2017

The Application of the Phillips Curve in Developed and Developing Countries

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By

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A Thesis Submitted to

Department of Economics

Skidmore College

In Partial Fulfillment of the Requirement for the B.A Degree

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May 2, 2017

Abstract

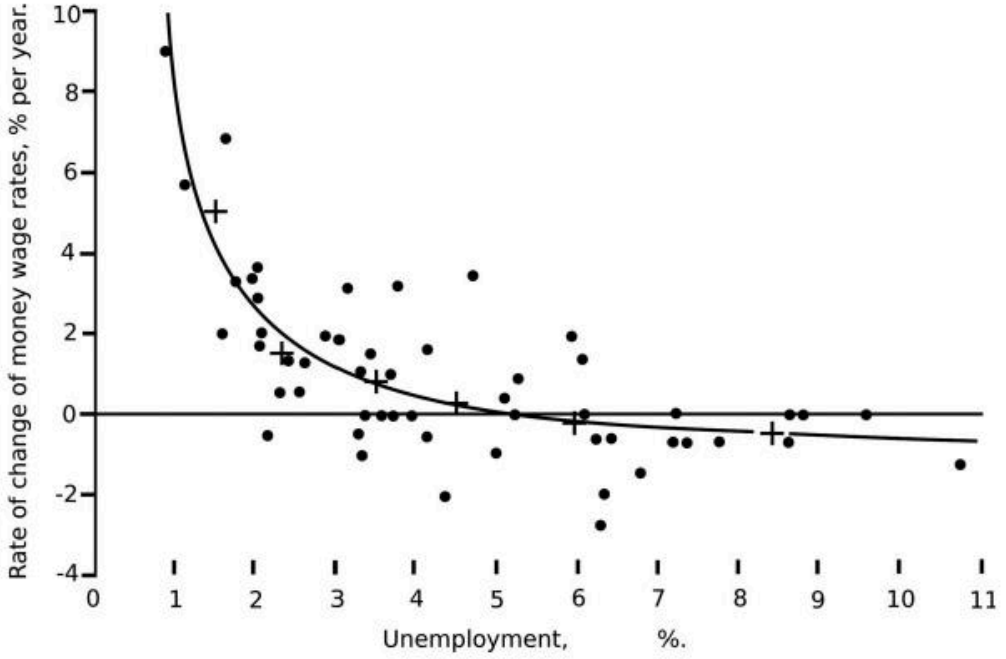
This research utilizes data drawn from multiple government sources regarding unemployment, consumer price index (CPI), GDP, and industrial productivity from Colombia, Japan, and the United States. The research seeks to identify common trends and characteristics of the Phillips curve by applying the Phillips curve to both developed economies, like the United States and Japan, and also developing countries like Colombia. The results suggest that while there are similarities within economies, like the inflation and unemployment comovement in the United States, each economy must be viewed and analyzed independently. There were no findings indicating that there are common differences of Phillips curve when categorized by the stage of development of a particular economy. The findings indicate that the Phillips curve still exists in certain economies, and does not in others; additionally, they indicate that the inverse correlation between inflation and unemployment continues to weaken.

I. Introduction

Central banks from advanced economies around the globe are required to make difficult monetary policy decisions on a regular basis. In order to do this, they rely on complex econometric models that are designed to replicate economic conditions and shocks to see how different sectors will react, and what policy to enact to help correct for said shocks. In addition to these models, they consider relationships between certain economic metrics that history has shown to be true over time such as the Phillips curve and the Taylor rule. The Phillips curve, which is the inverse relationship between inflation and unemployment, has come under fire by economists in the years following the financial crisis. It has been condemned as no longer being a relevant relationship to help judge the state of an economy and subsequently help guide economic policy. For some time now, economists at the United States Federal Reserve have discussed a flattening of the traditional Phillips curve. Some believe that it dates back to the 1980s, while others, blame the change in the Phillips curve on more recent factors such as an aging labor force and a slowing in productivity.

