The Effects of an Increasing Federal Minimum Wage on Federal Unemployment and Job Automation Levels

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THE EFFECTS OF AN INCREASING FEDERAL MINIMUM WAGE ON FEDERAL UNEMPLOYMENT AND JOB AUTOMATION LEVELS

by

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A thesis submitted in partial fulfillment of the requirements
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ABSTRACT

The industrial revolution was the start of increasing technological advancements that are continuing to grow today. Technology improves accuracy, efficiency and is more productive in comparison to human labor as it does not require breaks and cannot violate any labor laws. With many innovations available today, firms have more options to choose from and can select the relatively cheaper solution. The push for a fifteen-dollar minimum wage affects the firm's options, and the use of technology might increasingly become the more viable choice. This study took data from the years 1993 to 2016 and estimated two regressions using the unemployment rate and job automation rate as the dependent variables. The independent variables considered were the year, population growth rate, the minimum wage, inflation, the gross domestic product growth rate, and the consumer price index. After normality checks and transformations were done two regressions were run, and the models were studied to determine the effects. Both regressions were found to be valid with F-statistic p-values lower than one percent. All the statistically significant variables were retained in the model, and the insignificant variables were omitted then the regression was run again and checked for accuracy. The models with the lower Akaike's information criterion and Bayesian information criterion values were the final models. Overall the regressions found that the year and consumer price index had the most substantial effects on the unemployment rate, and the consumer price index had the strongest effect on the automation rate. Limitations of the study include the data available, a possible lag in the effect of the minimum wage, and the possible inaccuracy in using industrial robot installation as a measure for job automation.

For anyone that inspired and taught me that there is no limit to what I can accomplish.

For anyone that is no longer here and is not able to see me grow to my full potential.

For anyone that encouraged me and made me persevere when I wanted to give up.

This is for you.

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I. INTRODUCTION

1.1 History of the Federal Minimum Wage

On June 25th, 1938 President Franklin Roosevelt signed the Federal Labor Standards Act (FLSA). This act was the first in United States history to establish a minimum wage, overtime pay, and child labor standards at the Federal level. Numerous states had already implemented a minimum wage, starting with Massachusetts in 1912. Initially set at twenty-five cents an hour, the Federal minimum wage has since been adjusted for cost of living and is now at seven dollars and twenty-five cents an hour (Bureau of Labor Statistics). The minimum wage is an example of a price floor, and it raises the wage that firms must pay employees. Workers for whom the minimum wage exceeds their reservation wage join the supply of labor. With a new influx of workers, the labor market becomes out of equilibrium, the demand of labor to falls short of the supply of labor, creating unemployment. Today most workers making minimum wage are under twenty-five years of age and are in either the hospitality or the leisure industry holding service positions (Bureau of Labor Statistics).

1.2 Minimum Wage Adjustments

Most minimum wage increases have been small adjustments ranging from twenty-five cents to one dollar and twenty-five cents an hour (Bureau of Labor Statistics). The most recent increase was in 2009 when the minimum wage was raised from six dollars and fifty-five cents to seven dollars and twenty-five cents. In 2012 a movement, now known as the 'Fight for $15', began when fast-food workers in New York started a strike against the current minimum wage and pushed for union rights (Fightfor15.org). This movement has been part of the more recent push to double the minimum wage, to a "grand" fifteen dollars an hour. The success of this movement would mean that the minimum wage would increase by more than one-hundred-percent. Economists are wary of an increase this large, as the effects of a one-hundred-percent increased minimum wage are unknown (Repetti and Roe, 2016). Firms facing higher wage rates look to reduce costs, and with decreasing costs of technology, companies have started substituting technology for labor. Companies have stated they felt pressured to streamline technological innovations to save costs on labor, therefore confirming that some firms have selected automation due to the minimum wage (Forbes, 2016). One of the questions posed in this study is whether the change in the minimum wage played a significant role in the amount of technological implementation.

1.3 History of the Industrial Revolution

The industrial revolution first started in the mid-eighteenth century in Britain; however, the movement did not start until 1790 in America. The shift from an agriculture economy to an industrial economy allowed productivity as well as the standard of living to increase. One well-known textile manufacturer, Samuel Slater played a pivotal role in mechanizing textile manufacturing. Most of the technological improvements and innovations in America followed similar, if not exact, designs like those in Britain (US History). Henry Ford's invention of the assembly line aided industrialization with the rise of mass production. With the exponential rise in the production of goods, improved transportation systems were critical to reaching new consumers. National railroad systems helped to connect regions that were remote from each other, and the invention of the steamboat reduced shipping costs (History of Massachusetts). Technological advances allowed industrialization and urbanization to increase at the rate they did and led to America becoming the largest economy in the world.

1.4 Goal of this Study

This study evaluates the effects of higher minimum wages on both unemployment and job automation in the United States economy. Separate regressions were used to analyze the dependent variables, and the goal was to determine whether the minimum wage had significant effects on the unemployment rate and job automation. Other variables were included to control for other impacts on each dependent variable and to maximize the fit of the regression model. Studies done so far have found that unemployment rates are increased by both an increase in the minimum wage rate and by an increase in the use of industrial robots. The goals are to determine whether or not the minimum wage and use of industrial robots are related and if so, whether that connection is equivalent to the relationship between minimum wage and unemployment. There is not much research done on the effects of industrial robots on the economy, however many researchers have created predictions on the number of jobs that will be automated in the future. Overall this study aims to answer the following questions: What are the effects of minimum wage on unemployment? What are the effects of minimum wage on the use of industrial robots? Are these effects equivalent? Could employers be substituting labor for industrial robots due to the minimum wage increase?

II. LITERATURE REVIEW

2.1 The Labor Market Model

Neoclassical economic theory based on supply and demand, with perfect information, is a simple way to examine the labor market. There are three fundamental assumptions neoclassical economic theories are dependent upon; the first is the idea that people are rational, the second that a firm's goal is profit maximization while an individual's goal is utility maximization, and the third that people act based on the information they possess.

The labor market is made up of workers supplying labor, and firms demanding labor to match their demand to provide a good or service. An individual's supply curve is dependent on their labor-leisure curve; an individual must decide how many hours to spend working(earning income for goods) or on leisure. The individual's choices are constrained by the amount of time in a day, and the maximum income they can earn in one day, dependent upon the market wage rate. When firms are perfectly competitive, they are wage takers, and the firm pays their workers the market wage rate. This wage curve is equivalent to the firm's marginal cost of labor, meaning that the market wage rate is equal to both the supply of labor and the marginal cost of labor.

