LABOR COST EFFECTS ON APPLE PRICE

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CHAPTER I

INTRODUCTION

With almost 7 billion people in the world, agriculture is essential in order to keep all of these people nourished. The United States is a world leader in agriculture due to its size and the nation's diverse climates that are suited to yield a large variety of goods. The labor force working in the agriculture industry is pivotal in the harvesting of these commodities and getting them to people all around the world. But while these laborers are extremely important to the world food supply and its distribution, they are not necessarily compensated accordingly. Due to some of the federal laws currently in place, farm workers are generally paid less than other wage and salary workers in the United States.

While apples are not usually a staple in the diets of most people around the world, it is a popular commodity enjoyed by many. In order to harvest the apples, it takes a large amount of labor, which raises questions at the retail level about labor costs and how they translates into the price of the fruit. Apples are a good commodity to test these questions due to the large amount of labor that it takes in order to get the fruit from the fields into the stores.

Problem Statement

How much does the cost of labor affect the price of apples? And, how much would an increase in the wages of farm workers raise the retail price of apples?

Hypothesis

I believe that the cost of labor will only minimally affect the retail price of apples and a raise in the wages of these workers would increase the price of apples only slightly.

Objectives of the Study

1. To determine how much labor it takes to harvest an acre of apples trees.

2. To analyze the retail value of apples and what impact the cost of labor has on that price.

3. To evaluate how much a 5%, 10%, and 15% increase in the cost of labor would have on the retail value of apples

Significance of the Study

Figuring out how much the cost of labor affects retail price of apples could be beneficial to several different groups of people. The first group that could benefit from this information is the consumers who purchase apples in the store. By knowing how much labor it takes to put apples into stores, they would be able to figure out how much the store is actually making. This knowledge would also be helpful for the store management so that they can price the apples appropriately to maximize profit. Finally, the information discovered in this study will help people understand how much the cost of labor actually affects the price of certain things that they buy in the stores and why the prices of these items may fluctuate.

CHAPTER II

REVIEW OF LITERATURE

Demographics of Farm Workers

According to the Merriam-Webster Dictionary, agriculture is "the science, art, or practice of cultivating the soil, producing crops, and raising livestock and in varying degrees the preparation and marketing of the resulting products" (Agriculture 2003). In the United States, agriculture is extremely dependent on the labor of hired farm workers. In 1998, 875,000 people 15 years of age or older did hired farm work each week as their primary job and another 63,000 people did this kind of work each week as their secondary job (Runyan 2000). While the number of agricultural workers have been declining for the past several decades due to technological advances as well as the declining number of farms, they are still very important to the harvesting and production of food crops across the nation (Huffman 2008). Because of their importance to the food consumption of the American public, as well as many other people all around the world, it is important that we understand who these workers are.

There have been many studies and surveys written with the sole purpose of breaking down some of the demographics within the agriculture labor market. One such survey was the National Agricultural Workers Survey set up by the Labor Department that was designed to obtain some information about the number of legal and illegal, or undocumented, laborers that we have working in the United States. This survey was successfully able to accumulate data about the legal status, age, race, and level of education of a majority of the workers in the agriculture industry. The survey also found that there were great differences between the hired

farm workers that were citizens and the hired farm workers that were non-citizens. For example, the percentage of non-citizen farm workers that were Hispanic was significantly higher (95%) than that of farm workers that were citizens (12%). Another piece of information that was discovered from this survey was that the farm workers who were citizens tended to be more educated than the non-citizens (Huffman 2008).

Farm Worker's Wages and Compensation

While a great number of people rely heavily on farm workers to produce much of the food that we eat, these laborers have historically been paid less than the rest of the wage and salary earners in the United States. According to the Department of Labor, an employee that is employed in agriculture, generally on smaller farms, is exempt from the minimum wage and maximum hours requirements (U.S. Congress 1938). And, if the lowly wages weren't bad enough, the rate of unemployment in the hired labor force is almost double that of the rate of other wage and salary earners in the United States (Runyan 2000). All of these things have compound the life of poverty that many of these farm workers experience. The payment options in agriculture are also a little different from that of normal wage and salary earners in America. Approximately 77% of hired farm workers in the United States are paid on an hourly wage while less than 20% of these laborers are paid on a piece rate (Emerson 2006).

Piece rate is a way of paying an employee by the piece, such as per basket of apples picked, rather than by the hour. While it can be seen in other industries, piece rate instances are mainly limited to the agricultural industry. But, employers may only pay their employees on a piece rate basis if they receive at the least the equivalent of the required minimum hourly wage

rate and overtime for hours worked in excess of 40 hours in a work week (U.S. Congress 1938). After much research on the topic, piece rate has been shown to motivate workers to work at a much faster rate though they may be more careless with the product, which is a negative when the workers are harvesting delicate fruits (Moretti 2001).

