Magna Cum Laude Team Prize: $15,000
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Going Green Does Not Save You Green

Team #072

Summary

Possibly one of today's most intriguing areas of scientific research, the dedication to becoming "green," is sweeping America and the world. People everywhere are infatuated with cleaning up America and finding a way to combat global warming. Not exactly a new science, ethanol fuel has burst onto the scene as the leading alternative fuel source. Many political candidates are basing their political positions on the use of ethanol as the future of fuel, thus releasing us from the economic grasp that the Middle East has on us. However, many Americans are questioning how "green" these methods really are. Recent studies have shown that ethanol is neither a cost-efficient, energy saving nor an environmentally friendly alternative to gasoline.

According to Jerry Taylor, a senior fellow at the Cato Institute, which researches environmental policy, increasing the production of ethanol is worse for the environment than the production and use of gasoline. "It takes about as much energy to produce ethanol as it does to use it as energy," said Taylor in an interview with ABC's John Stossel on *20/20*. "In terms of making fertilizer for the corn fields, running the tractors to cultivate the corn, building silos and processing the corn, you lose as much energy during the manufacturing process as you do when you use it as energy as well as generating huge amounts of carbon dioxide. It's just not practical."

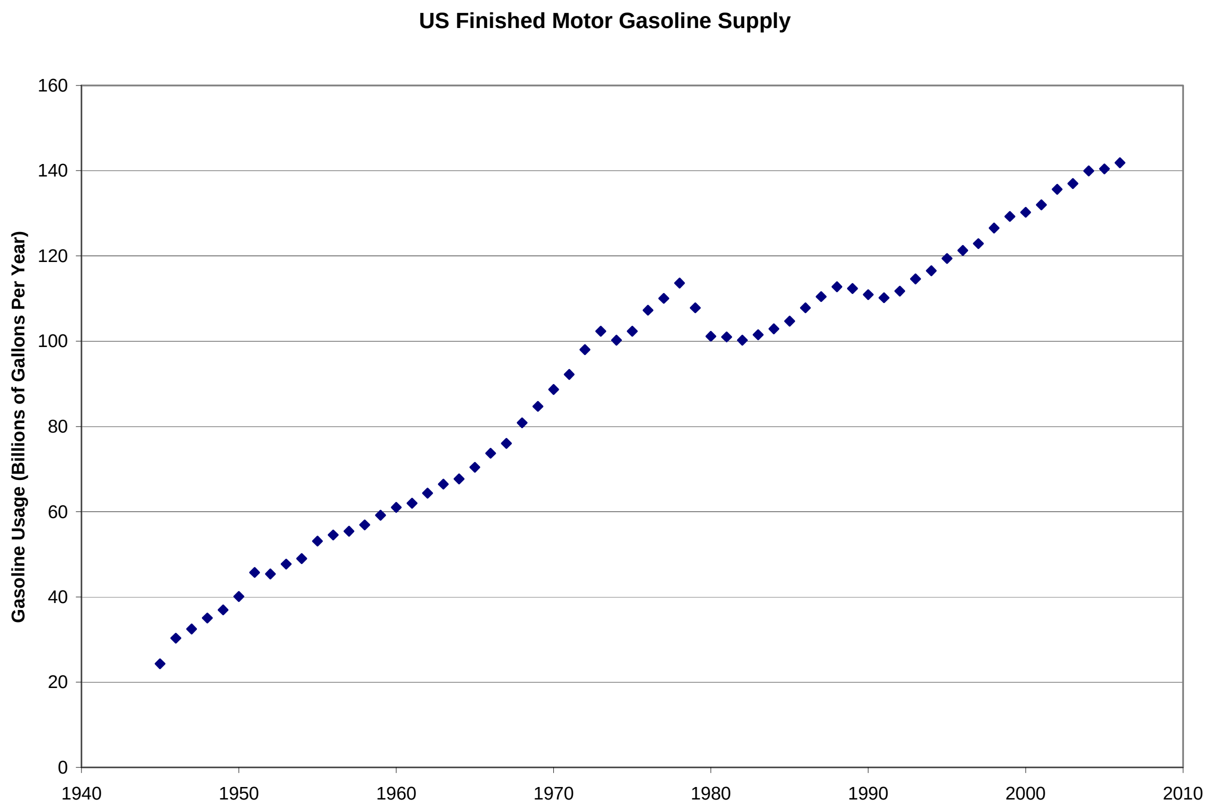
Furthermore, ethanol cannot be moved in pipelines across the country because it degrades the pipes with its moisture absorbing properties; according to the USA Fuels Service, ethanol absorbs moisture in a process called "wicking action" that can result in a loss of 5-15 octane points. This water-ethanol mix sinks to the bottom of the pipe and forms a milky slime. Because of this transportation dilemma, trucks would have to ship ethanol across the country, resulting in even more pollution and fuel consumption.

These problems might be outweighed by a low at-the-pump price to consumers for ethanol, which may be less than that of gasoline. However, the cost associated with infrastructure damage and the detriment to food markets affects consumers and makes ethanol a less viable alternative. Livestock fed with corn become more expensive as the price of corn increases; since 2000, the price of beef is up 31% and eggs 50%. Also plaguing mass production of ethanol is the harmful environmental effects of ethanol's greenhouse gas emissions, which appear to be even worse than gasoline's.

With a 10% ethanol requirement for gasoline, the 134 ethanol producing plants in the U.S. would have to produce 14.7 billion gallons of ethanol per year, an impossible number because the U.S. is only capable of producing 7.23 billion gallons of ethanol per year. In addition to the implausibility of increased ethanol production, there will also be an immediate global impact on developing nations that rely on the U.S. for grain and other foods. A model was created to determine the effect of the 10% ethanol mandate on American grain prices. The results were that corn prices will increase steadily. Other grains tend to follow the same pattern that corn seems to be following. A reasonable conclusion is that the prices for wheat and soybeans will increase as well. If these trends repeat themselves worldwide, then developing countries, whose citizens depend on the U.S. for grain products, will not be able to keep up with the rising prices.

Ethanol Required for a 10% Mixture

In the last few years, Americans have been consuming more and more resources and causing greater and greater environmental damage, largely ignorant of the consequences of their consumerism. Walls are filled with power-hungry TVs and roads are crowded with gasoline-thirsty SUVs, products that are becoming increasingly popular even as warnings of global warming and other climate change are voiced. One of the most significant sources of greenhouse gas emissions in the United States is automobile exhaust. As evident in gasoline usage trends for the last 60 years, Americans have been consuming increasing quantities of gasoline since World War II. The data below show the U.S. finished gasoline supply (a component of the nation's total petroleum consumption) obtained from the Department of Energy's Energy Information Administration.