A firm's labor demand curve is dependent upon the firm's desire to produce output because labor demanded is a derived demand. The more output a firm wants to produce, the more labor they will demand. The marginal revenue product of labor is how a firm determines their demand for labor. Marginal revenue product is the amount of additional revenue earned from hiring an extra worker; it can be found by multiplying the price of the output with the marginal product of a worker. If the worker's marginal revenue product is higher than the wage rate, the firm will employ the worker. In fact, the firm will employ workers up until the point where marginal revenue product of the worker is equal to the firm's marginal cost, the market wage rate. The minimum wage law affects the cost of labor for a firm. Rather than being able to employ the worker at their marginal revenue productivity, the firm must pay a worker the set wage. If the worker produces additional revenue for the firm that is below the wage rate, then the worker will not be hired (Schuldt et al. 2012).

2.2 The Advantages and Disadvantages of the Minimum Wage

The United States is not the first country to enforce a minimum wage. In fact, the first minimum wage in history was in Australia / New Zealand over forty years earlier than the Federal Labor Standards Act in 1938. Workers wanted better treatment and working conditions, causing a minimum wage to be instituted in those countries. The United States minimum wage, originally meant to set a standard of living for employees, was implemented after the Great Depression when the economy was still not stabilized. The Fair Labor Standards Act aimed to help the employed in America and possibly eliminate poverty after the economic crisis. Proponents of the minimum wage argue that the minimum wage does establish a higher standard of living and reduces poverty rates as opposed to no minimum wage. The justification for the minimum wage not causing unemployment is that the labor market model does not follow a simple supply-demand model and is more complex. Other arguments are that the minimum wage promotes equity by lessening the inequality gap, gives the poor more purchasing power, and even increases worker productivity. Arguments against the minimum wage are just the opposite of those supporting it. Opponents say that minimum wage laws do not reduce poverty levels, that there will be higher unemployment levels, more displaced workers and that cheaper alternatives will substitute for labor. Many studies have reported mixed findings on whether or not the minimum wage aids or hurt those affected by it. However, these varying results might be partially due to the different approaches they take.

2.3 Problems with Previous Minimum Wage Increases

An increase in the minimum wage rate causes a ripple effect beyond the labor market. Some measures influenced by the minimum wage in the economy are the amount of output produced, which in turn affects the Gross Domestic Product, the cost of skilled labor or technology relative to unskilled, costs of goods or services, and the unemployment rate.

In a study done by Partridge and Partridge in 2012, they found that an increased minimum wage had a positive effect on long-term unemployment. The effect was not immediate, so they concluded that policymakers should consider the total unemployment as workers might experience an extended unemployed spell when trying to find a new job, years after the minimum wage was increased. Repetti and Roe (2016) conducted a study of respondents that could adjust pricing. They found that 61% of restaurants would increase their prices, which was a higher percentage than expected. They also found that employers would make more significant adjustments in decreasing employees' hours; 87.9% of respondents would reduce staffing hours when the minimum wage was increased by 100%. For comparison, the same questions were asked with a 25% minimum wage increase. Results show that 20% of restaurants would raise prices and 71.2% would decrease employee hours. Repetti and Roe's findings supported the Economic Policy Institute (EPI) findings in 2015 which concluded that when faced with a fifteen-dollar minimum wage 70% of New York restaurant owners would raise their prices while 83% responded they were very or somewhat likely to reduce staffing hours or amount of staff (EPI).

Burkhauser and Sabia (2010) found the minimum wage increase between the years of 2003 to 2007, at both the state and federal level, had no effect on poverty rates at the state level (2010). In 2007, the threshold for "poor" was a household income of $20,650 or less for a household of four. They found that 4.4% of workers in the labor force were classified as living in poor households, however, 48.9% of those workers already earned wages greater than $9.50 an hour. Of workers earning minimum wage, 63.2% were living in households earning an income of over twice the poverty line. They concluded that the minimum wage is not an effective way of aiding the poor as many of the poor workers already earn wages higher than $9.50 an hour. In 2012, Schuldt et al. examined the problems with the minimum wage and determined that it disrupts the market because a firm will not hire the worker for a price exceeding the increase in revenue associated with the added employee. If a firm acted contrary to this, the firm would not be profitable. The minimum wage was described as a way to keep the lower class down and not allow the market to reach equilibrium, as low-wage workers have a harder time finding and retaining their jobs. Teenagers were found to be affected the most as their productivity is relatively low. Schuldt et al.'s study was very biased (Why do you write that their study was biased?); they concluded that the economy would reach its full potential by abolishing the minimum wage and believed that the minimum wage had no positive effects.

2.4 Automation Implemented in Society

Companies facing higher minimum wages have been looking for ways to cut costs, and with decreasing technology costs, it is possible they have started substituting labor for technology. McDonald's announced nationwide self-serving kiosks in 2016, which is now a reality (Forbes, 2016). Customers can now place orders through a kiosk and McDonalds saves the costs on extra employees they would have hired to facilitate entering these orders. Founded in 2015, Eatsa is a restaurant chain located in San Francisco with a mission to "revolutionize restaurants using technology" (Eatsa.com, 2018). Eatsa not only has self-serving kiosks to place orders, but customers also pick up their food in kiosks, making the restaurant entirely self-service. Of restaurants that closed in 2016 in the Bay Area of California, one-quarter reported their primary reason for closing was due to the rising labor costs (Forbes, 2016). Challenging companies like Uber Eats, DoorDash and Mr. Delivery, Starship has invented self-driving robots for food delivery. Planning to deliver all type of products, Starship focuses on minimal emissions and is trying to deliver lunch to customers faster than achieved by an actual person. With nine cameras on each robot, Starship's robots are capable of following street crossings and avoiding any obstruction in its way (Business Insider, 2018).

The use of industrial robots is relatively new, and the few robots in the market have already affected the United States labor market. World-renowned physicist, Stephen Hawking, wrote that automation will "accelerate the widening economic inequality" and that we as humans are limited by natural evolution, while automation and artificial intelligence do not face that challenge (World Economic Forum, 2016). Industrial robots have so far replaced between 360,000 and 720,000 jobs in the United States (Acemoglu and Restrepo, 2017). Their study examined the effect of these robots in the workplace between the years of 1990 to 2007, finding that increasing the number of industrial robots in the labor market increases unemployment and reduces wage rates. Based on the number of industrial robots used in the market today, Acemoglu and Restrepo conclude that another robot per thousand employees "reduces the employment to population ratio by about 0.18-0.34 percentage points and wages by 0.25-0.5 percent". They further state that since the use of robots has been limited, the effects could be higher if the use of industrial robots increases as anticipated. Schuldt et al. (2012) concurred with the finding that unemployment and automation are linked. They concluded that rather than hiring lower-skilled workers with productivity lower than the wage rate, companies would replace them with higher-skilled labor and automation.

