THE IMPACT OF OIL PRICE SHOCKS ON LOCAL TEXAS COMMUNITIES DURING THE COVID-19 PANDEMIC

An Undergraduate Research Scholars Thesis

by

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This project did not require approval from the Texas A&M University Research Compliance & Biosafety office.

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ABSTRACT

The Impact of Oil Price Shocks on Local Texas Communities During the COVID-19 Pandemic

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This thesis paper examines the effects of changes in the oil and gas industry on local Texas labor markets especially during the COVID-19 pandemic. The events surrounding the COVID-19 virus are unique in US history and create a need for unique and specific analysis. The paper analyzes multiple factors when determining results including oil production, oil price, COVID-19 cases, unemployment, and population. Using this data, we will run multiple OLS linear regressions with the aim of finding the magnitude of effect and determining whether the relationships between the studied variables experienced any significant changes during different time periods both including and excluding the year 2020. The results coming from my analysis show an economically significant correlation of oil prices, oil production, and COVID-19 cases with unemployment rate. This relationship also clearly changes between the some of the separate time periods that are used in the analysis.

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1. INTRODUCTION

Texas is the largest oil producing state in the United States, so it stands to reason that Texas would be one of the areas hardest hit by disruptions in the oil and gas industry. However, the strength of this connection is unclear. It is for that reason that I was motivated to begin the research shown in this paper. Throughout the years, oil price and oil production have moved around and affected the Texas economy. However, the recent introduction of the COVID-19 virus caused all sorts of new changes. Oil prices dropped, unemployment rates skyrocketed, and how all these variables impacted each other is unknown. Thus, it is important to look at past data to try and find the relationships and impacts between all these separate points.

When looking at past research, it is hard to determine the impact at the Texas state-level and county-level. The purpose of this paper is to identify how oil price changes affected Texas and, more specifically, local Texas labor markets through the analysis of unemployment data at county-level. The question arises of the magnitude of effect on the Texas labor market and whether certain local communities within Texas were hit harder by changes in oil prices than the others. In this paper, I seek to find if oil prices, oil production, and COVID-19 cases had an economically significant effect on the unemployment rates in Texas counties. Further, I want to find how the sudden inclusion of the COVID-19 virus disrupted these variables' relationships. The analysis shows that oil prices, oil production, and COVID-19 cases all have an economically significant impact on unemployment that changes during the year of 2020.

2. LITERATURE REVIEW

The main article referenced in inspiration and in content was "Who Benefits from Oil and Gas Unemployment?" [4] This article goes in depth into local Texas communities to find how booms in the oil and gas industry affect certain groups differently. The groups analyzed include gender, race, and ethnicity. This paper is pertinent to mine as it looks specifically at how the oil and gas industry relates to employment while also analyzing smaller, local groups. This article helps support my hypothesis, because it not only shows that different groups within Texas are affected differently by the oil and gas industry, but also shows that the oil and gas industry has an economically significant effect on employment in all industries. My paper differs from the referenced one, because it looks mostly at county-level data and is focused on a negative oil and gas shock during the COVID-19 pandemic.

Another article that analyzes a similar subject matter is "Do Higher Oil Prices Still Benefit Texas?" [6]. Brown and Yücel look at how oil prices affected the Texas economy across different time periods. They find that Texas has diversified its economy over time and is less dependent on the oil and gas industry. Previously, oil prices could have a significant effect on the entire Texas economy. Later, although still prevalent, the effect of oil prices on the economy was much less pronounced than in the years before. This article supports my argument by showing that oil prices can have a large effect on Texas economies. The article also shows that over different times and places, the effect of changing oil prices is different. My research diverges from this article by looking at a much more recent time period and by analyzing at a much more local level.

In order to see the effect of the price changes on Texas, it is also important to refer to previous research on the whole of the United States. Economists have looked much more extensively at the whole of the U.S., giving much more context than what is available solely in Texas. Oladosu et al. discovered a statistically significant GDP elasticity connected to oil prices the magnitude of which has been decreasing compared to the previous decade [7]. These results are important, as they show that oil prices do have an impact on the United States' economy as a whole. If oil prices have a statistically significant impact on the United States' economy, it is logical to deduce that the largest oil producing state within this country also derives statistically significant consequences from oil price shocks. This article further backs up the points presented by Brown and Yücel. Brown and Yücel found that the Texas economy's reaction to oil price shocks has decreased over time as the economy has diversified. Oladosu et al. report similar findings, showing that the magnitude of GDP elasticity in reaction to oil price shocks has lessened in magnitude over time, likely due to the similar reason that Brown and Yücel deduced.