The trend is obviously an increasing one, with linear regression suggesting consumption increases an average of 1.7 billion gallons per year. Obvious anomalies in the trend occur around 1973 and 1978, and also around 1985 to 1990. The former is the year of the 1973 Oil Crisis **[1]**, when the members of the Organization of Arab Petroleum Exporting Countries halted shipments of oil to nations that supported Israel after the Yom Kippur War. In the U.S., the price per barrel of oil skyrocketed, and the government instituted price control programs such as a national speed limit of 55 mph and the creation of the Strategic Petroleum Reserve. The result as seen in gasoline consumption is the decrease of approximately 1.9 billion gallons per year between 1973 and 1974. A few years later, between 1978 and 1980, a much more precipitous drop in gasoline usage is evident. This coincides with the National Energy Act of 1978 **[2]**, Congress's response to the Oil Crisis five years earlier. Among the stipulations of this act was the Energy Tax Act, which levied a tax on automobiles based on miles per gallon efficiency. Coupled with this were incentives for public utilities to use renewable energy sources and decrease power usage. The effect of this more responsible energy policy was a two-year decrease of almost 12 billion gallons in annual gasoline consumption.

In 2006, U.S. gasoline consumption was greater than 140 billion gallons. Some exponents of ethanol fuel suggest adding 10% ethanol to the nation's gasoline supply. To determine the amount of ethanol this would require, we first must calculate the increase in total fuel consumption by volume, because ethanol has lower energy density than gasoline. Let V be the current consumption of gasoline in gallons per year. Let f be the fraction of ethanol to be mixed with the gasoline supply (for this problem, $f = 0.1$), and let V' be the volume of gasoline-ethanol mixture consumption. The energy density of gasoline is E_g and the energy density of ethanol is E_e. Energy per volume of the gasoline-ethanol mixture will be the sum of the energy in the gasoline component and energy in the ethanol component. This is expressed below.

$$E_g V = E_g (1 - f) V' + E_e f V' \quad \textbf{1}$$

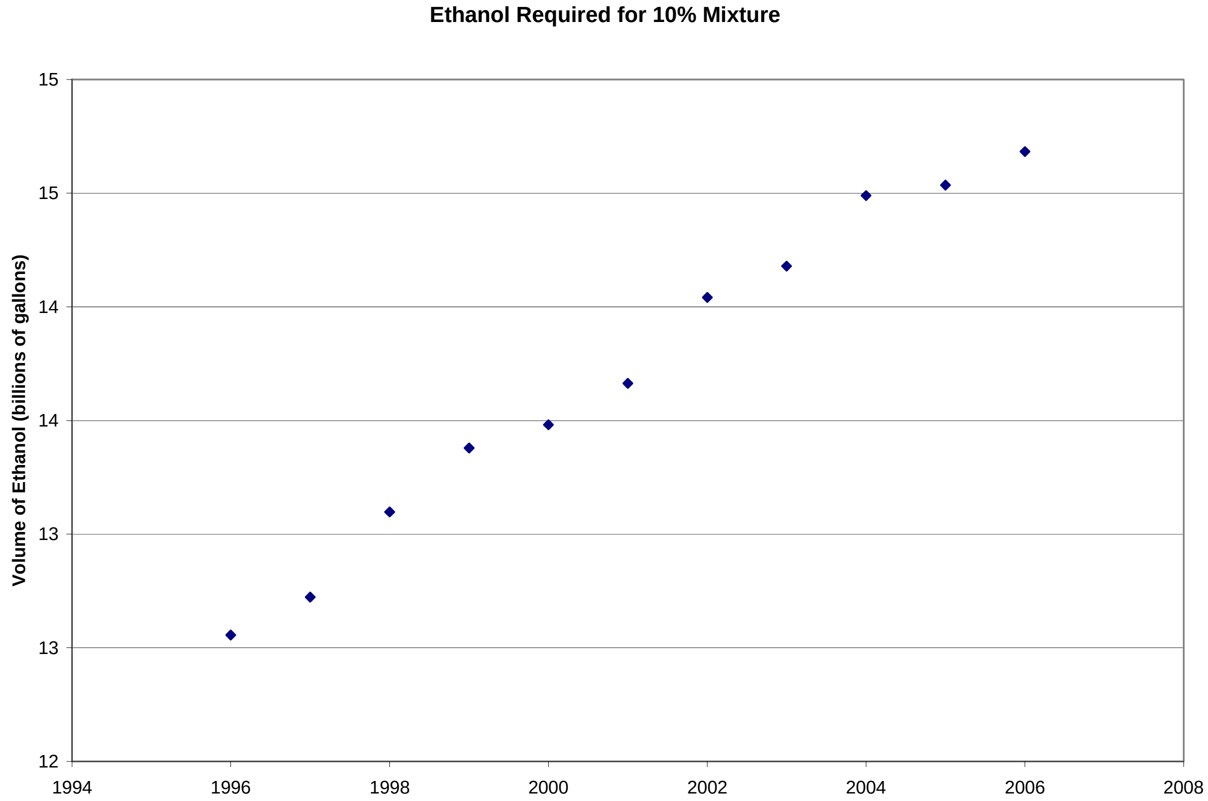
Solving for the consumption of the gasoline-ethanol mixture, we obtain the following formula:

$$V' = \frac{E_g}{E_g (1 - f) + E_e f} V \quad \textbf{2}$$

Define E as the ratio of the energy density of ethanol to that of gasoline. Experiments **[3]** have determined $E = E_e / E_g = 0.66$. A formula for the volume of ethanol required for this mixture follows:

$$V_e' = \frac{1}{1 + (E - 1) f} V f \quad \textbf{3}$$

The graph below shows the amount of ethanol that would have been required to use a 10% ethanol mixture from 1996-2006.



In 2006, a 10% ethanol mixture would have required 14.7 billion gallons of ethanol. However, the ethanol production capacity of the U.S. in 2006 was only 7.23 billion gallons. To implement a 10% requirement, the ethanol production capability of the country would have to be doubled, which would require the construction of new ethanol producing plants or the expensive importation of ethanol fuel.

Ethanol Emissions

Anyone who supports corn-based ethanol as an environmentally safe alternative to gasoline surely has not researched the greenhouse gas emissions of corn-based ethanol or the carbon dioxide produced in processing the corn needed to make the fuel. Consider the following data.

Table 1: Greenhouse gas emissions per vehicle mile traveled using various fuels.