III. DATA

The independent variables used for the regression models were the Federal minimum wage rate, annual Gross Domestic Product growth rate, annual population growth rate, and annual inflation rate, annual consumer price index rate, and the year. The data for the variables came from different sources, most from government sites such as the Department of Labor's Bureau of Labor Statistics, the Department of Commerce's Bureau of Economic Analysis, the Economic Research of the Federal Reserve Bank of St. Louis. The Federal minimum wage rate is measured in dollars per hour. Both the Gross Domestic Product (GDP) growth rate and population growth rate are measured in annual percentages.

The dependent variables in the regression models, *unemplog* and *robotslog*, are the log transformation of the unemployment rate and the log transformation of the number of industrial robots. The federal annual unemployment rate was found on the Bureau of Labor Statistics website, and the number of industrial robots in the economy is from the International Federation of Robotics. The annual federal unemployment rate is measured as an annual percentage, and the number of industrial robots will be represented by the number of industrial robots installed for the year, however, due to the non-normality of the variables the logarithm is taken to transform the variables.

Once all the variable's data were collected, they were combined onto an Excel spreadsheet to facilitate easy importing and manipulation into Stata. To make the regression easier to read the variables were labeled as follows; unemployment rate is labeled *unemp*, and its logarithmic transformation is *unemplog*, the rate of industrial robot installation is *robots*, and its logarithmic transformation is *robotslog*, the year stays as *year*, population growth is labeled *popgr*, minimum wage is *minw*, inflation stays as *inflation*, growth domestic product growth is *gdpgr*, and the consumer price index is labeled *cpi*.

IV. METHODOLOGY

4.1 Overview

Two regression models were formulated and estimated to determine the effect of the federal minimum wage on the unemployment rate and the number of industrial robots in the economy. The two models started were equivalent except for the dependent variables. An alpha level of five percent was used for the entire study for consistency. Both models underwent adequacy checks including the kernel density histograms, quantile plots, and the Shapiro-Wilk W test to determine if the dependent variables were normally distributed. These normality checks can be seen in Appendices 1A, 2A, 3A, 4A, and 5A. These tests examined the dependent variables, and it was found that neither the unemployment rate nor the industrial robot rate are normally distributed variables. A Box-Cox transformation was performed on both dependent variables, and it was found that a theta of zero, would normalize the distribution of the variables. After the dependent variables underwent the logarithmic transformation, new dependent variables were created and used for the regression models. Originally named *unemp* and *robots* in the regressions, the new dependent variables are named *unemplog* and *robotslog*, to represent the logarithmic transformations of the variables. These new dependent variables were then tested for normality with the same adequacy checks and the results from the test can be seen in Appendices 1B, 2B, 3B, 4B, and 5B. For unemployment rates, the Shapiro-Wilk W test's p-value rose from 0.008 to 0.122 after the transformation. The transformation also increased the p-value of the Shapiro-Wilk W test for robot rates from 0.0198 to 0.8499. The increased p-values over

0.05 means the logarithmic transformation of the dependent variables normalized the data and that there is now not enough evidence of non-normality to reject the null hypothesis.

4.2 Regression 1: Unemployment

The unemployment rate was the dependent variable used for the first regression model. All the independent variables were included in the initial regression; year, population growth, the logarithmic transformation of robots, minimum wage, inflation, gross domestic product growth, and the consumer price index. The p-values of all the variables were examined, and show that the year, population growth, the transformation of robots, minimum wage and consumer price index were all significant variables. The insignificant variables were dropped from the model, to uphold parsimony and the regression was re-estimated. Results of the F-test from the original and the simplest model show that both models have enough evidence to reject the null hypothesis, implying that all the coefficients are not equal to zero. Since the R-squared and adjusted R-squared between the two models were very close, the Akaike's information criterion and Bayesian information criterion test was run as seen in appendices 6A and 6B. This test aided in determining which model was preferred, and showed that the original model which included the insignificant variables was a better representation of the dependent variable unemployment rates.

4.3 Regression 2: Industrial Robot Installation

The second regression used the logarithmic transformation of robots as the dependent variable. The regression was initially run with all the variables similar to regression 1 with the exception of the dependent variable, and instead of the logarithmic transformation of robots as an independent variable, the logarithmic transformation of unemployment was included. The p-values of the independent variables show that they are all statistically significant except for the year and the minimum wage. These two variables were removed from the model, and the regression was re-estimated with only the significant variables. As previously done in regression 1, the two models' R-squared, adjusted R-sqared, and F-tests were compared. Both regressions' F-test values were below 0.0001, and with small difference of 0.002 or lower in the R-squared and adjusted R-squared the regression itself was not enough to determine which model was a better representation of industrial robot installation. The Akaike's information criterion and Bayesian information criterion was used for each model and the simpler model had the lower AIC and BIC values, therefore it was the regression used for the final model (shown in appendices 6C and 6D).

V. REGRESSION ANALYSIS

5.1 Results of Regression 1: Unemployment

The initial model for the regression ended up being the final model used because of the lower AIC and BIC regression values and the results of this regression can be seen in Figure 1.

Figure 1: Regression 1 Final

Source	SS	df	MS			
Model	1.1481003	7	.164014328	Number of obs	=	24
Residual	.270302471	16	.016893904	F(7, 16)	=	9.71
				Prob > F	=	0.0001
				R-squared	=	0.8094
				Adj R-squared	=	0.7261
Total	1.41840277	23	.061669686	Root MSE	=	.12998

unemplog	Coef.	Std. Err.	t	P>|t|	Beta
year	-.1968221	.0640733	-3.07	0.007	-5.604321
popgr	-2.293861	.6374193	-3.60	0.002	-1.746719
robotslog	-.7662764	.2471122	-3.10	0.007	-1.682506
minw	.2264703	.085891	2.64	0.018	1.040112
inflation	.0842447	.1074261	0.78	0.444	.1759367
gdpgr	.0885695	.0431239	2.05	0.057	.5752733
cpi	.0413173	.0135342	3.05	0.008	5.238114
_cons	396.1223	125.9271	3.15	0.006	.

