An Analysis of Okun's Coefficient During the Great Recession in the United States

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March 11, 2020

Abstract:

This study investigates the variability of the relationship between economic growth and unemployment over the course of the Great Recession in the United States. The study uses output and unemployment data from 1996 to 2019. The time period was split into two sub-periods, pre-recession (1996-2007) and post-recession (2008-2019). The coefficient for output growth as it relates to unemployment was estimated for all three periods and compared. This study concluded that there is a significant negative relationship and no variability of the coefficients across different business cycles surrounding the Great Recession.

1) Introduction:

Following the Great Recession in the United States from late 2007 to mid-2009, the unemployment rate continued increasing until the end of 2009, two quarters after the end of the recession. This phenomenon is known as a "jobless recovery", which follows a recession and implies that the current labor force's production capacity increases as fast or faster than output (Levine, 2013). In other words, a "jobless recovery" is a period of time where the growth of real GDP is positively correlated with the change in unemployment. This counters the significant negative relationship observed by Arthur Okun (Okun, 1962).

Okun's law is an empirically observed relationship between output growth and the unemployment rate. Okun's coefficient is the degree to which output growth affects changes in unemployment and is widely accepted to be negative. Due to the fact that the "law" was empirically observed and not derived from theory, it is subject to speculation during times of "jobless recoveries" or unexplained variability in the unemployment rate. This speculation prompts the question, is Okun's observation variable across different business cycles in the United States? In particular, is Okun's law variable during the Great Recession?

Okun's law has been used by the media, teachers, students, and others for estimating short-term changes in the unemployment rate. These estimations may be flawed or misleading if Okun's coefficient is variable according to economic conditions. If there is variability in Okun's law over different business cycles, it would be useful to know for future use of the law as a forecasting and prospective analysis tool.

There has already been testing and revision of Okun's law outlined by economic literature. There is a contrasting view of the law's variability over the business cycle. Ball,

Leigh, and Loungani (2013) and Owyang, Sekhposyan, and Vermann (2013) determined that there was no significant variability of Okun's law during the Great Recession. Özel, Sezgin, and Topkaya (2013) concluded that there was variability of Okun's law during business cycles. A goal of this study is to add to the literature by taking a side.

The analysis in this study determined that there was not a significant difference of Okun's coefficient before and after the Great Recession in the United States. This result agrees with the result of Ball, Leigh, and Loungani (2013) and Owyang, Sekhposyan, and Vermann (2013). The results did confirm the significant negative relationship between output growth and unemployment outlined by Okun. Although Okun's coefficient was not variable during the Great Recession, it can be concluded that the relationship between the change in unemployment from the preceding period and the current period's change in unemployment increased in strength after the start of the recession.

2) Literature Review:

A majority of literature relating to the relationship between unemployment and output are in reference to Okun's law (Okun, 1962). Okun empirically observed an inverse relationship between output growth and changes in unemployment. Okun observed that each extra percentage point above 4% unemployment, has been associated with a 3% decrease in Gross National Product (Okun, 1962). This "law" was derived empirically, not from theory, therefore has been subject to test and revision.

Okun's law was revisited and updated by Knotek (Knotek, 2007). Knotek outlined the three specifications of Okun's law, gap, difference, and dynamic versions. Knotek used the difference and dynamic version of the law to estimate Okun's coefficient using all available data following WWII. Knotek notes that the gap version uses controversial assumptions in defining and calculating potential output, therefore the difference and dynamic versions of Okun's law were applied. Knotek analyzed Okun's law across several business cycles and concluded that there is variability in the law over time and that unemployment's reaction to changes in output are lagged (Knotek, 2007).

Following Knotek's updates of Okun's law (Knotek, 2007), most of the literature attempts to diagnose or explain different variabilities in the law. The goal of this paper is to test the variability of Okun's law after the Great Recession in the United States. The literature addressing the subject breaks down into two buckets. First, the variabilities across physical space. Second, the variabilities across time and business cycles.