Greenhouse Gas	Gasoline	Ethanol from Corn
Carbon Dioxide (CO_2)	7.9	7.4
Methane (CH_4)	0.22	0.39
Nitrous Oxide (N_2O)	0.54	2.98
Nitrogen Oxides (NO_x)	1.06	2.33
Carbon Monoxide (CO)	0.99	0.78
Total	10.71	13.88

One may look at the chart and say that ethanol produces less carbon dioxide and is therefore environmentally safer. Two major problems fault this initial assumption. The first is that within corn-based ethanol produces significantly more harmful greenhouse gases overall. It may release slightly less carbon dioxide and CO but ends up producing more harmful gases like N_2O, NO_x (various oxides of nitrogen, many of which contribute to acid rain), and CH_4. Trading a greater release of harmful greenhouse gases for less carbon dioxide is an undoubtedly ridiculous tradeoff.

The second problem lies in the fertilizing, harvesting, and equipment needed to get the corn from a crop in the ground to fuel into a car. The large quantities of carbon dioxide emitted from tractors during plowing, fertilizing, and harvesting and from factories during fermenting clearly make this process simply impractical. Even though corn absorbs oxygen from the atmosphere and one would think carbon dioxide would be lower than that of gasoline, the fact of the matter is that the corn cannot be turned into corn-based ethanol without emitting tons of carbon dioxide along the way.

Carbon dioxide emission of 10% ethanol mixture:

$$\frac{0.9\times7.9+0.1\times7.4}{7.9}=0.99367.$$

In this equation we multiplied the 90% gasoline component of the mixture by the carbon dioxide emission of gasoline per vehicle mile traveled **[4]** and added it to 10% of the corn-based ethanol multiplied by the carbon dioxide emission of 100% ethanol per vehicle mile traveled. The resulting fraction, 0.99367, shows that there is just slightly less carbon dioxide, only 0.633%, that is emitted using 10% ethanol than using 100% gasoline. From the discussion above, we know that this estimate is lower than the actual value because of the emissions involved in producing the ethanol.

Total greenhouse gas emission (carbon dioxide, methane, nitrous oxides, and carbon monoxide) of 10% ethanol mixture:

$$\frac{0.9\times10.71+0.1\times13.88}{10.71}=1.0296.$$

In this equation we multiplied the 90% of the gasoline by the total greenhouse gas emissions of 100% gasoline per vehicle mile traveled and added it to 10% of the corn-based ethanol multiplied by the total greenhouse gas emissions of 100% ethanol per vehicle mile traveled. This value, 1.0296, shows that more greenhouse gases are produced by the corn-based ethanol than by pure gasoline. The relative carbon dioxide benefit of switching to 10% ethanol fuel is far outweighed by the detriment caused by an increase in other greenhouse gas emissions.

Cost Efficiency of Ethanol

In addition to environmentalist hype about the benefit of corn ethanol, some proponents suggest it may be cheaper than pure gasoline. However, an analysis of the cost of bringing corn ethanol to market contradicts this. While the at-the-pump price of a gallon of ethanol may be less than that of a gallon of gasoline, the associated costs and the detriment to food markets that affect consumers make ethanol mixtures a less viable alternative.

Cost for a Gallon of 85% Ethanol-Gasoline Mixture

Corn Ethanol Futures Market quote for April 2008 Delivery [6]	$2.35
Add cost of transporting, storing and blending corn ethanol	$0.28
Added cost of making gasoline that can be blended with corn ethanol	$0.09
Add cost of subsidies paid to blender	$0.51
Total Direct Costs per Gallon	$3.23

The table above is environmental scholar Ronald R. Cooke's estimate for the cost of bringing 85% ethanol fuel to the pump **[5]**, replacing the January 2007 ethanol futures estimates with July 2007 numbers that reflect the price-increasing effect of ethanol fuel. The futures market quote represents the market price of ethanol for April 2008. The actual price may increase or decrease in the intervening months, but the futures market is a valid estimator. The cost of transporting, storing, and blending ethanol represents the cost of bringing ethanol fuel to gasoline facilities and mixing this second type of fuel with gasoline. In the next line, there is an estimate of the cost of blending gasoline for mixing with ethanol. Lastly, the government provides a subsidy of $0.51/gallon of ethanol blended into gasoline.

We then adapted those estimates to analyze a 10% ethanol solution by multiplying ethanol-related costs by 0.1/0.85 = 0.1176 because the volume of ethanol used in the 10% fuel is lesser.

Cost for a Gallon of 10% Ethanol-Gasoline Mixture

Corn Ethanol Futures Market Quote for April 2008 Delivery [6]	$2.35
Add cost of transporting, storing and blending corn ethanol	$0.03
Added cost of making gasoline that can be blended with corn ethanol	$0.77
Add cost of subsidies paid to blender	$0.06
Total Direct Costs per Gallon	$3.21

This price, $3.21, is still higher than the current gasoline price in the U.S. This estimate, however, does not even consider the other economics effects of mixing ethanol with gasoline. For example, according to Cornell University researcher David Pimental, the average American car drives 10,000 miles per year, a distance that would require approximately eleven acres of farmland devoted to corn production to produce ethanol. In the same year, this same volume of corn could feed seven people **[7]**.

Cooke's estimates included other factors such as the increase in food prices for American families. This effect is global and is evident in, for example, consumer price indices in China. In April 2007, the price of pork increased 29.3% and eggs rose 30.9% **[8]**. These animal food prices are affected by the rising cost of corn as fodder, which when combined with increasing prices of wheat, soybeans, and, of course, corn threatens many people around the world who rely on these inexpensive staples for their subsistence diets. Thus, not only is corn ethanol fuel unfavorable to American drivers, but it is harmful to the billions of people who can barely afford their meals, let alone cars and gasoline.