The first statistic worth mentioning in this regression is the low F-test p-value; the model has less than a one hundredth of one percent chance of all its coefficient estimates being zero. This demonstrates that the regression has some validity. The statistic below the F-statistic is R-squared, which explains how much of the unemployment rates variation is explained by the independent variables; 80.94% of the variation in the unemployment rate is explained by the model. The p-values from the t-test were used in deciding if each independent variable was significant or not. Except for the inflation rate, all independent variables are significant at the 5.7% level or better. On average, one additional year is associated with a decrease in unemployment by 19.68%. This inverse relationship makes sense during periods of economic growth when the unemployment rate tends to decrease, this means that the data set I used on average had more economic growth, however the number is quite large. The population growth rate and log of industrial robot installation also have inverse relationships with the log transformation of the unemployment rate. A one percent increase in the population growth causes a decrease of 229.4% in the log of unemployment rates and an increase in the log of robots caused a decrease in the unemployment rate by 76.63%. The two variables with positive relationships with the unemployment rate are the minimum wage and the consumer price index. A one dollar increase in the minimum wage causes an increase in the log of the unemployment rate by 22.65%, and an increase in the consumer price index causes a 4.13% increase in the log of the unemployment rate. Inflation and gross domestic product were found to be statistically insignificant variables however the model was found to be more accurate with those variables included.

The units of measurement across the variables change so the regression was run with beta values in order to compare the independent variable affects. Although minimum wage was a significant variable on the unemployment rate, it was the weakest among the significant variables. The year, population growth rate, log of industrial robots, and consumer price index all had a stronger effect on the log of the unemployment rate. The simpler regression model can be seen in Appendix 7A.

5.2 Results of Regression 2: Industrial Robot Installation

The final regression for the industrial robot installation ended up being the simplest model and the results are shown in Figure 2.

Figure 2: Regression 2 Final

Source	SS	df	MS			
Model	6.65128464	5	1.33025693	Number of obs	=	24
Residual	.186918532	18	.010384363	F(5, 18)	=	128.10
				Prob > F	=	0.0000
Total	6.83820317	23	.297313181	R-squared	=	0.9727
				Adj R-squared	=	0.9651
				Root MSE	=	.1019

robotslog	Coef.	Std. Err.	t	P>|t|	Beta
popgr	-1.048236	.3887131	-2.70	0.015	-.3635332
unemplog	-.3648819	.1107565	-3.29	0.004	-.1661809
inflation	.1834953	.0661001	2.78	0.012	.174529
gdpgr	.1319461	.017919	7.36	0.000	.3903152
cpi	.0158887	.0021999	7.22	0.000	.9174017
_cons	7.433846	.8179619	9.09	0.000	.

Similar to the final model of regression 1, this regression also has an f-statistic below 0.0001 and it is very unlikely that all the model's variables are zero. The statistically significant variables for this model were population growth, the logarithmic transformation of unemployment, inflation, gross domestic product growth, and the consumer price index. Minimum wage and the year were not significant variables and were therefore dropped from the model. This model had the lower AIC/BIC value which upheld the rule of parsimony. Population growth and the log of the unemployment rate had an inverse relationship with the log of robot installation, while inflation, gross domestic product growth and the consumer price index all had a positive relationship with the dependent variable. Of the significant variables, the consumer price index had the strongest effect on the log of industrial robot installation which can be seen with the beta value of 0.917. The logarithmic transformation of unemployment had the weakest effect on the dependent variable.

The effect of an increasing minimum wage had no significant effect on the rate of industrial robot installation, which was the effect being studied. Other factors played a key role in the rate of industrial robot installation such as the consumer price index, the gross domestic product growth rate, and the population growth rate. The relationships found for these variables make sense. As the population grows, the supply of labor expands as well, and a firm is more likely to find an employee at a more reasonable wage instead of investing in industrial robots. As the gross domestic product grows, it makes sense that a company might take advantage of new technology and invest in industrial robots. The consumer price index increasing could cause firms to invest in industrial robots in order to make the production of goods more efficient and less costly, ultimately decreasing the cost of goods. The initial model regression can be seen in Appendix 7B.

VI. CONCLUSION

6.1 Limitations of the Study

The findings of this study may be hindered on the number of observations used. Due to the new use of industrial robots for automation, there are not many years of data recorded that can be studied. The International Federation of Robotics only had data going back to 1993 and the data was for the entire continent of North America, not just the United States. If the breakdown of the industrial robot installation rate was available, then the numbers found would be more accurate.

Calculating automation rates was found to be another difficulty during the time of the study; currently the Bureau of Labor Statistics does not have an accurate measurement reflecting the percentage of automation. This is something many economists are looking into as it is acknowledged as an unknown and its effect on the economy is becoming more significant with the increase of technological innovations. Installation rates of industrial robots was used because it is a form of automation that substitutes human labor. Some economists have looked into the number of patents placed a year in order to represent the amount of technological innovation occurring, as a way to represent the amount of automation however this did not seem like an accurate representation.

Another belief is that the effect of the minimum wage is not immediate, and that there could be a lag in the effect. This would make it harder to measure the effects as the period of lag is unknown and isolating the minimum wage effect from other economic factors is difficult.

6.2 Final Thoughts

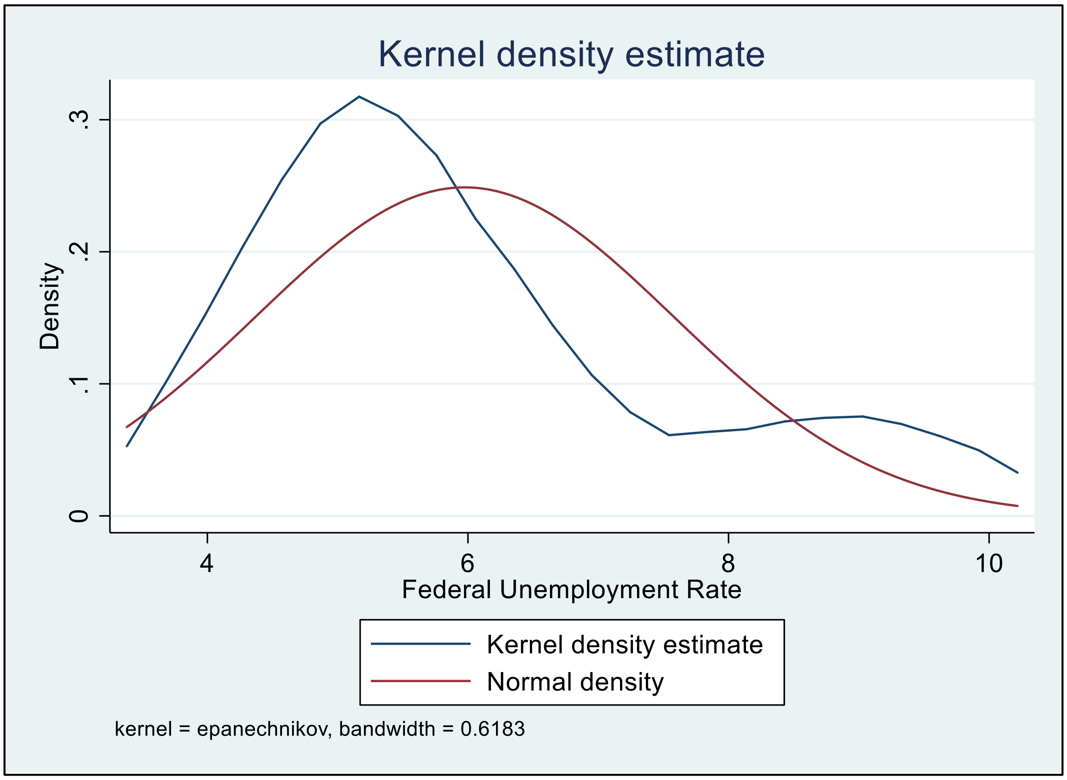
Overall with the increasing amount of technology available for relatively lower prices, companies have the option of substituting human labor with automated labor. Many known companies, such as McDonald's, have already started the investment, implementation, and use of industrial robots. The industrial robots replace human labor and are more efficient and productive, not requiring any breaks or labor laws for firms to follow. This first regression in this study found that an increasing minimum wage had a statistically significant effect on the unemployment rate. The relationship between the two is inverse, as the minimum wage increases the unemployment rate decreases. More notable results were the impacts of the year and consumer price index on unemployment rates, however this finding could be inaccurate due to the smaller number of observations.