Malley and Molana used quarterly data for G7 countries between the years of 1960 to 2001 and found that the relationship between economic growth and unemployment was more significant in Germany than other G7 countries (Malley, Molana, 2008). Later Owyang, Sekhposyan, and Vermann (Owyang, Sekhposyan, Vermann, 2013) completed a state-by-state estimation of Okun's law. They concluded that there was variability of Okun's law in different states, and that large transitory fluctuations in either unemployment or output growth could be the cause for some states having lower correlation with output growth and unemployment. Both studies determined that there is a degree of instability of Okun's law across physical space. This paper only uses data from the United States as a whole.

There are many studies world-wide that address variability of Okun's coefficient across business cycles. Novák and Darmo used panel data/ GMM to estimate Okun's coefficient in the European Union (Novák. Darmo, 2019). Their study estimated Okun's coefficient from 2001-2014, later splitting that time period into two sub-periods, 2001-2007 and 2008-2014. They concluded that the relationship between change in unemployment rate and GDP growth was stronger in the 2008-2014, "post-crisis" period. They also concluded that despite the strong relationship, economic growth needs to be high to induce a fall in unemployment (Novák, Darmo, 2019). This study uses similar methods to Novák and Darmo, applying them to the United States as opposed to the European Union.

In a study carried out by Grant (Grant, 2017), the time variability of Okun's law was tested. Time variation is the ability to remember historic perspectives. Grant used the gap version of Okun's and found substantial time variation in Okun's in the US since the Great Recession. She concluded that the probability that Okun's coefficient is equal to the widely accepted coefficient of -2 fell dramatically during the Great Recession, but has risen since the economy has recovered (Grant, 2017).

Özel, Sezgin, and Topkaya analyzed the relationship between the unemployment rate and output was estimated for G7 countries. The study broke up the time periods into pre-crisis, 2001-2007, and post-crisis, 2008-2011. They found that productivity and economic growth have significant and strong effects on the reduction of unemployment in the pre-crisis period, the effect of productivity becomes insignificant and small after the crisis, and the effect of economic growth as a decreasing effect over the unemployment continues and increases over time (Özel,

Sezgin, Topkaya, 2013). The result of variability over business cycles is contradictory to the findings of Ball, Leigh, and Loungani (2013) and Owyang, Sekhposyan, and Vermann (2013).

In addition to their findings involving state-by-state differences in Okun's coefficient, Owyan, Sekhposyan, and Vermann analyzed Okun's coefficient over business cycles. They concluded that the estimated coefficient during expansions was 0.16, while it was 0.17 for periods of recession. These results indicate that there was no clear difference in Okun's coefficient during different stages of the business cycle. In addition, they found that the intercept values were lower in periods of expansion than in periods of recession (Owyang, Sekhposyan, Vermann, 2013). Ball, Leigh, and Loungani analyzed unemployment rate and output data from 1948-2013. They concluded that Okun's law is a strong and stable relationship in most countries and that the relationship did not change significantly during the Great Recession (Ball, Leigh, Loungani, 2013). To conclude, the literature demonstrates a contrasting view of the variability of Okun's coefficient over different business cycles. The goal of this paper is to estimate Okun's coefficient over the business cycle in order to address the contrasting results of the variability across business cycles.

3) Data and Methodology:

In order to analyze the behavior of Okun's coefficient during different business cycles, this study used quarterly data of economic output and the unemployment rate in the United States, and compared the relationship in several time periods. The total time period spanned from the second quarter of 1996 to the third quarter of 2019. The total time period was then split into two equally

sized sub-periods. The first sub-period, pre-recession, spans from the second quarter of 1996 to the end of 2007, marking the start of the great recession. The second sub-period is the post-recession period which spans from the first quarter of 2008, the start of the great recession, to the third quarter of 2019, the most up to date real GDP data at the time of completing this study. Both sub-periods are 47 quarters in duration, adding up to 11 and ¾ years years each.