Our Model

Assumptions

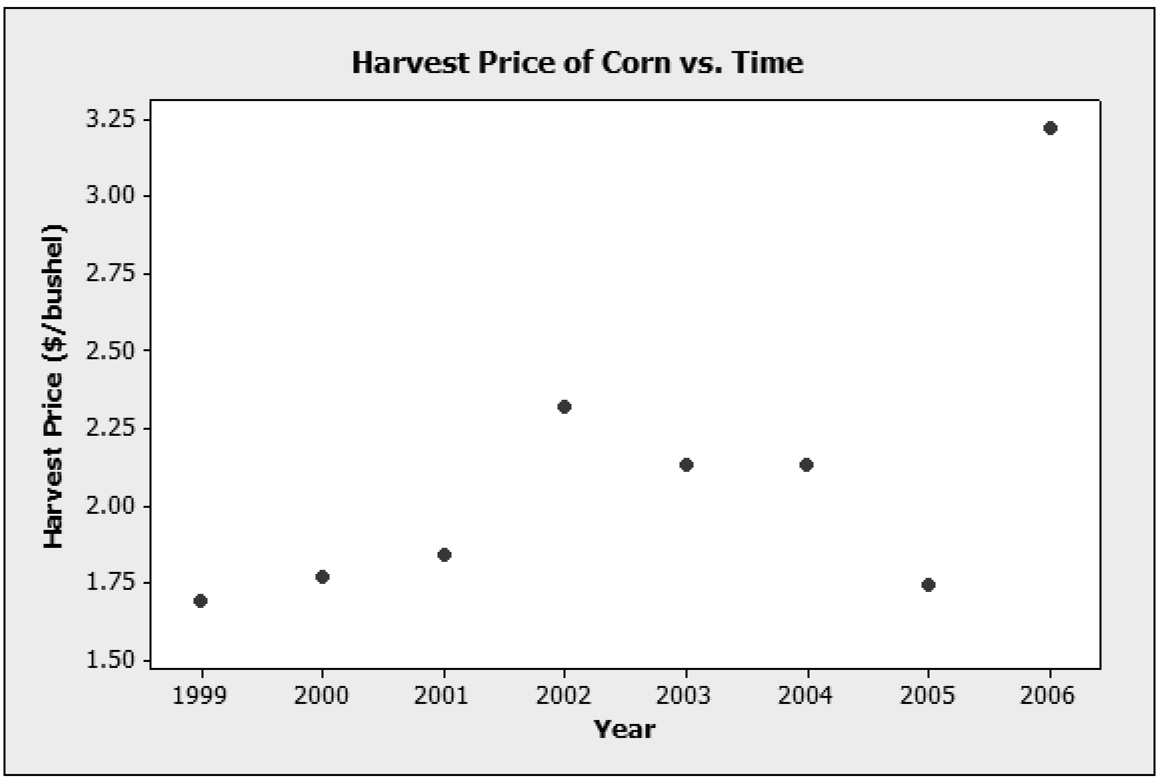
There will be no major events occurring to affect the current trends of the following:

1. gas consumption in the U.S.;
2. the relationship between corn prices and ethanol demand;
3. the abnormally low 2005 corn price, which was caused by one of the aforementioned major events and does not reflect the actual trend relating corn prices to the rise of ethanol;
4. farming technology, which will maintain a constant efficiency at 138 bushels per acre annually, the median yield per acre considering data from 1999 to the present.

Model design:

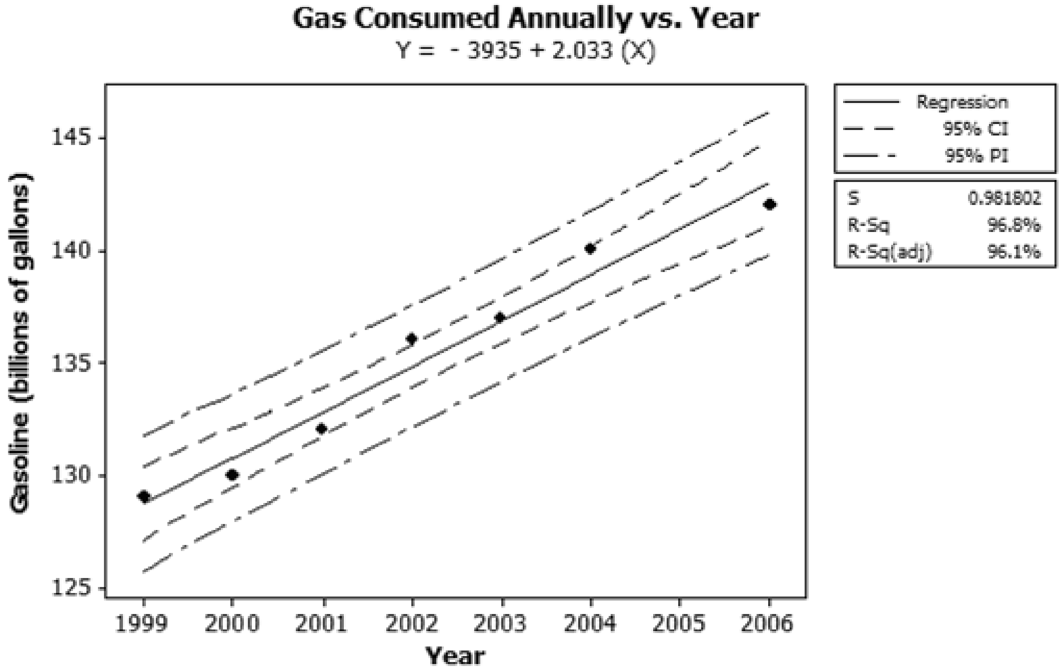
To simulate the trend of grain prices, especially corn, over the next 5 years, we wrote a Java program to carry out the following steps: given a year, we consider the trend of gasoline consumption in America and project what the consumption (in billions of gallons per year) will be for that year. We then determine how much gasoline will actually be needed, given that a greater volume of E10 fuel will be needed to perform the same amount of work as a given amount of 100% gasoline. Since our simulation is to determine the effect of replacing 10% of the annual U.S. gasoline usage with ethanol, we then take 10% of the projected E10 fuel quantity as the amount of ethanol that will need to be produced. With this value, we can predict the effect on the value of corn (in dollars per acre) using the current trend of corn prices increasingly linearly with the logarithm of the amount of corn needed. From here, it is a simple matter to find the harvest price, the price per bushel of corn at the time of harvest.

One assumption must be explicated before we begin: the omission of data from 2005. The data point here representing harvest price of corn is a clear outlier:

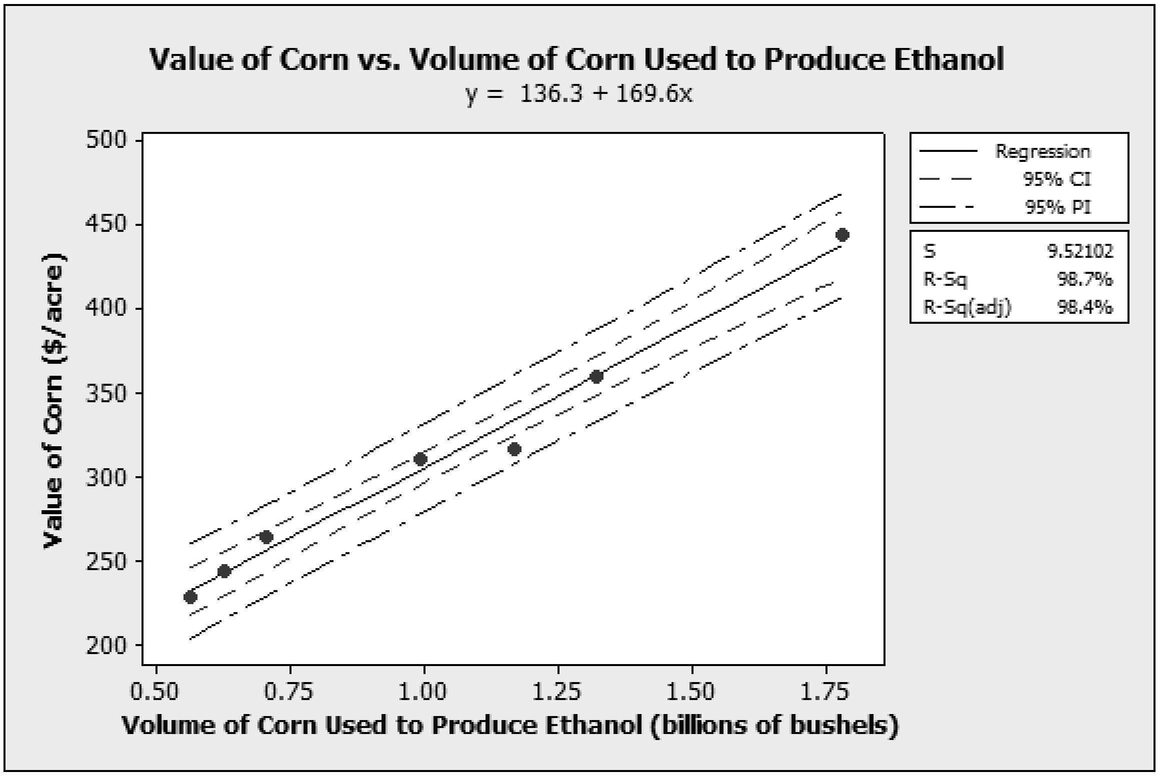


We consider the 2005 data point to not be reflective of the overall trend, and keeping the idea that we are to be making a simulation in mind, we make the decision to remove the data point and construct our models for the simulation sans that piece of data.

The following figure, generated in Minitab, is of the gasoline prices from 1999 to 2006.

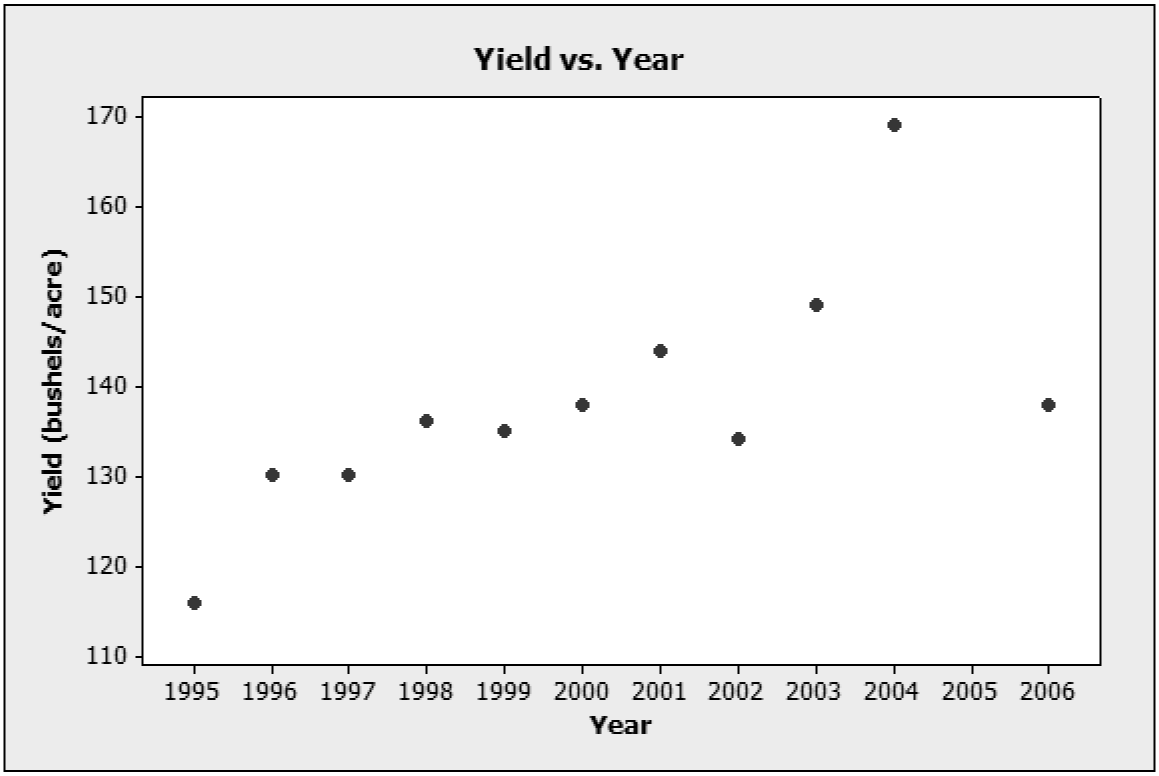


There is a clear linear trend ($r^2 = 0.961$); gasoline consumption has been increasing from year to year consistently from 1999 on. Thus, we used the model given by a least squares regression process, y = -3935 + 2.033x, where y represents billions of gallons of gasoline, and y represents the year being evaluated. We took as the error here the approximate vertical (note: not perpendicular) distance from the best fit line to the given 95% prediction interval, i.e., 3 billion gallons. With a projection for the gasoline consumption, we use a conversion factor (Equation 3) to determine the amount of ethanol that would be needed to replace 10% of the total gasoline to be consumed, and from there we determine the amount of corn in bushels that will be needed to generate that amount of ethanol, i.e, 0.388 bushels of corn to a gallon (There are 56 lbs of corn in a bushel, 21.7 lbs of corn are needed to make a gallon of ethanol). This number is key, as it allows us to address the actual issue, i.e., the effect of ethanol on cost. To calculate this effect, we depend on the following dataset:



This data set too reflects an extremely linear correlation ($r^2 = 0.987$) between the value of corn and the volume of corn that is being put towards ethanol. The line of best fit, as found using least squares regression, was y = 136.3 + 169.6x, and we used it to predict the value of corn given the volume of corn that would be used to produce ethanol, as determined in the previous step of our simulation. Here too, the error was taken as the vertical distance between the line of best fit and the bounds of the 95% prediction interval, $30/acre.

