	47,200	$486	$22,939
1947	35,700	$558	$19,921
1948	36,500	$422	$15,403
1949	43,300	$330	$14,289

Year	Production[a]	Price[b]	Farm value[c]
1950	37,700	$546	$20,584
1951	42,700	$472	$20,154
1952	36,400	$464	$16,890
1953	38,600	$476	$18,374
1954	43,200	$498	$21,514
1955	38,300	$861	$32,976
1956	58,600	$804	$47,114
1957	37,500	$505	$18,938
1958	19,800	$772	$15,286
1959	82,800	$466	$38,585
1960	53,000	$526	$27,878
1961	66,400	$561	$37,250
1962	48,000	$654	$31,392
1963	59,700	$591	$35,283
1964	75,400	$630	$47,502
1965	72,900	$617	$44,979
1966	85,100	$610	$51,911
1967	76,600	$582	$44,581
1968	74,500	$597	$44,477
1969	122,000	$606	$73,932
1970	124,000	$646	$80,104
1971	134,000	$650	$87,100
1972	125,000	$785	$98,125
1973	134,000	$1,490	$199,660
1974	189,000	$900	$170,100
1975	160,000	$740	$118,400
1976	233,000	$810	$188,730

Note. [a]Tons. [b]Dollars per ton. [c]1,000 dollars.

Table B2

Almond Production and Price Raw Data (National Agricultural Statistics Survey, 2016): 1964 – 1995

Year	Production[a]	Price[b]	Value[c]
1964	83.0	57.20	$47,502
1965	79.6	56.50	$44,979
1966	95.4	54.40	$51,911
1967	82.8	53.80	$44,581
1968	80.4	55.30	$44,477
1969	132.0	56.00	$73,932
1970	149.0	53.80	$80,104
1971	162.0	53.80	$87,100
1972	151.0	65.00	$98,125
1973	155.0	128.80	$199,660
1974	230.0	74.00	$170,100
1975	186.0	63.70	$118,400
1976	284.0	64.80	$184,032
1977	313.0	84.50	$264,485
1978	181.0	145.00	$262,450
1979	376.0	153.00	$575,280
1980	322.0	147.00	$473,340
1981	408.0	78.00	$299,520
1982	347.0	94.00	$311,140
1983	242.0	104.00	$231,920
1984	590.0	77.40	$446,134
1985	465.0	80.00	$360,640
1986	250.0	192.00	$461,568
1987	660.0	100.00	$648,000
1988	590.0	105.00	$600,075
1989	490.0	102.00	$480,930
1990	660.0	93.00	$597,990
1991	490.0	119.00	$564,179
1992	548.0	130.00	$691,340
1993	490.0	194.00	$930,618
1994	735.0	125.00	$900,375
1995	370.0	250.00	$888,000

Note. [a]Million pounds. [b]Cents. [c]1,000 dollars.

Table B3

Almond Production and Price Raw Data (National Agricultural Statistics Survey, 2016): 1987 – 2015

Year	Production[a]	Price[b]	Value[c]
1987	660,000	$1.00	$648,000
1988	590,000	$1.05	$600,075
1989	490,000	$1.02	$480,930
1990	660,000	$0.93	$597,990
1991	490,000	$1.19	$564,179
1992	548,000	$1.30	$691,340
1993	490,000	$1.94	$930,618
1994	735,000	$1.34	$965,202
1995	370,000	$2.48	$880,896
1996	510,000	$2.08	$1,018,368
1997	750,000	$1.56	$1,160,640
1998	520,000	$1.41	$703,590
1999	833,000	$0.86	$687,742
2000	703,000	$0.97	$666,487
2001	830,000	$0.91	$740,012
2002	1,090,000	$1.11	$1,200,687
2003	1,040,000	$1.57	$1,600,144
2004	1,005,000	$2.21	$2,189,005
2005	915,000	$2.81	$2,525,909
2006	1,120,000	$2.06	$2,258,790
2007	1,390,000	$1.75	$2,401,875
2008	1,630,000	$1.45	$2,343,200
2009	1,410,000	$1.65	$2,293,500
2010	1,640,000	$1.79	$2,903,380
2011	2,030,000	$1.99	$4,007,860
2012	1,890,000	$2.58	$4,816,860
2013	2,010,000	$3.21	$7,388,000
2014	1,870,000	$4.00	$5,325,000
2015	1,900,000	$2.84	$2,525,909

Note. [a]1,000 pounds. [b]Dollars. [c]1,000 dollars.