Another crucial element for this analysis is a more specific look at 2020 and how oil prices were impacted during this time. Some previous analysis of this time comes from the U.S. Energy Information Administration (EIA) [9]. They find that the COVID-19 pandemic and the responses to it caused steep declines in oil price. As the COVID-19 pandemic began to take hold in the U.S. and around the world, a substantial decrease in oil demand pushed prices to incredible lows, going even below 0 into the negatives as well. Other impacts stemmed from this sizeable decrease in demand. The EIA found that in the time between March and May, U.S. weekly gross refinery inputs fell 20% to the lowest it has been since 2008. As demand plummeted, crude oil producers began to keep their oil in stock until a resurgence of demand occurred, causing a large increase in oil inventories. In addition to demand loss, supply had to fall deeply as well in response. In the time period after May, however, demand began to recover and along with it, oil prices. The EIA reports that "The second half of the year was characterized by relatively stable prices as demand began to recover" [9]. The West Texas Intermediate crude oil prices recovered up to above $40 a barrel by the end of December 2020, but this number is still below the level of $60 that it held coming into 2020. Furthermore, they report that crude oil production, refinery runs, and total petroleum product consumption have also not recovered to pre-pandemic levels. This analysis gives perspective on the relationship between oil price and the COVID-19 pandemic. This research shows that the relationship does exist and is incredibly volatile, changing radically multiple times throughout 2020. This research supports the findings of this paper by identifying this relationship and its behavior. If oil prices and COVID-19 cases are decreasing and increasing, respectively and simultaneously, the effect on the unemployment rate will logically be much larger than if only one variable is impacted. This paper builds upon this past research by showing how both variables work together to impact the unemployment rate. This paper also looks at previous time periods to establish variable relationships before the introduction of the COVID-19 pandemic.

3. METHODS

3.1 Data Description

There are 5 main points of data used in the analysis in this paper. These are unemployment rate, oil prices, oil production, population, and COVID-19 data. The unemployment data is sourced from the Labor Market and Career Information department of the Texas Workforce Commission. The unemployment data is the main dependent variable of this analysis and represents the labor markets. This data is collected at the county level within Texas and is monthly data. The oil price data comes from the Federal Reserve Bank of St. Louis and includes West Texas Intermediate (WTI) oil prices per barrel this data is not county level and is collected monthly. This is used as the independent variable in this study to measure this variable's effect on Texas Labor Markets. The oil production data is from Enverus Drilling Information and will be used to determine the oil-dependency of each separate community. This data is also collected monthly at the county level. The population data is from the Texas A&M Real Estate The COVID-19 data includes new confirmed cases reported from each county in Texas, monthly. This data is provided by Texas Health and Human Services. For this analysis, I utilized data from January 1990 to October 2020 for oil price, oil production, and unemployment rate. The COVID-19 data extends from March 2020 to October 2020. The data is sourced from 202 separate Texas counties. There are 52 Texas counties excluded from this analysis due to a lack of complete data.

3.2 Equations

For the first step of the analysis, I ran multiple regressions on the data that I collected. I decided to run fixed effect Ordinary Least Squares (OLS) regressions. The reason why I must run a fixed effects regression is due to the nature of my data. The data type for all my observed variables is panel data. Each data point is taken from a different date and different county. The exception being oil price, which changes by date, but not county. This means the regression must have a fixed effect. Since there are 370 time periods and 202 counties, there are around 74,000 observations for the unemployment rate and oil production variables. However, in each given time, the oil price is the same across every county. So, in order for the analysis to run correctly, I must create a fixed effect for date and county. The first regression for my analysis looks at only the era of 1990-2019, allowing me to find the relationship between the variables before the introduction of the COVID-19 virus. I ran the following regression equation on the data.

$$Unemployment_{it} = \beta_0 + \beta_1 OilPrice_t + \beta_2 OilProduction_{it} + u \qquad (3.1)$$

The basic OLS equation is shown in Equation 3.1. $Unemployment_{\mathrm{it}}$ is the dependent variable of the equation. The included subscripts are representations of the 2 dimensions of the panel data. For this data, the dimensions are *i* for county and *t* for date. The other variables are independent and are the factors that I decided to observe for their impact on the unemployment rate. β_0 is the Y-intercept of the OLS best fit line. β_1 and β_2 equate to the multipliers of oil price and oil production, respectively. u is the undefined error term of the equation.