This study used Real Gross Domestic Product (real GDP) as the economic output metric because it is a more accurate representation of production levels spanning several time periods. Also, Knotek used real GDP in the updated version of Okun's law (Knotek, 2007). The quarterly unemployment rate used in this study is the average of the 3 separate month's unemployment rate in each given fiscal quarter. The data is described in the table below.

Table 1: Variable List

Variable	Description	Source
Real Gross Domestic Product	Billions of chained 2012 dollars, quarterly, seasonally adjusted	FRED
Unemployment	Three-month average unemployment rate for given quarter (%)	FRED

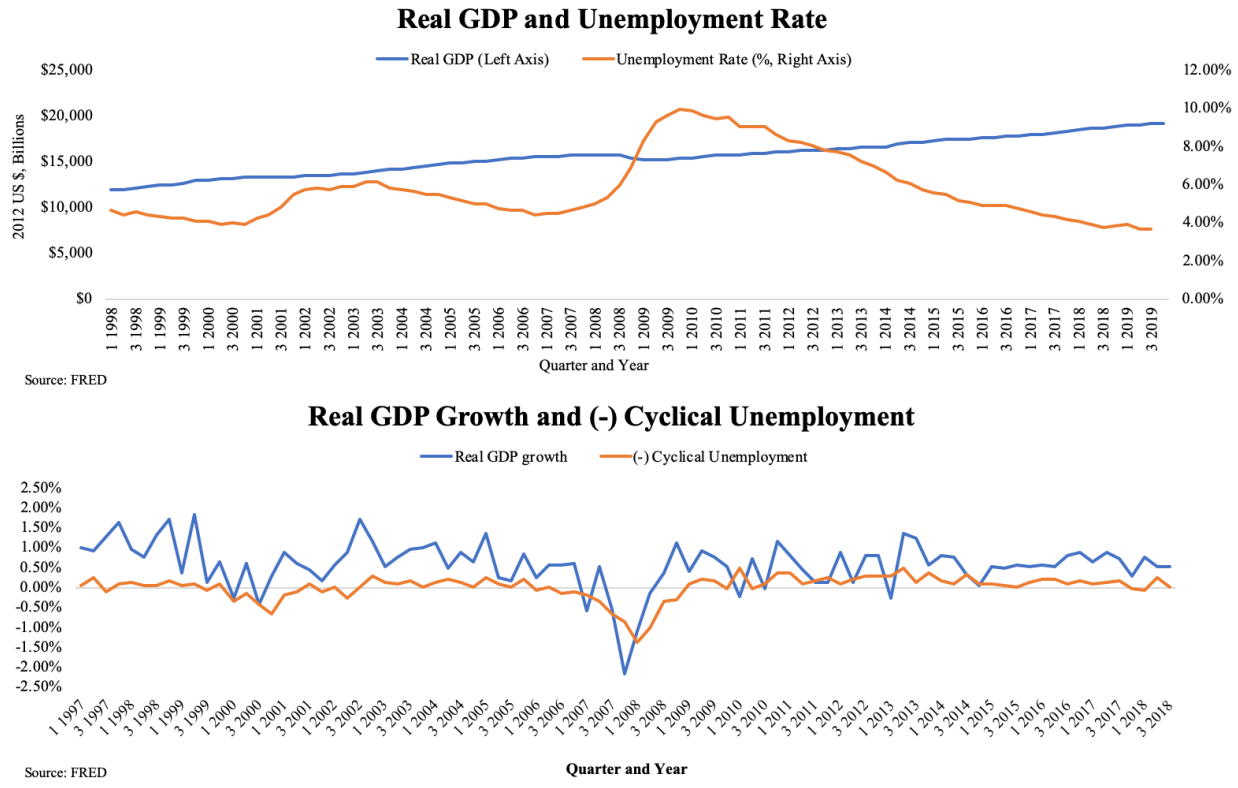
Real GDP and the unemployment rate do not have an immediately obvious relationship. This study used Knotek's difference version of Okun's law (Knotek, 2007). In order to use the difference version, cyclical unemployment (dUR_t), or the difference in unemployment from one period to another, and real GDP growth ($gGDPt$) must be calculated. The results of these calculations are summarized by the following table.