Appendix C: Calculated Almond Supply, Price, and Demand Segment

Year	Supply[a]	Price[b]	Demand segment	Elasticity	Demand[a]
1919	4,105.63	$846.64	1	0.55	1,039.40
1920	3,118.20	$692.71	1		3,118.20
1921	3,222.14	$615.74	1		4,157.60
1922	4,677.30	$558.01	1		4,937.15
1923	5,716.70	$500.29	1		5,716.70
1924	4,157.60	$577.26	1		4,677.30
1925	3,897.75	$769.68	1		2,078.80
1926	8,315.20	$577.26	1		4,677.30
1927	6,236.40	$615.74	1		4,157.60
1928	7,275.80	$654.22	1		3,637.90
1929	2,442.59	$923.61	2	0.89	2,442.59
1930	7,015.95	$384.84	2		7,277.38
1931	7,691.56	$338.68	2		7,691.56
1932	7,275.80	$317.49	2		7,881.73
1933	6,704.13	$357.84	2		7,519.65
1934	6,236.40	$346.35	2		7,622.72
1935	6,600.19	$538.77	2		5,896.01
1936	5,560.79	$773.45	3	1.08	11,025.50
1937	12,784.61	$529.15	3		13,584.77
1938	9,562.48	$496.42	3		13,927.67
1939	14,915.38	$402.14	3		14,915.38
1940	7,795.50	$623.44	3		12,597.05
1941	4,937.15	$1,354.63	3		4,937.15
1942	16,370.54	$850.49	4	0.51	27,011.43
1943	10,653.85	$1,408.51	4		10,653.85
1944	16,474.48	$1,431.61	4		9,976.62
1945	16,630.39	$1,385.42	4		11,330.71
1946	24,529.83	$935.15	4		24,529.83
1947	18,553.28	$1,073.72	5	2.67	18,553.28
1948	18,969.04	$812.01	5		20,909.33
1949	22,503.00	$634.98	5		22,503.00
1950	19,592.68	$1,050.60	5		18,761.44
1951	22,191.18	$908.20	5		20,043.37
1952	18,917.07	$892.84	5		20,181.60
1953	20,060.41	$915.93	6	4.44	22,605.37
1954	22,451.03	$958.26	6		22,451.03
1955	19,904.50	$1,656.71	6		19,904.50
1956	30,454.41	$1,547.03	7	0.40	6,869.24
1957	19,488.74	$971.74	7		38,857.33
1958	10,290.06	$1,485.51	7		10,290.06
1959	43,031.14	$896.68	7		43,031.14

Year	Supply[a]	Price[b]	Demand segment	Elasticity	Demand[a]
1960	27,544.09	$1,012.12	8	0.48	38,106.00
1961	34,508.07	$1,079.46	8		34,508.07
1962	24,945.59	$1,258.42	8		24,945.59
1963	31,026.08	$1,137.20	8		31,422.46
1964	37,648.17	$1,261.73	9	0.07	26,218.78
1965	36,105.95	$1,245.75	9		36,105.95
1966	43,272.71	$1,199.62	9		64,637.04
1967	37,557.45	$1,187.01	9		72,440.73
1968	36,468.82	$1,219.59	9		52,287.61
1969	59,874.19	$1,234.79	9		42,885.97
1970	67,585.26	$1,185.23	9		73,541.39
1971	73,481.96	$1,185.32	9		73,481.96
1972	68,492.44	$1,432.64	10	1.39	109,890.93
1973	70,306.81	$2,839.84	10		70,306.81
1974	104,326.24	$1,630.46	11	0.85	184,282.15
1975	84,368.18	$1,403.37	11		199,097.53
1976	128,820.23	$1,428.60	11		197,451.99
1977	141,974.41	$1,862.91	12	0.85	169,117.45
1978	82,100.22	$3,196.70	12		82,100.22
1979	170,550.72	$3,373.07	12		70,593.80
1980	146,056.74	$3,240.80	12		79,223.61
1981	185,065.68	$1,618.45	12		185,065.68
1982	157,396.55	$1,976.79	13	0.28	157,931.42
1983	109,769.35	$2,112.79	13		109,769.35
1984	267,619.49	$1,667.05	13		267,619.49
1985	210,920.44	$1,709.84	13		252,465.45
1986	113,398.09	$4,070.33	14	0.34	113,398.09
1987	299,370.95	$2,164.54	14		470,147.60
1988	267,619.49	$2,242.27	14		455,597.02
1989	222,260.25	$2,163.81	14		470,283.12
1990	299,370.95	$1,997.49	14		501,418.07
1991	222,260.25	$2,538.37	14		400,169.15
1992	248,568.61	$2,781.28	14		354,697.72
1993	222,260.25	$4,187.06	14		91,546.93
1994	333,390.38	$2,895.11	14		333,390.38
1995	167,829.17	$5,248.77	15	0.74	167,829.17
1996	231,332.10	$4,402.19	15		265,862.38
1997	340,194.26	$3,411.70	15		380,561.24
1998	235,868.02	$2,982.98	15		430,206.46
1999	377,842.43	$1,820.18	15		564,858.41
2000	318,875.42	$2,090.12	15		533,599.98
2001	376,481.65	$1,965.60	15		548,019.15
2002	494,415.66	$2,428.50	15		494,415.66

Year	Supply[a]	Price[b]	Demand segment	Elasticity	Demand[a]
2003	471,736.04	$3,392.03	15		382,838.47
2004	455,860.31	$4,801.92	16	0.44	789,697.12
2005	415,037.00	$6,085.99	16		415,037.00
2006	508,023.43	$4,446.23	16		893,478.78
2007	630,493.37	$3,809.52	16		1,079,257.45
2008	739,355.53	$3,169.25	16		1,266,073.35
2009	639,565.21	$3,586.03	16		1,144,465.68
2010	743,891.45	$3,902.96	16		1,051,992.32
2011	920,792.47	$4,352.62	16		920,792.47
2012	857,289.54	$5,618.71	16		551,377.44
2013	911,720.62	$8,103.36	-	-	-
2014	848,217.69	$6,277.87	17	45.67	848,217.69
2015	861,825.47	$2,930.88	17		861,825.47

Note. [a]Metric tons. [b]Dollars per metric ton.