But no matter the method of payment, the median earnings per week along with the median and mean hourly wages are lower for farm workers than for other wage and salary workers. For example, the median earnings of an agricultural worker is are $400 per week while other wage and salary workers earn approximately $673 per week. According to the Current Population Survey (CPS), full-time farm workers make about 59% of what all other full-time wage and salary workers make in the United States (Kandel 2008). Some people believe that this is due to discrimination because farm workers on large farms, who are made up mostly of immigrants or minorities, are the only significant group of adult minimum-wage workers that are excluded from the maximum hours and overtime provision under the Fair Labor Standards Act. And, in most cases, these workers are the ones that are in need of assistance from the government (Linder 1987). Part of the reason that farm workers make a good deal less than other workers in the United States are the amount of undocumented workers in the agriculture industry. Since undocumented workers normally don't demand fair compensation due to fear of their employer, they are willing to work for a lower level of compensation (Aguiar 2009). Immigration policy has a lot to do with the average compensation level of farm laborers due to the fluctuating effect it has upon the farm labor market.

Immigration

Immigration has been one of the most heated topics of debate for many years in the United States. Two questions that are at the center of this debate are what impact does international migration have on the United States economy and its citizens and how should the immigration policy be tailored to most benefit the United States. Under the current immigration policy, the United States wants to control the flow of both documented and undocumented immigrants. Documented immigrants are broken down into temporary and permanent workers. Permanent documented immigrants are defined as a foreign-born person who legally resides in the United States holding a housing card or a green card. Temporary documented immigrants, though, just hold visas that allow them to be in this country on a short-time basis for school, work, or something else of that nature (Aguiar 2009).

In contrast to documented immigrants, undocumented migrants are those people that enter the country without any of the appropriate papers or entered the United States as a temporary worker and failed to leave the country at the set time. It is estimated that in recent years, 500,000 immigrants have entered the country as undocumented migrants per year (Aguiar 2009). Some people feel that these undocumented workers are a huge problem in this country for the economic and social problems that they bring. And, while the deportation of undocumented immigrants appears to be a good idea, it is definitely not as easy as it sounds.

To address the topic of immigration, the United States uses a supply and demand approach. On the supply side, the U.S. assigns quotas on different types of visas and green cards to control the amount of documented immigrants. Border enforcement is a big part of the supply

side of the equation because they are charged with the duty of stopping illegal entry into the country by undocumented migrants through Mexico, Canada, or by sea. In contrast, the demand side is attempting to be controlled by monitoring the hiring needs of employers to control the inflow of documented and undocumented workers. The supply side is much more difficult to control than the demand because the amount of migrant workers is harder to control with visas and enforcement at the border (Aguiar 2009). In order to try to control both sides of the supply and demand immigration equation, the United States has enacted some laws to make it harder for migrants to enter the country and find work.

One such law is the Immigration Reform and Control Act (IRCA) of 1986, which is the current immigration policy in place in the United States. Under this policy, it became illegal to hire an undocumented worker (Aguiar 2009). While this was a good idea in principle, many employers break these rules and hire undocumented workers to get labor at a cheaper price. To discourage these employers, the penalty for engaging in a pattern or practice of this violation is a fine of no more than $3,000 for each unauthorized alien to whom such a violation occurs, no more than 6 months in jail, or both (U.S. Congress 1986). Another thing that the policy did was to expand and strengthen border enforcement (Aguiar 2009). This has provided a little help for the problem of illegal immigration but has definitely not come close to becoming a long-term solution as evident by the 500,000 undocumented migrants that enter this country on average per year. The final major stipulation of this act was to legalize people that have been unlawfully in this country since before January 1, 1982 (U.S. Congress 1986). This part of the law resulted in 2.7 million individuals being given legal permanent residency. And, out of these 2.7 million people, approximately 2 million were from Mexico (Aguiar 2009). This immigration policy has

had a major effect on the agriculture industry, especially those industries that require a great deal of labor such as the production of many fruits and vegetables.

But while the IRCA's was put in place to help solve the problem of illegal immigration in the United States, the unauthorized population continued to grow even after implementation of the act. Because of this many people believe that the act has been a failure and have prompted discussions about new legislation to address the problem. One of the most prominent proposals is the Agricultural Job Opportunities, Benefits and Security Act (AgJobs), which represents a compromise between growers, farm labor advocates, and Federal legislators. AgJobs would provide farmworkers with temporary legal residency and the possibility of obtaining permanent legal residency in the United States. And while many people have been in support of this act since the idea was imagined in 2003, it did not receive enough backing but has remained a critical element of comprehensive immigration reform ever since (Cairns 2010).

The Apple Harvesting Process

Historically, the harvesting of fruits and vegetables has been extremely hard, labor-intensive work. Presently, these commodities still require a lot a labor to produce even with some of the advances in technology that have made things a little easier. This labor-saving technology are classified as labor aids, labor-saving machines, and automation and can range from tree shakers to mechanical eyes that replace human eyes for selecting and harvesting the crop. Mechanical harvesters are widely used for processing hard fruits, such as apples. The mechanical harvester has one motorized part that grips the tree trunk and shakes it with enough force to make all of the fruit fall onto a sloping canvas that has been set up to try to prevent the

damaging of the product. Conveyors are then used to move the apples into boxes. After the harvesting of one apple tree, the gripping arm releases and moves on to the next tree. The main advantage of these machines is that it has greatly reduced the amount of labor required for harvesting and it eliminates some of the hazards that exist when laborers are climbing ladders to handpick the fruit (Huffman 2008). But while there are many advantages to these improved mechanized tools, there are also a few downfalls to these systems.