Table 2: Descriptive Statistics

Variable	Equation	Mean	Median	Max	Min
d_UR	UR_t-UR_{t-1}	-0.01%	-0.10%	-0.47%	1.40%
gGDP	(GDP_t-GDP_{t-1})/ GDP_{t-1}	0.57%	0.62%	-2.16%	1.83%

When using the difference version to analyze the relationship between change in unemployment and growth of real GDP (Knotek, 2007), the overall relationship between unemployment and output increases in clarity. The following figure demonstrates that increased clarity.

Figure 1: Relationships between Real GDP and Unemployment



In the top graph of Figure 1, the relationship between real GDP and the unemployment rate isn't clear. The bottom graph in figure one demonstrates that cyclical unemployment and real GDP growth may be negatively correlated. Note, the bottom graph in Figure 1 is displaying the negative of cyclical unemployment.

Following the updated version of Okun's law outlined by Knotek (Knotek, 2007), the difference version of Okun's law is expressed as:

$$\Delta UR_t = a + b(gGDP_t) \quad (1)$$

This equation was updated for purposes of this study by using a lagged variable of the change in unemployment. This was done to account for the delayed reaction unemployment has when GDP changes (Knotek, 2007). The final equation used in this study can be rewritten as:

$$dUR_t = a + \beta_1^*(gGDP\,t) + \beta^*_2\, dUR_{t-1} + u_t \quad (2)$$

Where dUR_t is cyclical unemployment at time t, a is the constant, and gGDP is the percent growth in real GDP from time period t-1 to t. In this study, β_1^* signifies the strength of the relationship between growth in real GDP and the change in unemployment, otherwise known as Okun's coefficient. The lagged variable, dUR_{t-1}, is the change in the unemployment rate from t-2 to t-1, and its given coefficient is β^*_2. The final variable, u_t, is the error term.

This study did not use simple ordinary least squares regression (OLS) in the analysis for several reasons. First, there are not enough predictor variables in the model. Growth of real GDP is not the only factor that can cause changes in the unemployment rate. Omitting the other factors affecting changes in unemployment, such as labor productivity, wage cost, education, etc., could

cause an OLS regression to be biased. Secondly, GDP and the unemployment rate are not independent. GDP is considered exogenous, which is not true. GDP and the unemployment rate are inherently causal. (Nováк, Darmo, 2019). Changes in unemployment rate may influence volume of GDP and growth in GDP induces changes in the unemployment rate. Due to this, normal OLS could give a bias estimation. Therefore time-series generalized method of moments (GMM) estimation is proper.

Time-series GMM assumes certain moment conditions, and minimizes a certain norm of the moment conditions. In practice, GMM estimates by least squares, using every observation and adjusting the covariance matrix of the estimator. The covariance matrix is also known as the weight matrix. GMM is an efficient and consistent estimation technique that can be completed under weak assumptions (Hansen, West, 2002).

This study used the equation (2) to complete GMM estimation for Okun's coefficient from 1996-2019. Next, this study used the same equation to estimate Okun's coefficient in the pre-recession period, 1996-2007, and post-recession period, 2008-2019, and compared and contrasted the results to analyze the behavior of Okun's law over the business cycle.

4) Results and Discussion:

The unemployment rate is variable across the total time period 1996-2019. There were several peaks following the recession in 2001 and the Great Recession in 2008. These peaks in unemployment were delayed or lagged. Following the recession in 2001, unemployment didn't begin to decline until after the third quarter of 2003, after almost two years of non-negative

growth in real GDP. After the second recession, unemployment increased to 9.93% in the fourth quarter of 2009, two quarters after the end of the recession.