With the value of corn per planted acre, we can find the harvest price of corn, the price paid per bushel of corn. For this, we needed the yield per acre planted, and a graph of the yield against time is shown below:

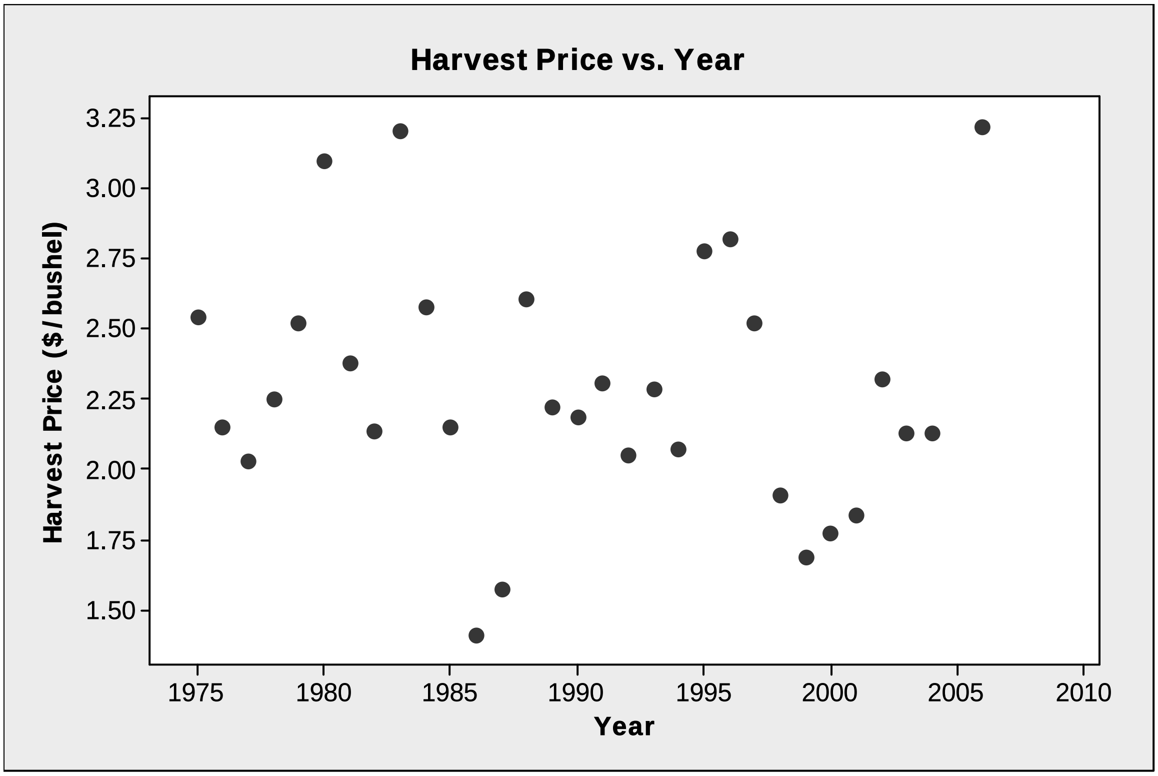


Though a general sort of linear positive trend can be seen here, the yield per acre reflects conditions as diverse as the environmental conditions, the individual farmer's efficiency, the efficiency of the machinery, etc., and, as a result, we decided that it was not feasible to assume that it would follow any sort of trend. As such, the yield per acre was set as a constant in our simulation, the mean yield from 1999 to 2006: 138 bushels per planted acre.

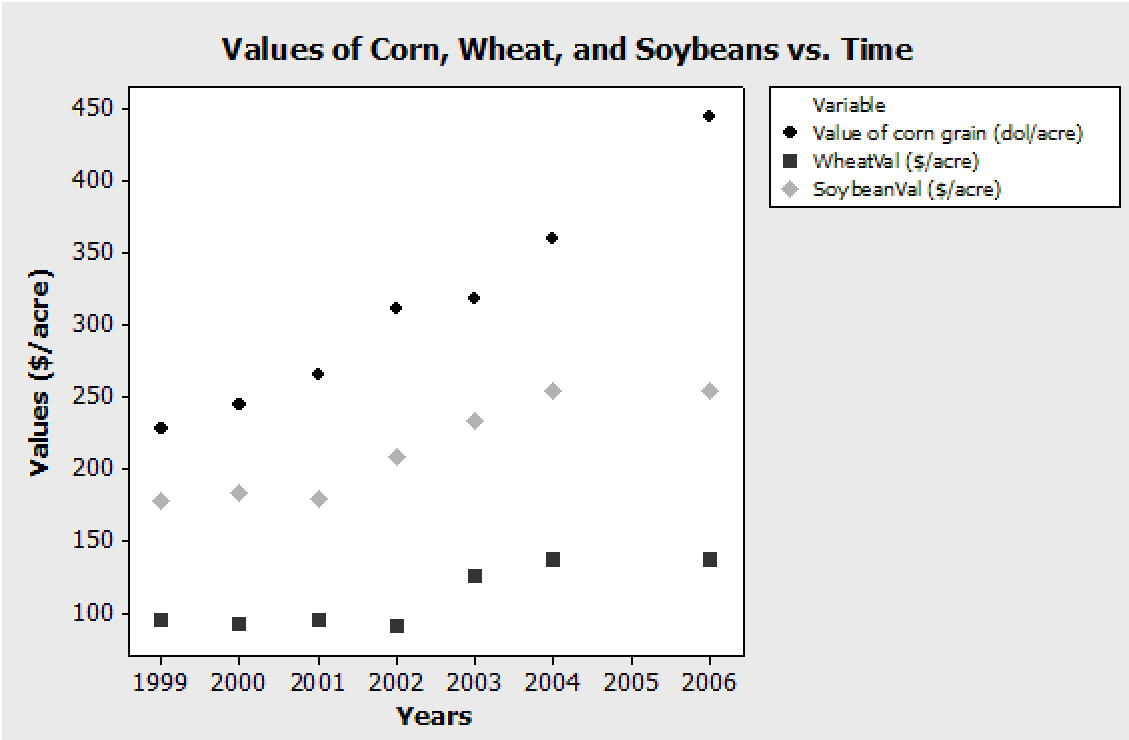
With the yield in bushels per planted acre set, we can then use the previously determined value of corn per planted acre to find the harvest price by taking the ratio of the value of corn to the yield, resulting in the harvest price. This price returned by the simulation also carries with it a listed maximum error, resulting from the errors we attribute to each of the models. This error is found by carrying out the simulation for the listed year once with the values of the model given by our best fit line and once with the maximum error values incorporated. The difference between the two was taken as our error. As a matter of interest, when run for the next five years, our simulation returned the following:

Year	**Harvest Price (corn)**	**Acreage needed for corn (millions of acres)**
2009	\$8.36 +/- \$2.47	44.3
2010	\$8.46 +/- \$2.49	44.9
2011	\$8.56 +/- \$2.52	44.6
2012	\$8.66 +/- \$2.54	45.2
2013	\$8.76 +/- \$2.56	45.8