After running these regressions, I run single regressions observing only one independent variable's correlation with unemployment rate without the influence of the second independent variable. In order to do this, I use Equations 3.2 and 3.3 below.

$$Unemployment_{it} = \beta_0 + \beta_1 OilPrice_t + u \qquad (3.2)$$

$$Unemployment_{it} = \beta_0 + \beta_1 OilProduction_{it} + u \tag{3. 3}$$

Next, I use the regression Equation 3.4 on two separate time periods. First, I run the regression on solely the 2020 data, to see how the relationships between variables are changed during the period where the COVID-19 virus enters. The second time period for this regression equation spans from 1990 to 2020. This time period spans all data for the analysis and gives a look at how the total relationships are impacted by the inclusion of 2020. This equation adds a third independent variable of new confirmed COVID-19 cases, titled COVIDCases.

$$Unemployment_{it} = \beta_0 + \beta_1 OilPrice_t + \beta_2 OilProduction_{it} + \beta_3 COVIDCases_{it} + u \tag{3. 4}$$

Afterwards, I run Equations 3.2 and 3.3 again on the 2 new time periods in analysis. After that analysis is complete, there is one last equation to include. Equation 3.5 seeks to find how much of the coefficient between COVID-19 cases and unemployment rate can be explained by the oil price and oil production variables.

$$\frac{\Delta Unemployment_{it}}{\Delta COVIDCases_{it}} = \frac{\Delta Unemployment_{it}}{\Delta OilPrice_t} \times \frac{\Delta OilPrice_t}{\Delta COVIDCases_{it}} + \frac{\Delta Unemployment_{it}}{\Delta OilProduction_{it}} \times \frac{\Delta OilProduction_{it}}{\Delta COVIDCases_{it}} \tag{3. 5}$$

All analysis for this paper will use the equations and data previously listed. Firstly, I will run the main regression equations and analyze their results. The purpose of this is to identify the coefficients of the relationships between the variables. The next step is to compare the different regression results and identify differences between the results. Next, clarifying why the differences exist and how the variables caused them to change. Finally, find the results of Equation 3.5 and determine the meaning of the output.

4. RESULTS

Before running the regression equations, first, I find the summary statistics for the 1990-2019 data which is outlined in Table 4.1. This data includes the number of observations, the mean, the standard deviation, the minimum, and the maximum of each variable included in the data.

Table 4.1: Summary Statistics

Variables	Observations	Mean	Standard Deviation	Min	Max
Unemployment Rate	74,740	5.81	3.06	0	54.1
Oil Price	74,740	47.48	28.92	11.35	133.88
Oil Production	74,740	284,867.5	880,017.2	0	1.86e+07

The summary statistics tell us that my data lines up as far as observations and give us an idea of the general area the data will fall in through the mean. I can also identify possible outliers in my data set through the minimum and maximum portion of the statistics.

The next output to look at is the results from the first regression equation that included only oil price and oil production as regressors for unemployment rate during the 1990-2019 time period. That output is shown in Table 4.2.

Table 4.2: Ordinary Least Squares Regression Equations 3.1, 3.2, and 3.3

Unemployment Rate	**Model 1**	**Model 2**	**Model 3**
Oil Price (β_1)	-0.422** (0.012)		-0.421** (0.012)
Oil Production (β_2)		-0.095** (0.010)	-0.120** (0.010)
Intercept (β_0)	7.357** (0.045)	5.520** (0.031)	6.993** (0.052)
Observations	74,740	74,740	74,740
Overall R-Squared	0.0075	0.0004	0.0056

**Statistically significant at the 99% confidence level.

The first important piece of information presented in Table 4.2 is the coefficients of oil price and production. Both values are negative, meaning as they increase, unemployment rate decreases. While these numbers are numerically small, the most important factor is their significance. I can derive from the information given in this table that both coefficients are statistically significant at the 95% confidence level. This knowledge is important because it tells us whether the results are statistically relevant. In order to test for statistical significance, I use the t-value, which is calculated by dividing the coefficient by the standard error, and the given 95% confidence interval. Since the t-value is above the threshold for the 95% confidence level and the coefficient value is within the confidence interval, the results of this regression are statistically significant.

The next important regression output is from the time period of just 2020. These results come from the regression Equations 3.1 and 3.4. The results also include the third independent variable of new confirmed COVID-19 cases. This output is shown in Table 4.3 below.