The defined sub-periods were chosen such that they were equal in size and used the most recent data. The most current macroeconomic data, at the time of writing this paper, is the third quarter of 2019. That is 47 fiscal quarters after the start of the first quarter in 2008. Therefore, the pre-crisis sub period is made up of the 47 quarters preceding the start of 2008. The unemployment rate at the beginning of the first sub-period, 1996-2007, was 5.3%. After several years, the United States and other developed countries entered a recession in the early 2000's, in which the unemployment rate behaved as described above. After the third quarter of 2003, there was a steady decline in unemployment until the later half of 2007 where it began to increase sharply.

At the start of the second sub-period, the unemployment rate was 5.00% and real GDP growth had already become negative, implying the onset of the recession. Unemployment increased sharply until the 9.93% peak, previously described above. Since this peak in 2009, the unemployment rate has steadily decreased to 3.63% in the third quarter of 2019, the lowest it has been since 1970.

In order to analyze Okun's coefficient over the business cycle, estimations were completed for the total period and both of the sub-periods. The results of the GMM estimation for total period, pre-recession period, and post-recession period are summarized in Table 3.

Table 3: Okun's Coefficient Estimations Using GMM and OLS

	Coefficients	Total Period (1996-2019)	p-value	Pre-Recession (1997-2007)	p-value	Post-Recession (2008-2019)	p-value
GMM	Real GDP Growth	-0.1689563	0.000	-0.1935315	0.000	-0.1791835	0.004
	Lag	0.5955085	0.000	0.4334759	0.001	0.6266572	0.000
	constant	0.0009316	0.008	0.0014518	0.000	0.0006309	0.165
OLS	Real GDP Growth	-0.1689563	0.000	-0.1935315	0.000	-0.1791835	0.004
	Lag	0.5955085	0.000	0.4334759	0.000	0.6266572	0.000
	constant	0.0009316	0.001	0.0014518	0.001	0.0006309	0.113

This study chose to include an OLS estimation, similar to Ball, Leigh, and Loungani, (Ball, Leigh, Loungani, 2013) and Owyang and Sekhposyan (Owyang, Sekhposyan, 2013) to double check the results. The coefficients outlined in Table 3 are exactly the same for GMM and OLS. This suggests that the model is “exactly identified”. This means that the number of equations is exactly the same as the number of non instrumental coefficients. Therefore the weight matrix has no impact on the value of coefficient that minimizes the objective function (Drukker, 2015). Simply put, the weight matrix is the identity matrix in this study. The only distinction between the two is a few slight differences in significance of the coefficients.

The predictor Real GDP Growth was negative and significant in the whole period and the two separate sub-periods. This confirms the negative relationship found in Okun (1962). The coefficient for the entire period can be rounded to -0.17, meaning that a 1% growth in real GDP will cause a 0.17% decrease in the unemployment rate on average.

Both sub-periods coefficients were similar to the whole period. The coefficient for Real GDP Growth in the pre-recession period can be rounded to -0.19. This is a slightly larger impact than in the entire period, suggesting a 0.19% decrease in the unemployment rate if real GDP