What this indicates to us is that if we were to replace 10% of U.S. gasoline consumption with ethanol, every year the price of corn would increase. A graph of the harvest price of corn against time is provided:



Previous to 1999 (the year which we began to consider our data that would ultimately be used to generate our models for the simulation), the prices are a veritable paragon of random scatter. From 1999 to 2006, a definite positive trend marking increased prices of corn can be seen, as indicated in our graphs of that data set referenced earlier in the paper. It would be unwise to ignore the fact that it is around this time that corn ethanol emerges as a “silver bullet” for the cause of energy independence and the environmental movement; ethanol usage and rising prices are in direct correlation with one another. These rising prices also serve to increase the price of other grain crops, as farmers eager to profit from the growing marketability of corn will tend to divert land to corn. The following is a graph reflecting the price trends of corn, soy beans, and wheat, two other crops that are of great import to many developing nations:



The increase in the value of each of wheat and soy beans in tandem with corn, and, by extension, the effect it would have on people who depend on those crops for their livelihood, cannot be denied.

Effect on Developing Countries

A developing country is defined as a country that is poor and whose citizens are mostly agricultural workers. There are over 150 developing countries, 1/3 of which are considered least developed countries. A least developed country must meet the following criteria:

- a low-income criterion, based on a three-year average estimate of the gross national income (GNI) per capita (under $750 for inclusion, above $900 for graduation);
- a human resource weakness criterion, involving a composite Human Assets Index (HAI) based on indicators of (a) nutrition; (b) health; (c) education; and (d) adult literacy; and
- an economic vulnerability criterion, involving a composite Economic Vulnerability Index (EVI) based on indicators of (a) the instability of agricultural production; (b) the instability of exports of goods and services; (c) the economic importance of non-traditional activities (share of manufacturing and modern services in GDP); (d) merchandise export concentration; and (e) the handicap of economic smallness (as measured through the population in logarithm); and the percentage of population displaced by natural disasters. (E/2004/33)

Among these countries the average income is under $8,000 per year. This amounts to about $22 a day in spending money. This is extremely small considered with the average annual income of the U.S.: $43,740. With the increase in grain prices it is clear that developing countries will be seeing many problems. Because most of the food they are able to afford is made of various grains, an increase in the price in them will greatly affect their lives. If they are not able to afford to buy their food they will die. What started as an apparent environmentally safe and cost efficient solution will turn in to a life altering and cost burdening problem.

U.S. Energy Independence

There are many better ways for the U.S. to attain national independence from energy rather than resorting to a mass production of ethanol fuel and, along with it, corn. Modern technology provides several long term alternatives to this inefficient fuel, but there are short term options as well to alleviate the immediate climate-change and national security dangers.

For an immediate solution to America's national dependence on foreign oil, we can look to our Alaskan petroleum reserves. According to the National Petroleum Reserve, the U.S. geological survey estimated that there are between 5.9 and 13.2 billion barrels of technically recoverable oil on federal lands. This amount alone can replace imported oil from Saudi Arabia for 3 to 6 years. As petroleum is so critical to the American economy, in the event of national crisis American petroleum reserves could sustain the country for a few years. However, this is not a long term solution to the current energy problem, and we look toward continuing scientific advances to suggest safe and affordable alternatives.

We can also look toward our nuclear power plants for an energy solution. Currently, 104 nuclear reactors of various types fulfill 20% **[9]** of U.S. demand for nuclear power. Nuclear power production is for the most part environmentally friendly, because it does not release greenhouse gases like carbon dioxide into the atmosphere. A major controversy with these power plants, though, is the radioactive and high-temperature waste they produce. Disposing of this dangerous, hot waste is an ongoing problem, and solutions like burying the waste in desolate locations like Yucca Mountain, NV, where the U.S. Department of Energy currently deposits waste. Concerns that this waste could leak into the environment, especially into water supplies, are serious because of the great danger of radioactive waste, and they require well-planned systems of transportation and storage.

Another step toward becoming an energy independent country can be found in solar power. Solar power is energy that is obtained directly from the sun. The sun's radiation provides approximately 1300 watts per square meter. It reduced to about 1000 watts per square meter, however, by the time it reaches the earth's surface on a fair-weather day. The most practical use for solar energy is in electricity generation, while other possibilities include heating a home or a building. There are two types of ways to approach this. The first is a desiccant evaporator in which a solar collector is used to extract moisture from the air. When the moisture is removed, the air becomes drier and colder. The remaining hot moist air is separated from the cooler air and vented outside. The other way is to use an absorption chiller. Solar energy is used to heat a refrigerant that is under pressure. When the refrigerant is depressurized, it expands, thereby cooling the air around it. Solar power is just one of the many possible alternate forms of energy that America can adapt in order to take the necessary steps to becoming an independent energy nation, while hydroelectric, geothermal, and wind power provide other options.

Appendix: Data

Years	Harvest Price ($/bush)		Taxes/Insurance ($/acre)		Value of corn grain ($/acre)		
1975	2.54	4.74	217.68	*	*	*	85.7
1976	2.15	4.96	187.27	*	*	*	87.1
1977	2.03	5.64	180.26	*	*	*	88.8
1978	2.25	6.12	226.13	*	*	*	100.5
1979	2.52	6.94	276.19	*	*	*	109.6
1980	3.1	14.55	279.47	175	*	*	90.15
1981	2.38	14.92	260.09	215	*	*	109.28
1982	2.14	13.93	243.45	350	*	*	113.76
1983	3.21	13.45	252.82	375	*	*	78.76
1984	2.58	17	272.94	430	*	*	105.79
1985	2.15	17.47	252.17	610	*	*	117.29
1986	1.41	13.81	167.03	710	*	*	118.46
1987	1.57	14.65	186.56	830	*	*	118.83
1988	2.61	14.59	217.2	845	*	*	83.22
1989	2.22	14.87	255.37	870	*	*	115.03
1990	2.19	14.85	257.33	900	*	*	117.5
1991	2.31	17.98	254.98	950	*	*	110.38
1992	2.05	18.41	274.33	1100	*	*	133.82
1993	2.29	18.11	227.05	1200	*	*	99.15
1994	2.07	20.68	296.32	1350	*	*	143.15
1995	2.78	20.01	321.98	1400	396	1022	115.82
1996	2.82	6.98	366.46	1100	429	1107	130
1997	2.52	7	327.6	1300	481	1241	130
1998	1.91	7.05	259.76	1400	526	1357	136
1999	1.69	6.96	228.15	1470	566	1461	135
2000	1.77	7.13	244.26	1630	628	1621	138
2001	1.84	5.49	264.96	1770	706	1822	144
2002	2.32	5.42	310.88	2130	996	2570	134
2003	2.13	5.54	317.37	2800	1168	3014	149
2004	2.13	5.58	359.97	3400	1323	3414	169
2005	1.74	6.51	259.26	3900	1575	4065	149
2006	3.22	7.01	444.36	4300	1744	4600	138