The biggest problem involved in spreading this kind of mechanized farm equipment to apples is the lack of uniformity when it comes to ripening as well as problems with excessive damage to the harvested fruit and trees. In some cases, trees must be sprayed with chemicals to loosen up the apples so that they can be shaken off without damaging the tree. This can cause problems because most fresh fruit packers and processors aren't set up to deal with crops that include large amounts of damaged fruit. Also, the mechanized tree shaker works better if the tree is shorter (Huffman 2008). With taller, more spaced out trees, a problem arises for these mechanical equipment.

In Washington, Delicious apples were planted to uniformly ripen at the same time every year. Unfortunately, the trees were spaced far apart, which made the use of a tree shaker completely ineffective. To counteract this problem, the Washington growers began planting new varieties, such as Fuji and Gala. These apple varieties have dwarf trees and are pruned to grow on trellises, which positions the apples in the ideal position for mechanical picking. The drawback of this is that the fruit does not ripen at the same time and generally need to be picked four or more times, which once again makes the mechanical tree shaker obsolete (Huffman

2008). Situations and problems such as this make labor even more important when it comes to the harvesting and production of apples.

Leontief Input-Output Model

To analyze the importance that labor has on certain industries in agriculture, some agricultural economists use a Leontief Input-Output Model to show price pass-through, which is an empirical model of the United States production economy (Lee 2000). This Input-Output Model was first constructed in 1953 when Wassily Leontief decided to examine the amount of labor-intensive goods that the United States was exporting compared to the amount of capital-intensive goods the country was importing. After Leontief's discovery in 1953 and his reexamination of the model in 1956, many people have been using it to conduct studies of their own (Lee 1978).

In one such instance, a group of agricultural economists used the Input-Output Model to analyze a pass-through to output price for all costs incurred due to an increase in the minimum wage. In a perfectly competitive market, firms would equate the price of their product to average the marginal cost. With this analysis, it is believed that the increase in labor costs will be passed on to increase the price of the product as well as affect the indirect cost of related sectors of agriculture. In order to run the model, the food and kindred industry was split up into 12 different sectors, including an eating and drinking sector, which is made up of retail establishments that sell prepared food. And, with these 12 sectors set, the authors of the study were able to collect data on the number of wage and salary jobs in each sector, the percentage

change in the amount of jobs over the years, and the cost shares of output prices for each (Lee 2000). All of this information is vital for the completion of the study.

There are also a couple of assumptions that need to be made before the model is put into action. First, the unit cost of production consists of the fixed costs of intermediate inputs and fixed direct primary factor costs. Also, the unit value of an output consists of the unit value of its commodity services inputs, each weighted to the contribution of the output of the commodity plus the value of the labor and capital inputs per dollar of output (Lee 2000). Finally, with these things understood, it is possible to run the model. The first three equations of the model all help to comprise the full, main equation. Here is how the equations are set up:

$$Pq = A' * Pa + R + W$$

Where Pq represents the vector of the sector output price, Pa is the vector of the input prices, R is the vector of returns to residual, W is the vector of wage incomes, and A is the matrix of the input-output technical coefficients. The residual income is calculated by subtracting the cost of labor from the revenue. The first equation leads to this:

$$Pa = b * Pm + (I - b) * Pq$$

Where Pm is the vector of import prices and b is the diagonal matrix of weights. The second equation then moves into:

$$b = (m + q - x)^{-1} * m$$

Where m is the vector of imports, q is the vector of domestic outputs, and x is the vector of exports. These three equations are finally combined together to create the main equation:

$$Pq = [I - A' * (I - b)]^{-1} * (A' * b * Pm + R + W)$$

Where the expression $[I - A' * (I - b)]^{-1}$ shows by how much Pq goes up or down for every dollar that is added or subtracted due to wage income. This last equation is used to calculate the new sector output prices if the new vector of wage concentration after the minimum wage increase is fully passed through. The result of the study found that if a minimum wage worker received a 15% wage increase, the industry's total wage cost would go up 1.2%. With this information, the authors ran a simulated $.50 increase to the minimum wage, which resulted in food prices raising only a fourth of a percentage point (Lee 2000). This increase in the price of food is pretty minimal and insignificant. And, while the model has been commonly used to analyze the changes in price due to things such as exchange rate fluctuations, it will also work well for analyzing how an increase in the cost of labor will affect the price of apples.

CHAPTER III

METHODOLOGY

Procedures for Data Collection

In order to analyze the effect that labor has on the price of apples, it is necessary to collect data from a variety of different sources. First, it is important to understand what the average price of apples is per pound, both at the retail level and at the growers' level. Another piece of data that is necessary is the amount of apples that are imported into and exported out of the United States every year. Also, the total consumption in the United States is important to understand the demand for apples. The last piece of data that needs to be collected is the number of laborers that work in the apple harvesting industry and the total annual wages that they were paid. All of these pieces of data will allow me to properly analyze how much the cost of labor affects the price of apples.