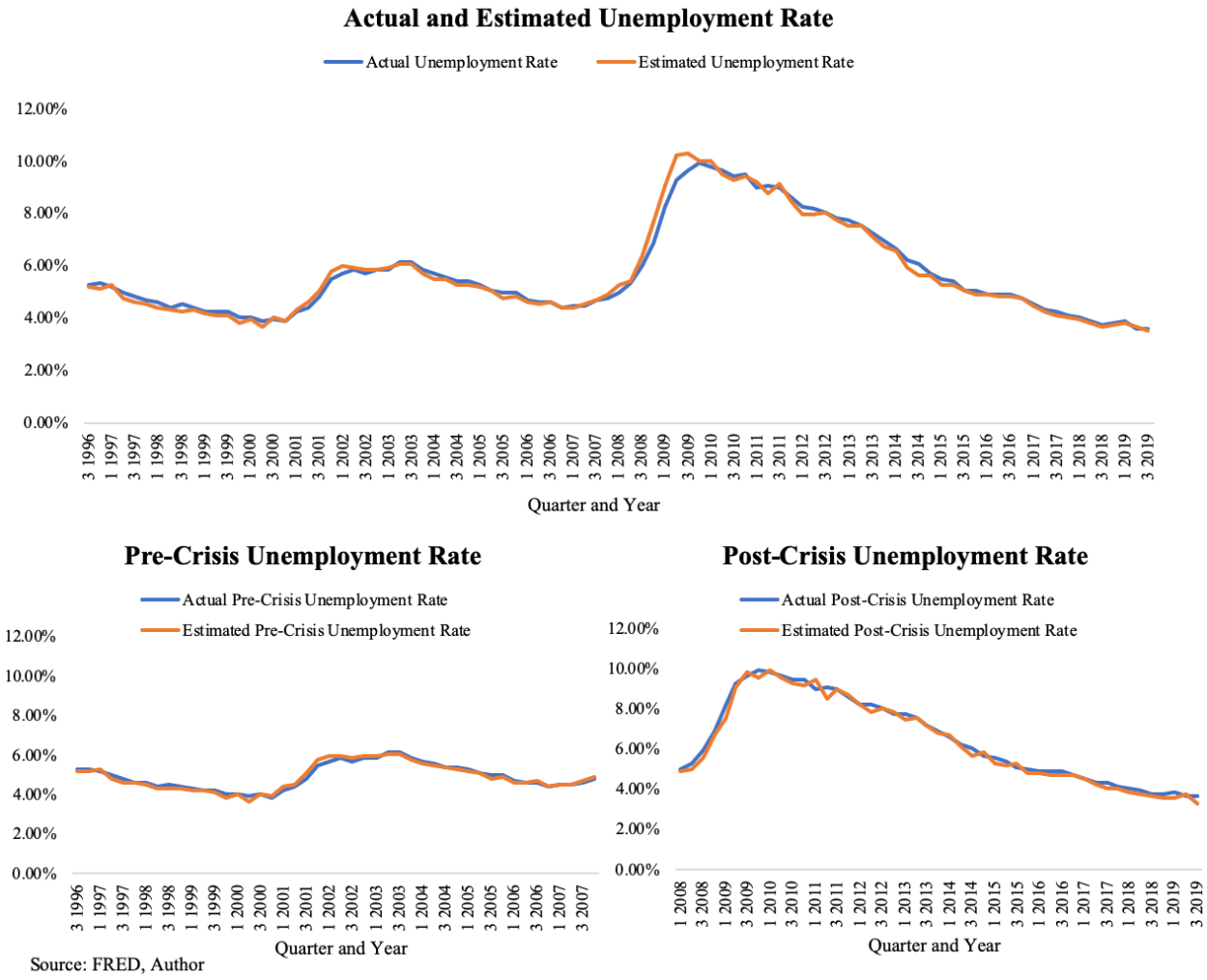
were to grow 1%. The Okun coefficient in the post-recession sub-period can be rounded to -0.18. This result is similar to the other two coefficients. A 1% growth in real GDP would imply a 0.18% decrease in the unemployment rate. These three resulting effects of real GDP growth on unemployment are consistent with the results found by Owyang, Sekhposyn, and Vermann (Owyang, Sekhposyn, Vermann, 2013), which state that there was no large variability of the coefficient across business cycles.

A separate result that is similar to what Owyan, Sekhposyn, and Vermann found when analyzing the relationship with the intercept. While the Okun's coefficients were all similar, the constant in the pre-recession period was higher than in the total period, .0014518 and .0009316 respectively. The pre-recession constant is much larger than the total period constant. In other words, the unemployment rate increases more in periods of stagnant output growth in the pre-recession period. The post-recession constant has a p-value of 0.165, making it insignificant in this study, therefore no interpretations can be made.