Appendix: Model Source Code

The Simulation.

```
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;
import java.util.*;
public class Main extends JPanel{
```

-Constructs a window to input the year to be predicted to from 2007 and the percentage of ethanol in gasoline-ethanol mixtures, and predicts the price per bushel of corn, wheat, and soy that would result, using statistical models.

```
      private JTextField inputs[] = new JTextField[2];
      //Ending year, Percentage of ethanol in gasoline (inputted by the
      user.)
      private JButton finished = new JButton("Begin");
       //Push when finished.
      private JLabel Title = new JLabel("The Simulation!");
      private JLabel Years = new JLabel("Extrapolate to: ");
      private JLabel Per = new JLabel("Percentage of Ethanol in fuel: ");
      private JRadioButton one = new JRadioButton("This Year Alone");
      //Runs the simulation only on this year (past years can be simulated).
      private JRadioButton two = new JRadioButton("Up To This Year");
      //Runs the simulation on every year to the year inputted (must be a
future year)
      private ButtonGroup grouper = new ButtonGroup();
      private GridLayout grid = new GridLayout(5,2);
      private boolean twoselected = false;
      public Main() {
            one.addActionListener(new radio());
            two.addActionListener(new radio());
            grouper.add(one);
            grouper.add(two);
            this.setLayout(grid);
            for(int a = 0; a < inputs.length; a++) {
                  inputs[a] = new JTextField(4);
            }
            setPreferredSize(new Dimension(350,100));
            add(new Panel());
            add(Title);
            add(Years);
            add(inputs[0]);
            add(Per);
            add(inputs[1]);
            add(one);
            add(two);
            add(new Panel());
            finished.addActionListener(new listener());
            add(finished);
      }

public void paintComponent(Graphics page) {
      super.paintComponent(page);
}
public static void main(String args[]) {
      JFrame frame = new JFrame("Input Window");
      Main main = new Main();
      frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
      frame.add(main);
      frame.pack();
      frame.setVisible(true);
}
public void doSimulation(double endyr, double perceth, boolean upto) {
```

-Constructs objects representing the statistical models of the class F (written previously by our team). The class F calculates the value of the equation at the x-coordinate inputted with the method getY(double x). This method uses the various models derived statistically to determine a prediction for the price per bushel of corn and, from that price, the price per bushel of soy and wheat.

```
int startyear;
if(upto) startyear = 2007;
else startyear = (int)endyr;
```

```
for(int curyear = startyear; curyear < endyr+1; curyear++) {
      double gaserror = 0, yielderror = 0, cornvalerror = 0, cprevprice = 0,
cmaxedprice = 0, sprevprice = 0, smaxedprice = 0, wprevprice = 0, wmaxedprice
= 0;
      for(int a = 0; a < 2; a++) {
            if(a == 1) {
                  gaserror = 3.0;
                  yielderror = 25.0;
                  cornvalerror = 50.0;
            }
            F CornforEthtoValofCorn = new F("136.3+169.6*x", "x");
            F YearvsGasConsumed = new F("2.033*x-3935.0", "x");
            F CorntoSoy = new F("82.6+0.419*x","x");
            F CorntoWheat = new F("36.7+.239*x","x");
            F CornNeededforEthNeeded = new F(".388*x", "x");
            Double GasConsumed = new Double(YearvsGasConsumed.getY(curyear))
+ gaserror; //Error of +/- 3.0
            System.out.println("Gas Consumed " + GasConsumed.toString());
            F GasConsumedtoEthNeeded = new F(GasConsumed.toString() + "/((0-
.34)*x+1)", "x");
            F YieldperAcre = new F("138.0","x");
            double EthNeeded = GasConsumedtoEthNeeded.getY(perceth)/10;
            System.out.println("Ethanol Needed " + EthNeeded);
            double CornNeeded = CornNeededforEthNeeded.getY(EthNeeded);
            System.out.println("Acreage needed " +
CornNeeded/YieldperAcre.getY(curyear));
            System.out.println("Corn Needed " + CornNeeded);
            double ValofCorn = CornforEthtoValofCorn.getY(CornNeeded) +
cornvalerror;
            // Error +/- 50
            System.out.println("Value of Corn " + ValofCorn);
            double PriceperBushel = ValofCorn / (YieldperAcre.getY(curyear) -
yielderror);
             // Error +/- 25 Acres on yieldperacre
            double SoyperAcre = CorntoSoy.getY(ValofCorn);
            double WheatperAcre = CorntoWheat.getY(ValofCorn);
            SoyperAcre /= (50.0);
            WheatperAcre /= (35.0);
            if(a == 0) {
                  cprevprice = PriceperBushel;
                  sprevprice = SoyperAcre;
                  wprevprice = WheatperAcre;
            }
            else {
                  cmaxedprice = PriceperBushel;
                  smaxedprice = SoyperAcre;
                  wmaxedprice = WheatperAcre;
            }

      System.out.println("___________________________________________________
________");
      }
            System.out.println("Year: " + curyear + "  Price Per Bushel of
Corn: $" + cprevprice + " +/- " + (cmaxedprice-cprevprice));
            System.out.println("Year: " + curyear + "  Price Per Bushel of
Soy: $" + sprevprice + " +/- " + (smaxedprice-sprevprice));
            System.out.println("Year: " + curyear + "  Price Per Bushel of
Wheat: $" + wprevprice + " +/- " + (wmaxedprice-wprevprice));
            System.out.println("");
            System.out.println("");

}
}
public class radio implements ActionListener{
```

```
public void actionPerformed(ActionEvent err) {
      if((JRadioButton)err.getSource() == one) twoselected = false;
      else if((JRadioButton)err.getSource() == two) twoselected = true;
}
}
public class listener implements ActionListener{
public void actionPerformed(ActionEvent err) {
            int year = 0;
            double portion = 0;
            try {
                  year = Integer.parseInt(inputs[0].getText());
                  portion = Double.parseDouble(inputs[1].getText());
            }
            catch(Exception e) {
                  System.out.println("Fill in the boxes!");
            }
            doSimulation(year, portion/100.0, twoselected);
}
}
}
```

Works Cited

[1] http://www.bookrags.com/research/oil-embargo-enve-02/
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[3] http://www.runet.edu/~whim/tech/articles/ethanol.html
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[10] http://www.wipo.int/ldcs/en/statistics/number_ldcs.html

Data Sources:
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