Table 4.3: Ordinary Least Squares Regression Equations 3.1 and 3.4

Unemployment Rate	Model 1	Model 2
Oil Price (β_1)	-4.642** (0.123)	-4.735** (0.177)
Oil Production (β_2)	-1.896** (0.144)	-1.195** (0.146)
COVID-19 Cases (β_3)		0.300** (0.035)
Intercept (β_0)	17.7339** (0.673)	19.7396** (0.728)
Observations	2,020	2,020
Overall R-Squared	0.0273	0.0179

**Statistically significant at the 99% confidence level.

The results of the regression and time period have perceptible differences from the previous regression results. Firstly, the coefficients of oil price and oil production are much larger. This implies a more reliant relationship between variables during the 2020 time period. The overall R-squared results are also larger, meaning that this data fits along the regression line closer than it did on the previous regression. Another thing to point out within the regression results is the coefficient of the COVIDCases variable, which is a statistically significant positive value. This means that as COVID-19 cases increase, unemployment rate also increases. This relationship makes sense as COVID-19 caused severe shocks to many different aspects of the U.S. and Texas economies, which is bound to have an effect of the unemployment rate.

The next table of results uses Equations 3.1, 3.2, and 3.3 but are regressed on the data that spans through all dates in the analysis. These results use the 1990-2020 data, making them different from the results labeled in Table 4.1. The results are laid out in Table 4.4.

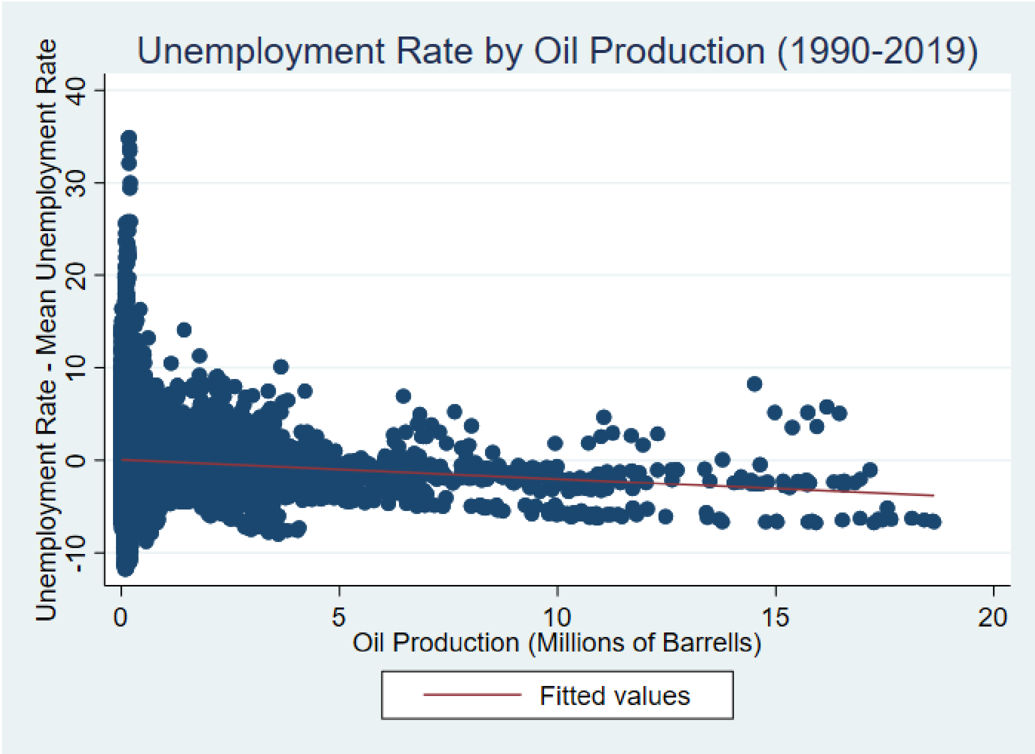
Table 4.4: Ordinary Least Squares Regression Equations 3.1, 3.2, and 3.3

Unemployment Rate	Model 1	Model 2	Model 3
Oil Price (β_1)	-0.422** (0.012)		-0.422** (0.012)
Oil Production (β_2)		-0.095** (0.010)	-0.121** (0.010)
Intercept (β_0)	7.357** (0.045)	5.520** (0.031)	6.993** (0.052)
Observations	74,740	74,740	74,740
Overall R-Squared	0.0075	0.0004	0.0056