Lastly, the lag variable (dUR_{t-1}) was positive and significant for both sub-periods and the entire time-period. For the whole period, the previous quarter's cyclical unemployment has a coefficient of 0.60. This suggests that for every 1% change in the previous quarter's cyclical unemployment there is an average increase of 0.60% in unemployment in the given current quarter. The pre-recession period's lagged unemployment coefficient was 0.43 which is less than the post-recession coefficient of 0.63. This result implies that the previous quarters change in unemployment has a greater effect on any given quarter's change in unemployment after the recession.

The fit of the estimates is illustrated in Figure 2, where the estimated unemployment rate is layed over the actual unemployment rate for all three separate time periods.

Figure 2: Actual vs. Estimated United States Unemployment Rate



Source: FRED, Author

The estimation has a similar path over time compared to that of the actual unemployment rate, demonstrating the relevance of the estimations and results. The figure also demonstrates that separating the pre-recession and post-recession time periods limits deviations of the estimate from the actual data. The estimation deviates from the real unemployment rate most during times

of rapid expansion and contraction. The model typically overestimates the change in unemployment rate during times of output expansion and contraction. During expansion, the estimated unemployment was lower, painting a brighter picture than reality. On the other hand, during recessions, the estimations of unemployment were larger, a more negative view of unemployment than reality.

In all, the relationship between real GDP growth and cyclical unemployment in the United States remained stable throughout the different business cycles. The separating factors between the pre-recession and post-recession periods are the constant and the effect of the previous quarter's cyclical unemployment. Both of these distinguishing factors render the post-recession period better off. The constant in the whole period is lower, suggesting that with stagnant economic growth the unemployment rate increases more during the pre-recession period than the whole period. The coefficient of the lag is larger in the post-recession period, implying that previous quarter's unemployment growth will have a larger increasing effect on the given current periods growth.

The goal of this study was to estimate Okun's coefficient during different business cycles to analyze whether or not there was any variability. There was no significant variability in Okun's coefficient for the chosen time periods.

Some drawbacks of this paper are the amount of data and the time split. The goal of this study was to analyze the variability of Okun's coefficient for only the United States, which limits the amount of data to quarterly data from a single place. Other studies use panel data that includes various countries to test variability of Okun's law, increasing the amount of available data. Secondly, there is only one time split at the beginning of the Great Recession. There are

two business cycles included in the post-recession period. There is the actual recession and the recovery period starting in 2009. The results may have been different if this study chose to conduct estimations of Okun's coefficient for three equally sized sub-periods that were pre-recession, recession, and recovery.

5) Conclusion:

This study used quarterly data from 1996 to 2019 to analyze the relationship between the unemployment rate and growth of real GDP in the United States. This study first estimated Okun's coefficient for the whole period, later splitting the time period into two sub-periods, pre-recession and post-recession. The resulting estimations demonstrated that the Okun's coefficient was not variable in the different sub periods. The total period, pre-recession, and post-recession had Okun coefficients of -0.17, -0.19, and -0.18 respectively. This result is consistent with those found in Owyang, Sekhposyan, and Vermann (Owyang, Sekhposyan, Vermann, 2013). The differences in the estimations for the given sub-periods were the intercept value and the coefficient for the lag of cyclical unemployment.

In order to further this research, economists may analyze several different factors. First, estimate the time parameters for "jobless recoveries" and analyze Okun's coefficient on a short term basis, surrounding several recessions. The time splits could be dynamic and the analysis could optimize the degree of variability in Okun's coefficient. Second, a researcher could estimate the behavior of Okun's coefficient at different stages of economic development. The second study would seek to answer questions such as the following. How does Okun's law hold

in developing versus developed countries? What is the level of economic development or maturity necessary for Okun's coefficient to be stable?

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