Most of the yearly data on apples can be found on the United States Department of Agriculture (USDA) website. One variable that is not on the website though is the number of workers in the apple industry. In order to figure out this information, an apple production company should be contacted. Kingsburg Orchards, for example, has a good relationship with Cal Poly and would be willing to cooperate with the request for information about certain labor statistics. They can be contacted by calling (559) 897-2986. Since there aren't any statistics on how many people work in the apple industry, I will ask the company how many workers it takes to harvest an acre of apples. With this number, I will be able to extrapolate how many workers are in the apple industry based on the number of acres of apples that are grown in the United

States. Once all of this information has been pulled together, I will be able to successfully run the Leontief Model.

Procedures for Data Analysis

In order to fully understand how much labor affects the price of apples in the United States, the Leontief Input-Output Model needs to be implemented. Once all of the data is collected from the different databases, it is fairly easy to plug the variables into the equations. First, I will test the effect that labor has on the price of apples with the current amount of labor compensation. And, once I have figured out this information, I will analyze how much the price of apples would increase if the amount of the labor costs were to increase by a certain percentage. Now, this is how the data will be plugged into the four equations.

The first step is to find the diagonal matrix of weights, b, by using the third equation, b = (m + q - x)^-1 * m. In order to find b, the amount of imported apples need to be divided by the sum of the number of imports and the domestic output minus the apples exported out of the United States. This number can now be plugged into the second equation.

By finding the diagonal matrix of weights, it is now possible to find the input price. In this second equation, Pa = b * Pm + (I - b) * Pq, the diagonal matrix of weights is multiplied by the imported price of apples. From there, this number is added to the input, or the amount of labor, minus the diagonal matrix of weights times the output price of the apples. This number will give you the input price contributing to the price of apples.

The outcome of the cost of labor equation leads to equation number 1, Pq = A' * Pa + R + W, which will yield the apple industry's retail price. To get to this retail price, there are a number

of variables that need to be inputted. The first thing that needs to be done is multiplying the matrix of input-output technical coefficients by the cost of labor. This number is then added to the residual income and the wage income of the farm laborers. The residual income is found by subtracting the revenue made from the apples on the farm level from the cost of labor. All of these equations and numbers then lead to the final equation, which will yield how much labor affects the price of apples at the retail level.

The fourth equation, Pq = [I - A' * (I - b)]^-1 * (A' * b * Pm + R + W), is where we will finally find out the information that we have been looking for; how much the cost of labor affects the price of apples. In order to solve this equation, to find the output price of apples, there are several variables that need to be taken into consideration and filled in with data. Starting off, the input-output technical coefficient is multiplied by diagonal matrix of weights times the price of imported apples. All of these variables are then added to the residual income and the wage income of the farm workers. Once you combine these numbers together, you multiply them by the expression [I - A' * (I - b)]^-1, which shows how much the price of apples goes up or down based on every dollar that is added or subtracted from the income wages of the farm workers. Basically, this is the input subtracted by the input-output technical coefficient, then multiplied by the input minus the diagonal matrix of weights. This expression is then raised to the negative one power. Once all of these calculations are completed, we will be able to understand how much labor affects the retail price of apples.

Once the information about how much labor wages affect the retail price of apples, I will run hypothetical situations where the cost of labor in the apple industry are increased. This will be done three times, with a 5% increase, 10% increase, and finally a 15% increase. These

increases are meant to simulate such occurrences as an increase in the minimum wage or a wage increase due to union labor negotiations. In order to analyze all of this data and how the percentage increases will affect the price of apples, I will but using an Excel spreadsheet. The numbers that I receive from this spreadsheet should give apple consumers a good idea of how labor affects the price of the fruit they are buying in the stores.

Assumptions

This study assumes that each acre of apples takes the same amount of workers to harvest. By doing this, it can be assumed that all the laborers work at the same speed and take the same amount of time to harvest one acre of apple trees. Another assumption is that the amount of labor stays the same no matter the state of the economy. Along with this, it is impossible to figure out how much each worker was paid over the years so we will assume that the workers were paid the federal minimum wage per hour. This information can be found online by searching "federal minimum wage through history". These two assumptions will eliminate the possibility of cutting labor costs as a result of the economic condition of the United States. Finally, it can be assumed that the imported price of apples is the same price that the domestic growers receive for their apples.

Limitations

The first limitation to this study lies with some of the data that is available to be analyzed. For instance, the data on the number of workers in the apple industry is not available on the USDA website so the number of laborers will need to be estimated based on the amount of apple acreage in the United States. Next, there is no way of knowing the labor differences associated

with the different varieties of apples due to the lack of data available. Because of the lack of certain data available, this study will be slightly limited and adapted accordingly.

CHAPTER IV

DEVELOPMENT OF THE STUDY

In order to properly analyze the financial effect that labor has on the price of apples, there were some preliminary research that needed to be done. For starters, much of the historical data for apples can be found on the United States Department of Agriculture (USDA) website under the fruit and tree nut yearbook data archive. It is here that they present spreadsheets containing data about a number of different fruits and tree nuts, including apples. The first important spreadsheet to this case is found in Table A-9, where there is data concerning the retail price of apples from 1989 to 2008. This is then broken into the percentage of this retail price and is based on the cost of marketing and the percentage that is the price that the growers receive per pound produced. This price is measured by dollars per pound and the trend seems like it has been increasing over time.