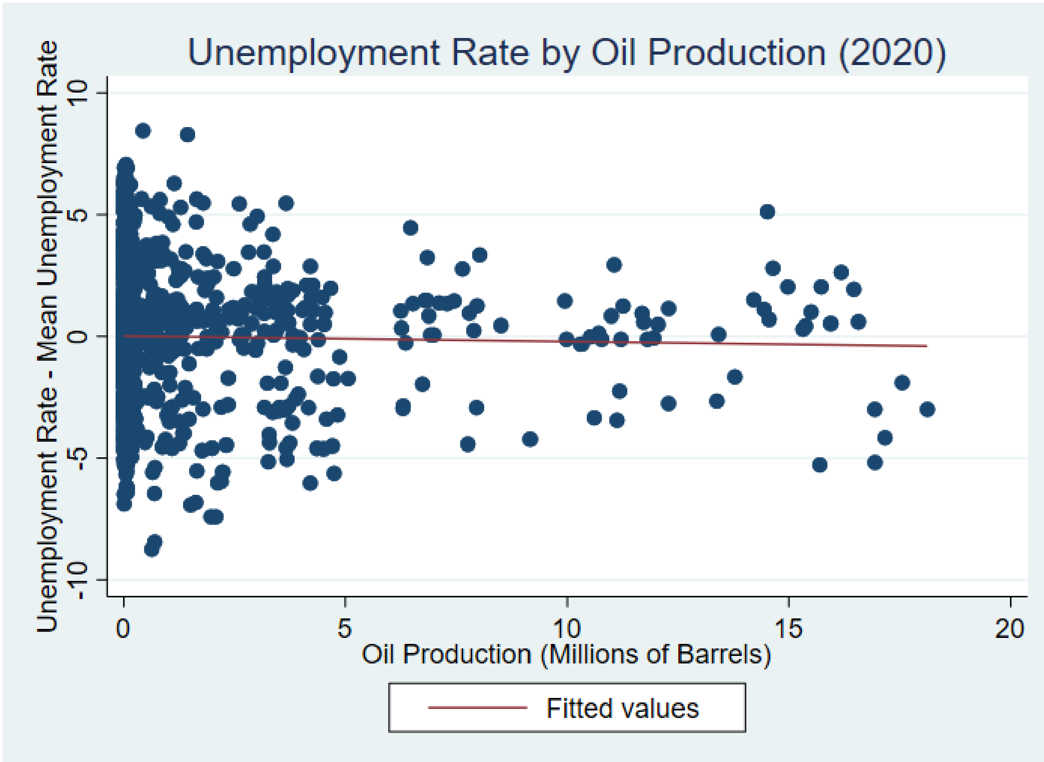
**Statistically significant at the 99% confidence level.

When looking at the results for 1990-2020, the inclusion of 2020 in the data set causes very little change in the relationships shown from the 1990-2019 analysis. While 2020 alone has clear differences when compared with the 1990-2019 regression output, when looking at all the time periods together. The inclusion of 2020 makes no clear impact in the overall results. The inclusion of 2020 making almost no difference hints that while 2020 may be an outlier to previous results, its difference is not large enough to make any significant change in the overall results. This means that it is likely that the change in relationship in 2020 is not necessarily attributable to COVID-19 cases, but to other outside influences not included in the analysis in this paper. However, it is also highly likely that the much smaller sample size taken from 2020 in comparison with the almost 30 years analyzed in the previous period, is not large enough to make a significant impact on the results. This idea could prevent any obvious change in results no matter how large of an outlier the year 2020 could be in the context of the total results.

The next portion of results is graphs of the regression results. The first two graphs are of unemployment rate variance by oil production. The first encompasses the time period of 1990-2019 and the second looks specifically at 2020. These are shown in Graph 4.1 and 4.2.