The second regression had surprising results as well. It showed that the minimum wage was not a significant variable in the effect on the amount of industrial robot installations. This means that there was no effect of the minimum wage on the second dependent variable. The two regressions could not be compared on the effects of the minimum wage because of this result. The consumer price index had the strongest effect on the automation rate. While some firms seem to be substituting the use of robots for human labor, the effects are not as easy to measure at this time. A lag in the effects of the minimum wage may be buffering the true impact on automation or unemployment rates. The use of robots also opens new industries to create these robots as well as manage and maintain them. These new job possibilities may also alleviate any impact on the unemployment rate. Hopefully a more accurate way of recording job automation rates becomes available so that the effects of it and other variables on it can be studied with more accuracy. This issue is more prominent with each day as more companies are taking a stance with the fight for a fifteen-dollar minimum wage.

APPENDICES

APPENDIX 1: KERNEL DENSITY HISTOGRAM OF UNEMPLOYMENT RATES AND THE LOG OF UNEMPLOYMENT RATES

1A:


Kernel density estimate
Density
0
.1
.2
.3
4
6
8
10
Federal Unemployment Rate
Kernel density estimate
Normal density
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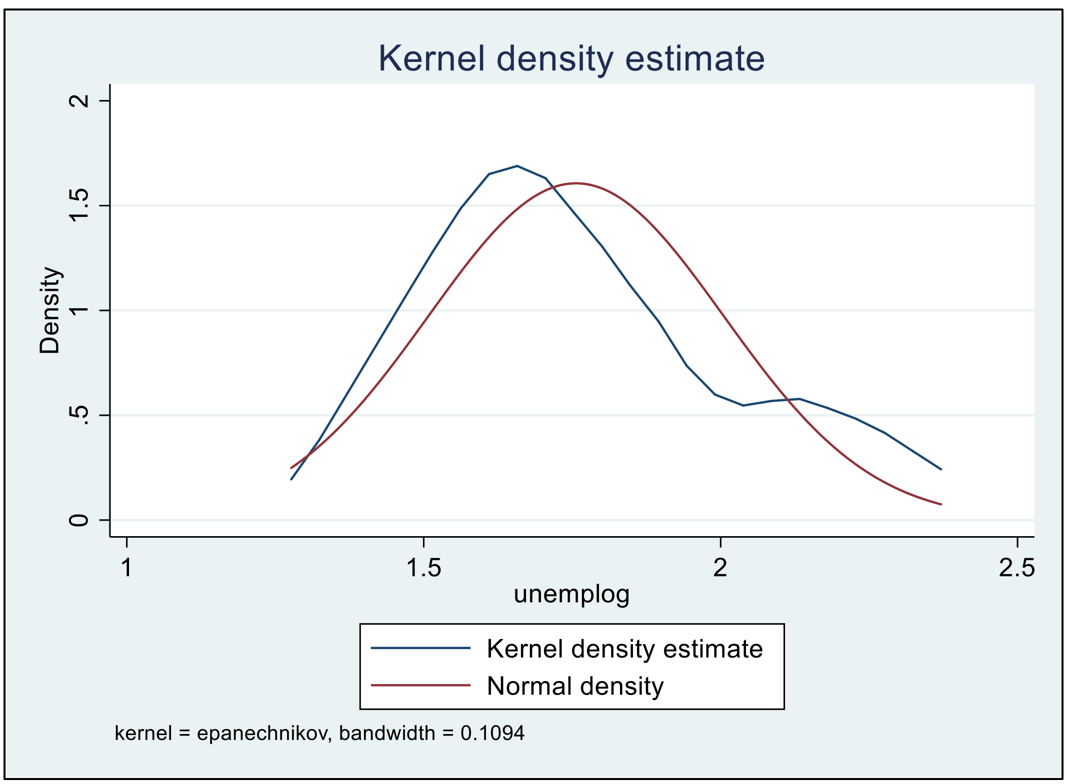
2A:


Kernel density estimate
Density
0
.5
1
1.5
2
1
1.5
2
2.5
unemplog
Kernel density estimate
Normal density
kernel = epanechnikov, bandwidth = 0.1094