The next set of data also comes from the fruit and tree nut yearbook data archive. In the Table B-4 spreadsheet, the USDA gives statistics on the production, utilization, and season-average grower price of apples in the United States from 1980 through 2008. Apple production is broken up into the total produced and the total utilized in the United States in millions of pounds. Utilization, which is also measured by millions of pounds, is separated into two categories, fresh and processed. Finally, the grower price is shown for fresh apples, processed apples, and all apples. Fresh apples and all apples are measured in cents per pound, while processed apples are quantified in dollars per ton. When looking at these statistics, there are no

real trends that can be identified because all of the categories seem to be fluctuating throughout the years.

The final spreadsheet from the fruit and tree nut yearbook data archive on the USDA website is from Table F-1. This table, which is showing data from the 1980-81 season to the 2008-09 season, illustrates the supply and utilization of fresh apples. Under the supply section of this spreadsheet, utilized production, imports, and total supply are measured in millions of pounds. The utilization section is also broken into exports, total domestic consumption, and consumption per capita. And, while the exports and total domestic consumption are measured in millions of pounds, the consumption per capita is displayed in pounds. Some of this information is very interesting because while the United States is importing and exporting more apples per year than two decades ago, the consumption per capita has gone down over the years.

There is one spreadsheet that is needed from the USDA website that can not be accessed through the fruit and tree nut yearbook data archive. This spreadsheet is found by typing in "U.S. apples statistics" in the quick search caption box on the USDA home page. This will produce a list of tables, one which is labeled Table 06, the bearing acreage for apples in the United States. This table shows the amount of apple acreage in the United States by state as well as the total for the nation from 1980 through 2009. One trend that is present in this data is that the amount of acreage is increasing until 1997, which is when it peaks and begins to slowly decrease throughout the years. Also, the percentage of the United States' acreage that the top three states (Washington, New York, and Michigan) held significantly increased from approximately 47% in 1980 to 66.5% in 2008. This information will allow me to figure out how much the total cost of labor for harvesting apples is in the United States per year.

In order to calculate the number of labor hours it takes to harvest an acre of apples, a call was placed to Kingsburg Orchards in order to speak to one of their sales representatives. He revealed that it takes a crew of 35 people approximately 9 hours to pick an acre of apples, equivalent to 315 hours worth of labor. Once this information was discovered, data on the federal minimum wage was the only piece of data necessary. These numbers can be found by searching "federal minimum wage through history" online. With all of this information accumulated together, the cost of labor for a given year can be determined. In Table 1, cost of labor is calculated by multiplying the amount of acreage in the United States by the federal minimum wage.

Table 1 Cost of Labor for Harvesting Apples in the U.S.

hours to pick an acre of apples 315

Year	Acreage	Minimum Wage	Cost of Labor
1980	412,200	$3.10	$402,513,300
1981	414,900	$3.35	$437,823,225
1982	418,255	$3.35	$441,363,589
1983	424,460	$3.35	$447,911,415
1984	422,880	$3.35	$446,244,120
1985	430,680	$3.35	$454,475,070
1986	442,390	$3.35	$466,832,048
1987	454,490	$3.35	$479,600,573
1988	447,900	$3.35	$472,646,475
1989	450,410	$3.35	$475,295,153
1990	451,460	$3.80	$540,397,620
1991	449,200	$4.25	$601,366,500
1992	455,050	$4.25	$609,198,188
1993	459,730	$4.25	$615,463,538
1994	459,450	$4.25	$615,088,688
1995	462,600	$4.25	$619,305,750
1996	467,550	$4.75	$699,571,688
1997	467,950	$5.15	$759,131,888
1998	466,250	$5.15	$756,374,063
1999	454,200	$5.15	$736,825,950
2000	433,650	$5.15	$703,488,713
2001	409,300	$5.15	$663,986,925
2002	394,800	$5.15	$640,464,300
2003	388,650	$5.15	$630,487,463
2004	381,860	$5.15	$619,472,385
2005	369,060	$5.15	$598,707,585
2006	359,990	$5.15	$583,993,778
2007	350,890	$5.85	$646,602,548
2008	350,590	$6.55	$723,354,818

This number is then multiplied by 315, which is the number of man-hours that it takes to harvest an acre of apples. As the table shows, the cost of labor is generally trending depending on the way that the minimum wage and the amount of total acreage are fluctuating.

Once the cost of labor has been calculated, it is now possible to find the residual income, which is found by subtracting the cost of labor from the revenue earned by the grower. The variables that are need to find the residual income are the grower price, the total apples produced, and the cost of labor, which are all shown in Table 2 below.