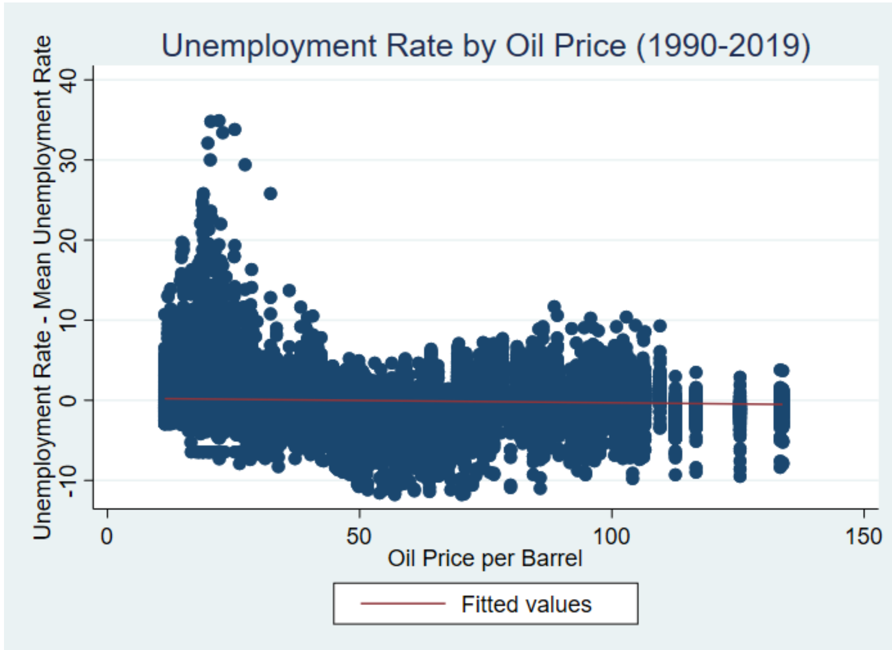


Graph 4.1: Unemployment Rate by Oil Production

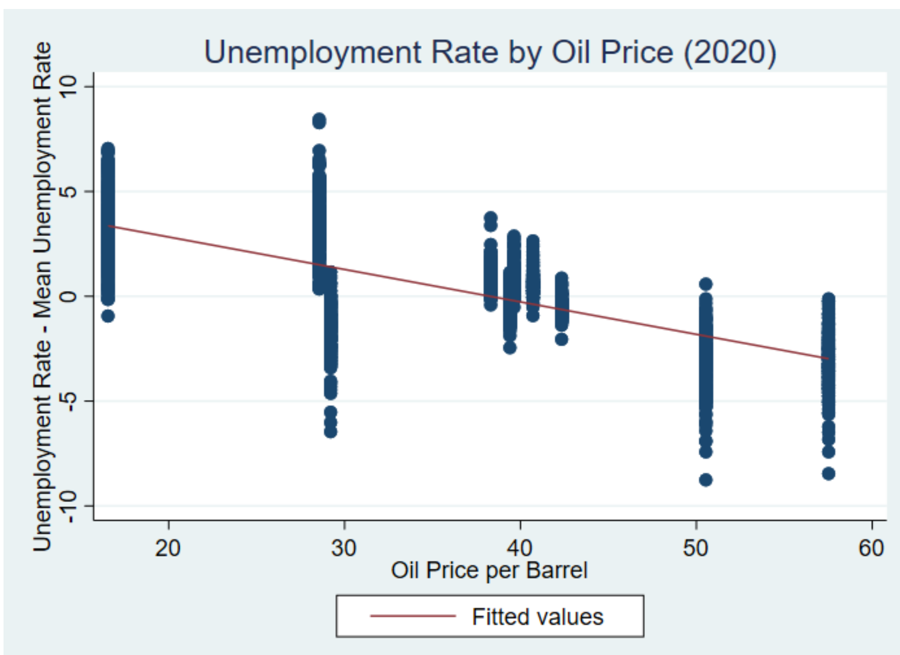


Graph 4.2: Unemployment Rate by Oil Production

There are some clear things to observe in the graphs. Firstly, the variance in the unemployment rate skews much more negatively in Graph 4.2 of 2020 than it does in the previous Graph 4.1 of 1990-2019. Next, the negative coefficients from the regression results are clear in the graphs and there is no large, noticeable difference between the results from each of the graphs, although the slope seems to be larger in Graph 4.1. Lastly, the distribution of the oil production by millions of barrels looks to be similar in both of the graphs with the main difference being a smaller number of observations in Graph 4.2 due to the more limited time period compared to Graph 4.1. Next, are the unemployment rate variance by oil price Graphs 4.3 and 4.4.