APPENDIX 2: KERNEL DENSITY HISTOGRAM OF INDUSTRIAL ROBOT INSTALLATION AND THE LOG OF INDUSTRIAL ROBOT INSTALLATION

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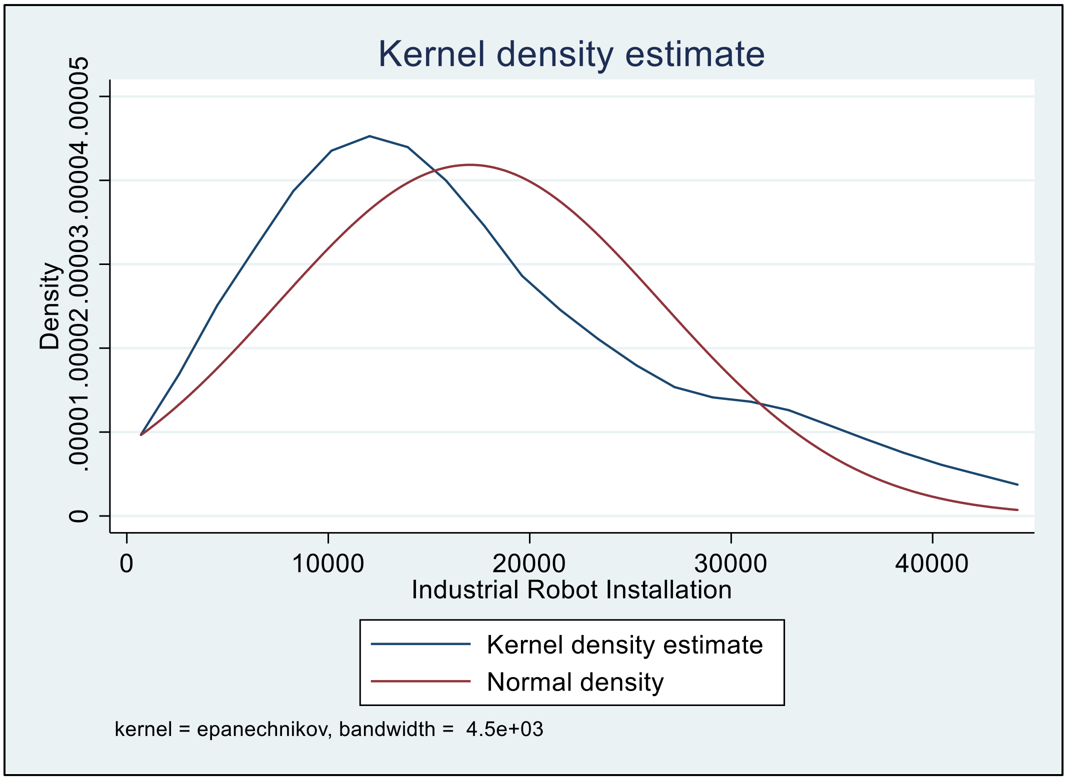
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Density
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.00003
.00004
.00005
0
10000
20000
30000
40000
Industrial Robot Installation
Kernel density estimate
Normal density
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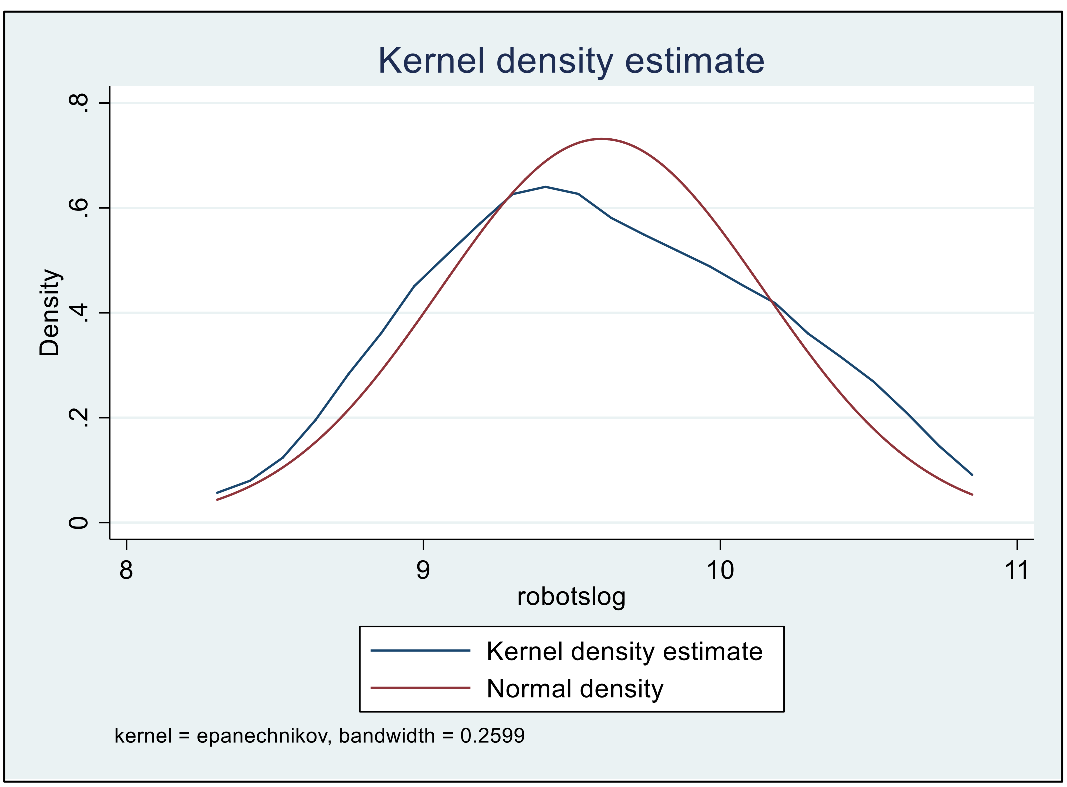
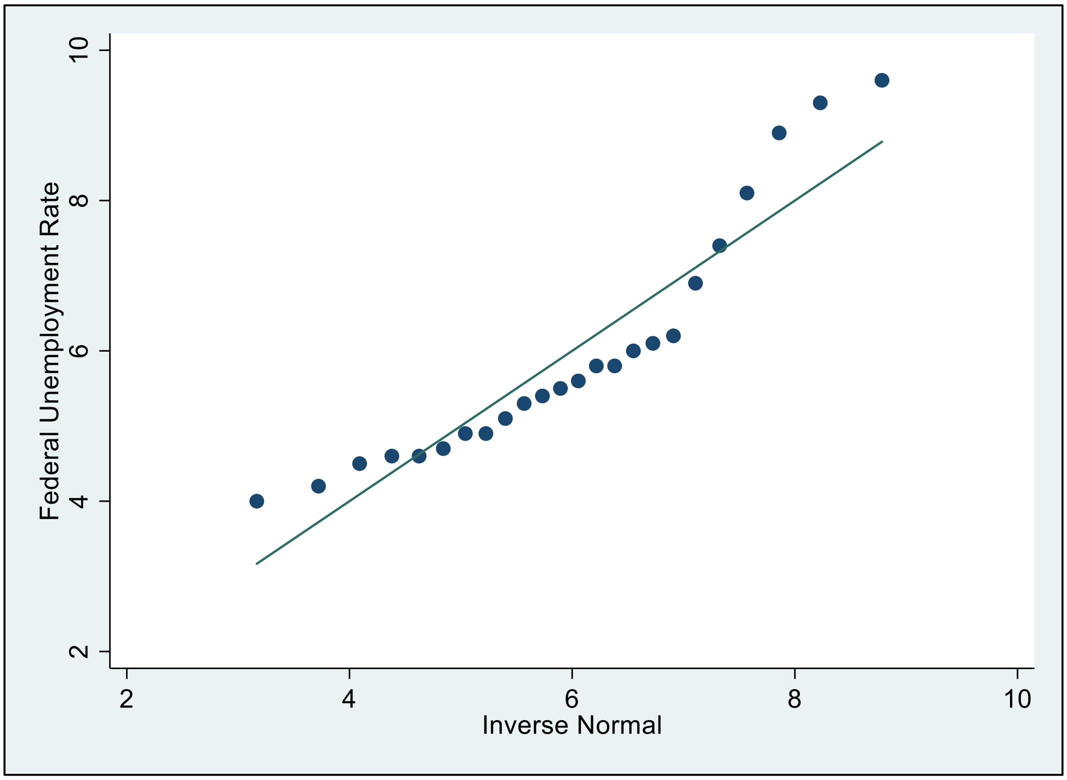
2B:

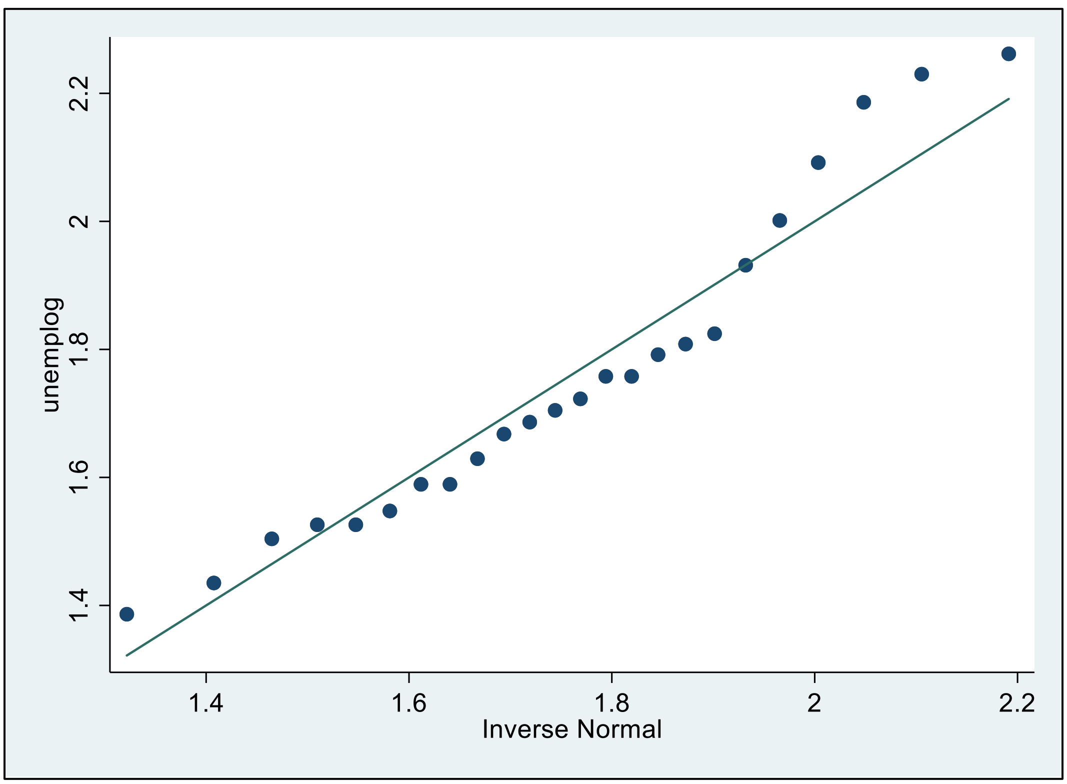

Kernel density estimate
Density
0
.2
.4
.6
.8
8
9
10
11
robotslog
Kernel density estimate
Normal density
kernel = epanechnikov, bandwidth = 0.2599

APPENDIX 3: QUANTILES PLOTS FOR UNEMPLOYMENT RATES AND THE LOG OF UNEMPLOYMENT RATES

3A:

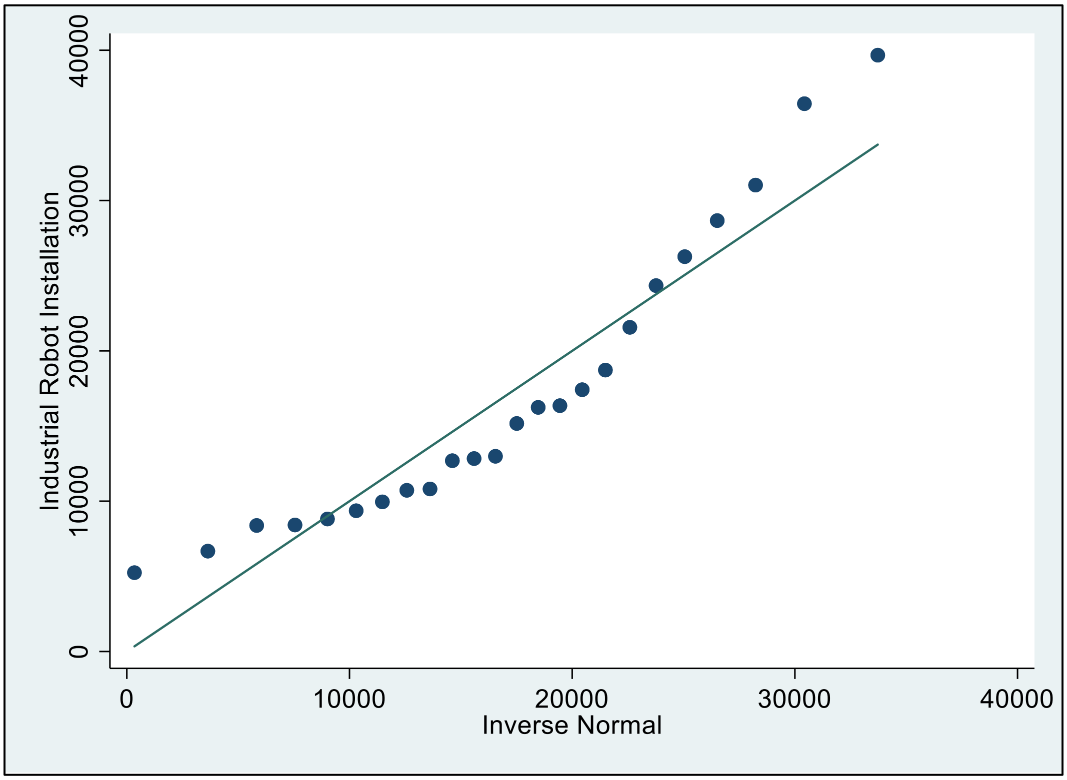

Federal Unemployment Rate
2
4
6
8
10
2
4
6
8
10
Inverse Normal

3B:


unemplog
1.4
1.6
1.8
2
2.2
1.4
1.6
1.8
2
2.2
Inverse Normal

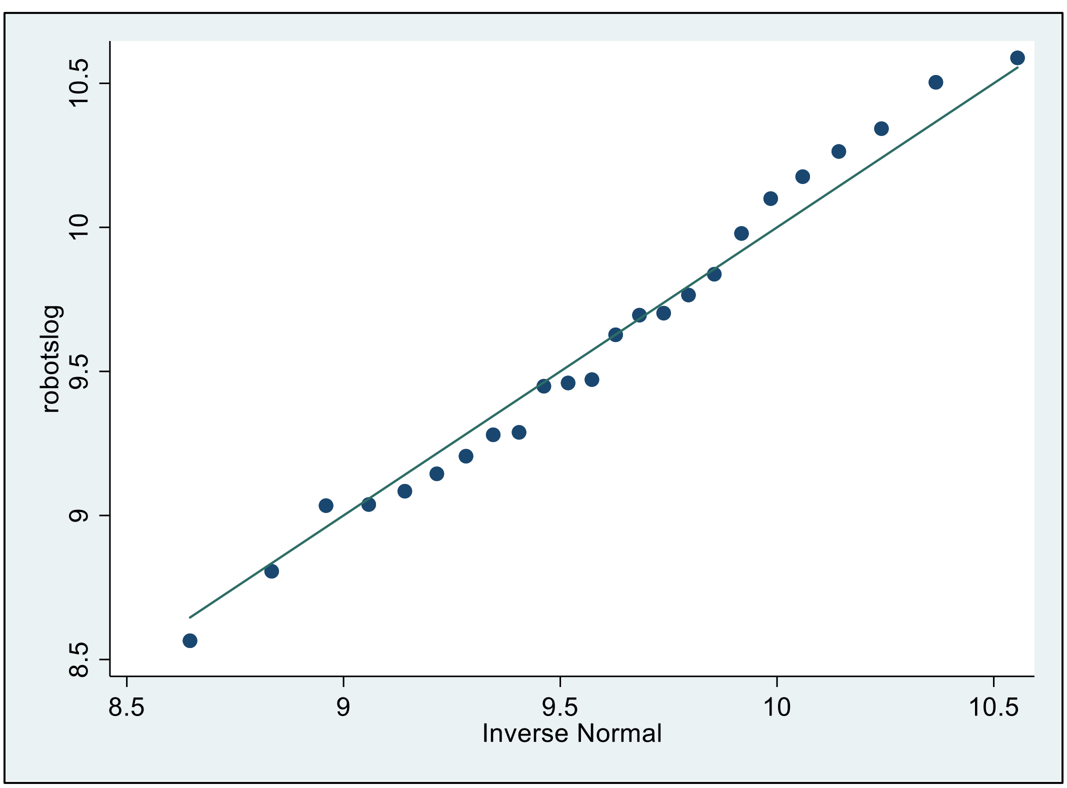
APPENDIX 4: QUANTILES PLOTS FOR INDUSTRIAL ROBOT INSTALLATION AND THE LOG OF INDUSTRIAL ROBOT INSTALLATION

4A:



Industrial Robot Installation
0
10000
20000
30000
40000
0
10000
20000
30000
40000
Inverse Normal

4B:



robotslog
8.5
9
9.5
10
10.5
8.5
9
9.5
10
10.5
Inverse Normal

APPENDIX 5: SHAPIRO-WILK W TEST FOR THE ORIGINAL AND NEW DEPENDENT VARIABLES

5A:

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
unemp	24	0.87843	3.279	2.421	0.00773
robots	24	0.89825	2.745	2.059	0.01976

5B:

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
unemplog	24	0.93434	1.771	1.165	0.12192
robotslog	24	0.97770	0.602	-1.036	0.84993

APPENDIX 6: AIC/BIC REGRESSION 1 SIMPLEST AND FINAL MODEL AND REGRESSION 2 ORIGINAL AND FINAL MODEL

6A: AIC/BIC REGRESSION 1 SIMPLEST

Akaike's information criterion and Bayesian information criterion

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
.	24	-.1122559	16.82868	6	-21.65735	-14.58903

Note: N=Obs used in calculating BIC; see [R] BIC note.

6B: AIC/BIC REGRESSION 1 FINAL

Akaike's information criterion and Bayesian information criterion

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
.	24	-.1122559	19.78069	8	-23.56137	-14.13694

Note: N=Obs used in calculating BIC; see [R] BIC note.

6C: AIC/BIC REGRESSION 2 ORIGINAL

Akaike's information criterion and Bayesian information criterion

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
.	24	-18.98818	25.14926	8	-34.29852	-24.87409

Note: N=Obs used in calculating BIC; see [R] BIC note.

6D: AIC/BIC REGRESSION 2 FINAL

Akaike's information criterion and Bayesian information criterion

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
.	24	-18.98818	24.20711	6	-36.41422	-29.3459

Note: N=Obs used in calculating BIC; see [R] BIC note.

APPENDIX 7: UNEMPLOYMENT SIMPLER MODEL AND INDUSTRIAL ROBOT INSTALLATION INITIAL MODEL

7A:

Source	SS	df	MS		
Model	1.07271281	5	.214542561	Number of obs =	24
Residual	.345689961	18	.019204998	F(5, 18) =	11.17
Total	1.41840277	23	.061669686	Prob > F =	0.0001
				R-squared =	0.7563
				Adj R-squared =	0.6886
				Root MSE =	.13858

unemplog	Coef.	Std. Err.	t	P>|t|	Beta
year	-.1865778	.0667491	-2.80	0.012	-5.312624
popgr	-1.916839	.586385	-3.27	0.004	-1.459626
robotslog	-.3402642	.1385954	-2.46	0.024	-.7471151
minw	.2445718	.0844875	2.89	0.010	1.123247
cpi	.0308197	.0129798	2.37	0.029	3.907254
_cons	373.4736	131.1928	2.85	0.011	.

7B:

Source	SS	df	MS		
Model	6.66539878	7	.952199825	Number of obs =	24
Residual	.172804391	16	.010800274	F(7, 16) =	88.16
Total	6.83820317	23	.297313181	Prob > F =	0.0000
				R-squared =	0.9747
				Adj R-squared =	0.9637
				Root MSE =	.10392

robotslog	Coef.	Std. Err.	t	P>|t|	Beta
year	-.0653888	.0624917	-1.05	0.311	-.8479716
popgr	-1.514066	.5715914	-2.65	0.018	-.5250851
unemplog	-.4898806	.1579789	-3.10	0.007	-.22311
minw	.0645572	.0806543	0.80	0.435	.1350338
inflation	.1838747	.0744863	2.47	0.025	.1748898
gdpgr	.1359795	.0186193	7.30	0.000	.4022465
cpi	.0261724	.0119374	2.19	0.043	1.511177
_cons	136.7958	123.4418	1.11	0.284	.

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