Table 2 Residual Income for Apple Growers

Year	Grower Price per lb	Total Produced million lbs	Cost of Labor	Residual Income total	Residual Income per acre
1989	$0.15	9,916.8	$475,295,153	$970,904,848	$2,156
1990	$0.17	9,656.8	$540,397,620	$1,067,459,580	$2,364
1991	$0.23	9,706.7	$601,366,500	$1,627,938,933	$3,624
1992	$0.25	10,568.5	$609,198,188	$2,010,909,104	$4,419
1993	$0.18	10,685.1	$615,463,538	$1,344,361,888	$2,924
1994	$0.18	11,500.9	$615,088,688	$1,494,368,054	$3,253
1995	$0.22	10,578.4	$619,305,750	$1,748,492,783	$3,780
1996	$0.24	10,381.9	$699,571,688	$1,815,443,588	$3,883
1997	$0.19	10,323.8	$759,131,888	$1,230,780,563	$2,630
1998	$0.18	11,646.4	$756,374,063	$1,381,710,871	$2,963
1999	$0.18	10,631.6	$736,825,950	$1,129,905,817	$2,488
2000	$0.19	10,580.9	$703,488,713	$1,358,905,046	$3,134
2001	$0.18	9,423.0	$663,986,925	$1,032,153,075	$2,522
2002	$0.24	8,523.9	$640,464,300	$1,414,505,925	$3,583
2003	$0.26	8,780.1	$630,487,463	$1,621,608,188	$4,172
2004	$0.28	10,412.1	$619,472,385	$2,291,577,240	$6,001
2005	$0.21	9,666.9	$598,707,585	$1,472,425,740	$3,990
2006	$0.27	9,823.4	$583,993,778	$2,067,505,606	$5,743
2007	$0.33	9,089.4	$646,602,548	$2,311,239,703	$6,587
2008	$0.39	9,769.3	$723,354,818	$3,124,121,166	$8,911

In order to find the residual income, the first step is to convert total produced from millions of pounds to pounds by multiplying the column by one million. This number is then multiplied by the grower price, which produces the revenue of the apple growers in the United States. The cost of labor is then subtracted from the grower revenue to equal the grower's residual income. This

can be taken one step further by dividing the residual income by the total number of acres to find the average residual income per acre in the United States per year. This information is key to understanding the amount of labor that is necessary to produce the apples that consumers buy in the supermarkets and the amount that the grower receives per acre that is harvested.

With this information in hand, it is possible to begin filling in the variables of the equations in the Leontief Input-Output Model. The first equation that needs solving, which is actually the third equation in the original model is: b = (m + q - x)^-1 * m. In order to find the

Table 3 Diagonal Matrix of Weights

Year	Imports	Total Produced	Exports	b
	million lbs	million lbs	million lbs	
1980	177.2	8,818.4	716.0	0.021402
1981	149.7	7,739.6	697.1	0.020814
1982	197.5	8,122.0	642.3	0.025725
1983	233.5	8,378.5	553.7	0.028976
1984	241.9	8,324.0	538.2	0.030133
1985	314.6	7,914.5	400.1	0.040184
1986	310.2	7,859.0	459.8	0.040237
1987	262.8	10,742.1	791.0	0.025730
1988	256.3	9,120.0	602.5	0.029212
1989	228.0	9,916.8	773.9	0.024326
1990	229.7	9,656.8	818.0	0.025324
1991	303.0	9,706.7	1,132.0	0.034135
1992	259.4	10,568.5	1,082.2	0.026617
1993	238.9	10,685.1	1,390.6	0.025059
1994	286.9	11,500.9	1,526.7	0.027963
1995	383.4	10,578.4	1,217.2	0.039345
1996	373.3	10,381.9	1,518.3	0.040414
1997	356.4	10,323.8	1,209.1	0.037630
1998	344.2	11,646.4	1,487.8	0.032772
1999	377.5	10,631.6	1,175.2	0.038388
2000	358.9	10,580.9	1,667.1	0.038708
2001	361.4	9,423.0	1,353.1	0.042865
2002	412.4	8,523.9	1,144.9	0.052936
2003	472.7	8,780.1	986.3	0.057187
2004	262.8	10,412.1	1,339.0	0.028153
2005	348.8	9,666.9	1,488.4	0.040905
2006	427.9	9,823.4	1,407.3	0.048378
2007	381.2	9,089.4	1,484.1	0.047725
2008	363.4	9,769.3	1,721.6	0.043209
	m	q	x	b

diagonal matrix of weights (b), it is necessary to have the total amount of apples produced in the United States (q), the amount of apples imported into the country (m), and the amount of apples that were exported internationally (x). The first part of this equation that needs to be completed is (m +q - x). Once this expression has been solved, it is raised to the negative one power and is multiplied by imports. The number that comes from the final multiplication is the diagonal matrix of weights, which is shown above in Table 3 above. Once this equation has been calculated, it is possible to move on to the second equation in the Input-Output model.

In Leontief's model, the second equation reads as follows: Pa = b * Pm + (I - b) *Pq. But while this equation is set up to find Pa, which is the vector of input prices, the variable that is unknown in this situation is I, which represents the input margin.