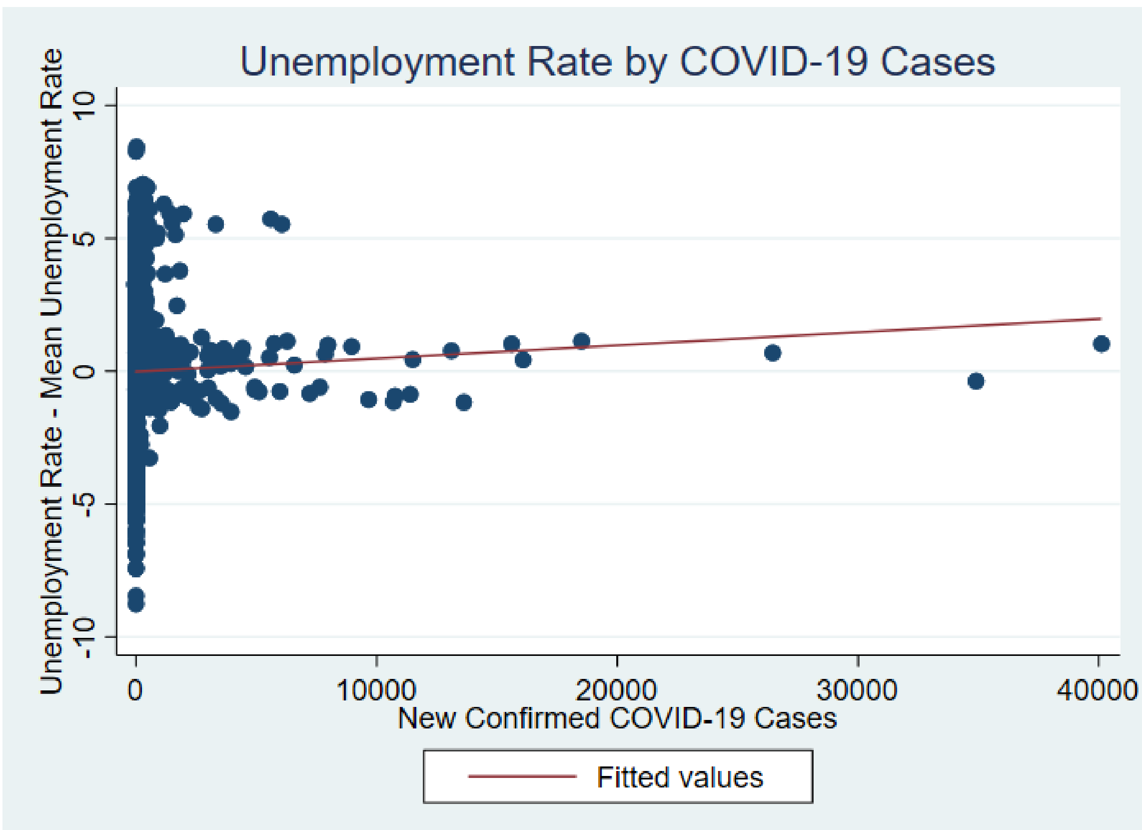


Graph 4.3: Unemployment Rate by Oil Price

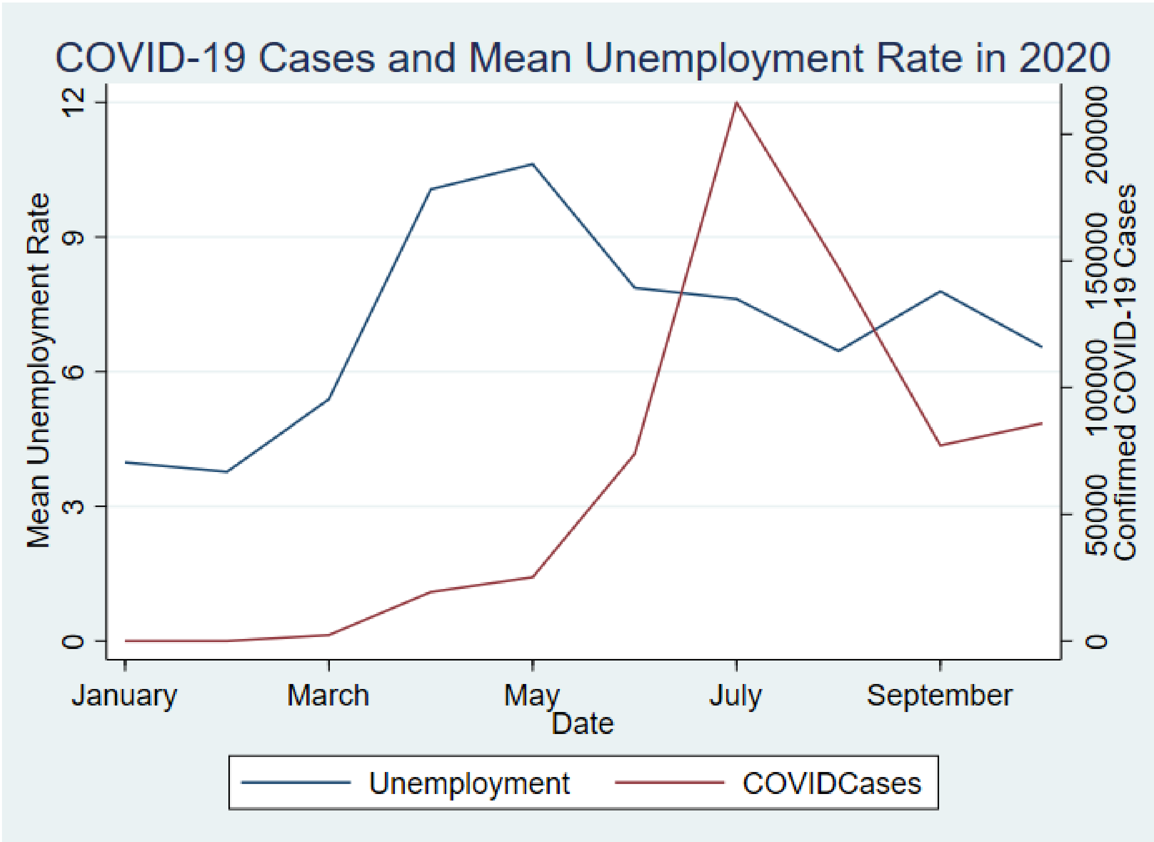


Graph 4.4: Unemployment Rate by Oil Price

Once again, the negative coefficients from the regression results also show in the graph as the best fit line is downward sloping. However, in the case of oil price, the coefficient is much larger in 2020 than in the previous period. This change is shown in the graph through the slope of the best fit line. The slope during 2020 is larger and therefore, more downward sloping This implies that during 2020, unemployment rate became more responsive to changes in oil price. The last important graphs from the analysis are related to COVID-19 numbers, shown in Graphs 4.5 and 4.6.



Graph 4.5: Unemployment Rate by COVID-19 Cases



Graph 4.6: COVID-19 Cases and Mean Unemployment Rate

The Graph 4.5 shows the relationship between COVID-19 cases and unemployment rate during 2020. This graph displays the positive relationship that the two variables have, as COVID-19 cases increase, so does the unemployment rate. The slope of this graph also appears to be relatively large. This shows a likely large impact to unemployment caused by the entrance of the COVID-19 virus during 2020. Graph 4.6 gives a general idea of how the unemployment rate moved in 2020 and how COVID-19 cases changed alongside. Both began to rise around March of 2020, but the unemployment rate reaches its peak in May then begins to decline while COVID-19 cases continue to increase until a peak in July. This graph demonstrates that while there may be a relationship between the two variables, it is not an incredibly close relationship.

This finding supports the idea that the unemployment rate reacts much more to policy and changes in demand resulting from the COVID-19 pandemic rather than the cases themselves.

The final piece of results come from Equation 3.5. After including the coefficients for oil production in each part of the equation, the result was 0.0017. This result shows that my regression model explains very little of the change in unemployment that comes from COVID-19 cases within Texas. This also fits with the hypothesis that much of the impact to the unemployment rate comes from responses to the COVID-19 pandemic, rather than the existence of the cases themselves.

5. CONCLUSION

In conclusion, the data shows an economically significant correlation at the 99% confidence level between all the main variables analyzed in every time period used. Those being oil price, oil production, and COVID-19 cases. Oil price and oil production have negative relationships with unemployment rate, meaning that as oil price and production increase, the unemployment rate decreases. A 1% increase in oil price correlates with a 0.4% decrease in the unemployment rate and a 1% increase in oil production correlates with a 0.1% decrease in the