Table 4 Input Margin

Year	Input Price	Import Price	b	Output Price	I
1989	$3.35	$0.15	0.024326	$0.66	5.08980
1990	$3.80	$0.17	0.025324	$0.69	5.52837
1991	$4.25	$0.23	0.034135	$0.85	5.02632
1992	$4.25	$0.25	0.026617	$0.85	4.99268
1993	$4.25	$0.18	0.025059	$0.80	5.32969
1994	$4.25	$0.18	0.027963	$0.77	5.53278
1995	$4.25	$0.22	0.039345	$0.80	5.33290
1996	$4.75	$0.24	0.040414	$0.89	5.34979
1997	$5.15	$0.19	0.037630	$0.87	5.94503
1998	$5.15	$0.18	0.032772	$0.91	5.71447
1999	$5.15	$0.18	0.038388	$0.86	6.01170
2000	$5.15	$0.19	0.038708	$0.88	5.86863
2001	$5.15	$0.18	0.042865	$0.83	6.21104
2002	$5.15	$0.24	0.052936	$0.91	5.69825
2003	$5.15	$0.26	0.057187	$0.94	5.51705
2004	$5.15	$0.28	0.028153	$1.00	5.16412
2005	$5.15	$0.21	0.040905	$0.91	5.68169
2006	$5.15	$0.27	0.048378	$1.02	5.06571
2007	$5.85	$0.33	0.047725	$1.07	5.49724
2008	$6.55	$0.39	0.043209	$1.27	5.20452
	Pa	Pm	b	Pq	I

Once rearranged, the equation shows: I = [(Pa - Pm * b) / Pq] + b, where Pm represents the

vector of import price and Pq is the vector of the sector output price. In order to figure out the input margin, the first thing that needs to be done is to multiply the diagonal matrix of weights by the vector of the import price and then subtract that number from the vector of the input price. Once this subtraction has been completed, that number is divided by the vector of the sector output price. Finally, the diagonal matrix of weights is added in to equal the input margin. The results that this equation yields, shown in Table 4, produces the needed variable to complete the full fourth equation of the Input-Output Model.

The equation that pulls everything together in the Leontief Input-Output Model is the fourth equation. Due to the fact that A', which represents the matrix of the input-output technical coefficients, is the only variable that is now unknown, there is enough information to solve equation four rather than solving for equation one and then moving onto the fourth. The equation reads as follows: $Pq = [I - A' * (I - b)]^{-1} * (A' * b * Pm + R + W)$. In order to complete this mathematical statement and figure out what the matrix of input-output technical coefficients is for a given year, all of the other variables first need to be plugged into the equation. Once all of the variables have been replaced by their respective numbers, it is possible to effectively solve for A', which is illustrated in Example 1.

Example 1	Calculation of A' for 2008
Pq =	A' * b * Pm + R + W
	I - A' (I - b)
1.27 =	A' (.043209) (.39) + (.87) + (6.55)
	(5.20452) - A' (5.20452 - .043209)
6.609 - 6.555A' =	.0169A' + 7.42
-.811 =	6.5719A'
-.123 =	A'

And, by knowing the matrix of input-output technical coefficients for every year, shown below in Table 5, it is possible to calculate the extent that labor affects the domestic price of apples.

Table 5	Matrix of Input-Output Technical Coefficients						
Year	Output Price	I	b	Import Price	Return to Residuals	Wage Income	A'
1989	$0.66	5.08980	0.024326	$0.15	$0.51	$3.35	-0.162
1990	$0.69	5.52837	0.025324	$0.17	$0.52	$3.80	-0.133
1991	$0.85	5.02632	0.034135	$0.23	$0.62	$4.25	-0.141
1992	$0.85	4.99268	0.026617	$0.25	$0.61	$4.25	-0.146
1993	$0.80	5.32969	0.025059	$0.18	$0.62	$4.25	-0.143
1994	$0.77	5.53278	0.027963	$0.18	$0.59	$4.25	-0.137
1995	$0.80	5.33290	0.039345	$0.22	$0.58	$4.25	-0.133
1996	$0.89	5.34979	0.040414	$0.24	$0.65	$4.75	-0.135
1997	$0.87	5.94503	0.037630	$0.19	$0.68	$5.15	-0.128
1998	$0.91	5.71447	0.032772	$0.18	$0.72	$5.15	-0.129
1999	$0.86	6.01170	0.038388	$0.18	$0.69	$5.15	-0.13
2000	$0.88	5.86863	0.038708	$0.19	$0.69	$5.15	-0.132
2001	$0.83	6.21104	0.042865	$0.18	$0.65	$5.15	-0.126
2002	$0.91	5.69825	0.052936	$0.24	$0.67	$5.15	-0.123
2003	$0.94	5.51705	0.057187	$0.26	$0.68	$5.15	-0.125
2004	$1.00	5.16412	0.028153	$0.28	$0.72	$5.15	-0.137
2005	$0.91	5.68169	0.040905	$0.21	$0.70	$5.15	-0.132
2006	$1.02	5.06571	0.048378	$0.27	$0.75	$5.15	-0.143
2007	$1.07	5.49724	0.047725	$0.33	$0.75	$5.85	-0.123
2008	$1.27	5.20452	0.043209	$0.39	$0.87	$6.55	-0.123
	Pq	I	b	Pm	R	W	A'

The final step to the Leontief Input-Output Model is to show by how much the domestic price of apples, by percentage, would go up or down for every dollar that is added or subtracted to the wage income of the farm laborers. In order to calculate this fluctuation in domestic price, the expression Pq = [I - A' (I - b)]^-1 is needed. As shown in Table 6, for every dollar that is added or subtracted to the farm worker's salaries, the domestic price increases or decreases by less than one percent.