unemployment rate. The likely explanation for this result is that when oil prices increase, oil producing companies can reap a higher profit from the sale of oil, meaning there is more money for the expansion of the oil industry and an increase in available jobs. For oil production, the logical explanation is more obvious. As oil production increases, more labor is needed to produce the oil, leading to a decrease in unemployment as hiring increases within the oil industry.

COVID-19 cases, however, revealed a positive relationship. A 1% increase in COVID-19 Cases is correlated with a 0.3% increase in the unemployment rate. Using Equation 3.5, I find that of the 0.3% increase, 0.0017% is attributable to decreases in oil production. When looking at the relationship between COVID-19 and unemployment rate, unemployment rate seems to respond more to government action taken in response to COVID-19 (lockdown, social distancing) than the number of COVID-19 cases. This is shown by the large spike in unemployment starting in March, when many lockdowns began. Afterwards, the unemployment rate stabilizes more even with a larger spike in COVID-19 cases later in the year.

When comparing the results coming from different time periods. The dates of 1990-2019 and 1990-2020 end up having very similar results. When looking specifically at 2020, however, unemployment rate becomes much more responsive to oil price. Possible explanations for this would be that employment is more unstable in 2020, causing minor changes to have larger effects on the unemployment rate. Another possibility is that the smaller sample size of one year cause the results to seem larger.

The motivation behind this research was to determine if oil price had a significant effect on unemployment rate for all industries within Texas. Further, I wanted to find out if this relationship was changed by the introduction of the COVID-19 virus. From the analysis done in this paper, the connection between oil price and unemployment rate was found to be statistically significant and negative. However, more research is needed to identify causation and to understand more about the relationship between the two variables. The other important variables in the analysis were oil production and new confirmed COVID-19 cases. Which were found to be statistically significant with negative and positive relationships, respectively. When looking at the introduction of COVID-19 into the analysis. The data shows a large change in the oil price's regression coefficient when looking at 2020 separately from the other time periods. For future research, the reasoning behind this change in relationship should be investigated more closely. This paper's contribution to the field of research is the identification of the relationships between these variables and how they have changed in 2020.

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