Table 6	Percentage Change in Pq			
Year	I	A'	b	% Change Pq
1989	5.08980	-0.162	0.024326	1.017
1990	5.52837	-0.133	0.025324	0.913

1991	5.02632	-0.141	0.034135	0.903
1992	4.99268	-0.146	0.026617	0.925
1993	5.32969	-0.143	0.025059	0.946
1994	5.53278	-0.137	0.027963	0.935
1995	5.33290	-0.133	0.039345	0.892
1996	5.34979	-0.135	0.040414	0.904
1997	5.94503	-0.128	0.037630	0.924
1998	5.71447	-0.129	0.032772	0.908
1999	6.01170	-0.13	0.038388	0.943
2000	5.86863	-0.132	0.038708	0.940
2001	6.21104	-0.126	0.042865	0.938
2002	5.69825	-0.123	0.052936	0.870
2003	5.51705	-0.125	0.057187	0.864
2004	5.16412	-0.137	0.028153	0.897
2005	5.68169	-0.132	0.040905	0.921
2006	5.06571	-0.143	0.048378	0.915
2007	5.49724	-0.123	0.047725	0.852
2008	5.20452	-0.123	0.043209	0.827
	I	A’	b	

This percentage change is consistent with the study done by Lee, Shluter, and O’Roark. In their study, “Minimum Wage and Food Prices: An Analysis of Price Pass-Through Effect”, they found that if a $0.50 increase were applied to the minimum wage in 2007, equivalent to a 9% increase, food prices at eating establishments would only increase by approximately .9% and prices would only raise by .3% for all 12 of the food and kindred product prices. This is all possible because cost of labor is fully passed through so that it only minimally affects the price of the final product.

With all of the information that has been gathered in this study, it is now possible to calculate how much the domestic price of apples would increase if the federal minimum wage, based on the 2008 numbers, were to increase by 5%, 10%, or 15% respectively. If the minimum wage of $6.55 were to increase by 5%, the new hourly wage would be 6.88, a $0.33 cent increase. Being that $0.33 is approximately one-third of a dollar, the percentage change in domestic price, which is 0.83%, can be divided by three to equal .27% change in price. When the domestic price in 2008, $1.27, is increased by this .27%, the new domestic price would only

increase by three-tenth of a cent. With a 10% increase, the minimum wage would increase to $7.21, which would in turn raise the price of apples by seven-tenths of a cent per pound. Finally, a 15% increase would raise the 2008 minimum wage nearly a dollar, making it $7.53. Since approximately a dollar was added to the hourly minimum wage, the percent change, .83%, in the domestic price can be taken directly off the table, making $1.28 and a tenth of a cent. These results confirm the hypothesis because of the minimal increase in the price of apples domestically.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Agriculture is an essential part of life in the United States due to the fact that everyone needs to eat. And, being that many commodities within agriculture, such as apples, are very labor intensive, the people that work in the industry are also very important. But while these laborers, many of who are legal or illegal immigrants from Mexico, are important to supplying Americans with food, many are compensated at a wage at or around the amount required by federal law. Since the apple industry is so labor intensive, discussions have been raised about how much the cost of labor affects the price of the fruit. In order to test the hypothesis that labor only minimally affects the retail price, the Leontief Input-Output Model, which uses a matrix representation of a nation's economy, was used. When all of the variables, such as import price and total pounds of apples produced per year, were plugged into the equation, it was possible to calculate by how much laborers wages affect the price. The results of the model concluded that an increase in the minimum wage of farm workers would only slightly increase the retail price of apples for every dollar added to the hourly wages.

Conclusion

Once the study of how much labor affects the retail price of apples was completed, the Leontief model yielded the hypothesized results. With all of the variables correctly plugged into the model, the conclusion was that the change in the domestic retail price was between .827 and 1.017% from 1989 to 2008. This means that for every dollar that is added or subtracted to the

hourly wages of the workers, the retail price of apples will increase or decrease by that percentage. And, when testing what an increase of 15% to the federal minimum wage would do to the retail price, the calculations showed that the price would only increase by about one cent. This shows that the extra cost for labor is absorbed by all the levels leading up to the retail level so that the price is only minimally affected.

Recommendations

In order to use this study to research other commodities, there are a few things that need to be understood beforehand. First, a strong background in mathematics is helpful due to the complicated nature of the Leontief Input-Output Model. In addition, the number of variables that are involved in this model sometimes makes it a difficult to use the model. Also, there is not very much information online to support the model, making it hard to do further research on the subject. These are the recommendations that I have for anyone that may try to use this study in the future.

There are also some recommendations that I have for people that may try to expand upon my study in the future. By continuing this study, comparing the apple industry to that of another commodity for example, readers would be able to see how much the cost of labor affects the retail price for a number of different commodities. It would be interesting to see how a less labor intensive industry would be affected by a change in the minimum wage. Something else to consider is how the total number of apples produced per year continue to increase while the amount of acreage has been decreasing over the years. Finally, another way to continue my work would be to run the same study using a different model to see if the results of the two studies

were similar or if there were any differences. These are a couple of suggestions that I have for anybody that is trying to expand upon the work that I have done.

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