In 1958 A.W. Phillips was tracking wage changes and unemployment in the UK from 1861 to 1957 and found there was a stable inverse relationship between the two. As Farmer writes, "When unemployment was high, he [Phillips] argued that there was an excess supply of labour that put downward pressure on money wages. When unemployment was low, he argued that there was an excess demand for labour, leading to upward pressure on money wages" (Farmer 2013). Phillips separated his data into three sub-periods: 1861-1913 before the onset of WWI, an interwar period from 1914-1947, and finally post war from 1948-1957. On the X-axis he charted the unemployment as a

percentage and on the Y-axis he plotted the rate of change of the monetary wage rate as a percentage each year. He found that in years with low unemployment there was a high rate of change in the monetary wage rate; the opposite was true for years where there was high unemployment. All data points seemed to fall along an "L" shaped curve for each of the sub periods, which drew the attention of economists globally.



(Schwarzer, 2012)

Phillips' theory was revised in 1960 when Samuelson and Solow focused in on the relationship between inflation and unemployment instead of changes in money wages. Since the discovery of this relationship, economists have begun to see the Phillips curve as the missing piece that could connect the short run and long run with respect to Keynes' belief in 'sticky' prices and wages. Furthermore, central bankers have paid very close attention to this relationship when considering economic policy (Schwarzer, 2012).

The United States Federal Reserve is tasked with overseeing the U.S. economy and implementing economic policy that adheres to guideposts laid out in the Federal

Reserve Act's dual mandate – to maximize employment while stabilizing prices. While the Federal Reserve has become more data driven incorporating numerous econometric models that are helpful for projecting the effects of different economic policy, the Phillips Curve equation directly addresses the relationship between economic output, which can be captured by unemployment data, and inflation. Because these are the two pillars of the dual mandate, Federal Reserve bankers, historically, have paid careful attention to the Phillips Curve; however, more recently some have begun to question its current validity in developed and emerging market structures. The Federal Open Market Committee (FOMC) members, such as Lael Brainard, for example, have drawn attention to the fact that the U.S. economy has been near full employment (maximum output) while also experiencing historically low inflation. Put simply, the Phillips Curve seems to be flattening, and while the reasons for this are still up for debate, Brainard has argued that there is a 'new normal' that FOMC members must consider when making policy that adheres to the dual mandate going forward (Brainard, 2016).

The model used to conduct this research closely mimics Coibion and Gorodnichenko's (2015) model which helped them consider why there was missing disinflation that was predicted by the Philips curve in the aftermath of the most recent United States recession. Data was gathered on unemployment, CPI, GDP and industrial productivity to help identify other economic factors that may effecting what has traditionally been an inverse relationship. In order to expand the area of research, these data points were collected for Colombia and Japan in addition to the United States. This was done to see if any characteristics considered had a unique effect on they type of economy, that is, a developed economy like Japan and the United States, or a developing

economy, like Colombia. The results indicate that consistency exists within the same economy over a given time period, but do not indicate that these consistencies transcend different economies depending on if they are developed or not. Furthermore, results indicate, Coibion and Gorodnichenko (2015) suggest in their search for missing disinflation, that in the United States there no longer exists an inverse relationship but rather a comovement between inflation and output.

Results indicate that while inflation and unemployment now move together in the United States the more traditional inverse relationship may still hold in both Colombia and Japan. This could be due to a slue of factors unique to each country's economy, but various possibilities must be discussed and considered including Japan's top heavy age distribution, natural volatility in a developing country and its effects on economic growth, and an increase in American saving habits as well as a slowdown in workforce productivity.

This paper builds upon literature on the Phillips curve centering on both the impacts of the global financial crisis in the United States and abroad as well as incorporating data from a developing economy in Colombia to offer a comparison. While research has been done on the current state of the Phillips curve and whether it remains relevant in the post crisis era, nobody has explored whether there are characteristics unique to developing economies that may effect the shape of the Phillips curve when compared to advanced developed economies. By comparing both the shape of the Phillips curve as well as identifying characteristics that may be unique to a specific economy this research aims to help draw monetary policy conclusions around the use of the Phillips curve in developed and developing countries. This paper's builds on he

current literature discussing whether the Phillips curve remains relevant in today's economic environment, which results indicate that it is, but in a different capacity, and goes further to consider whether the stage of development an economy is currently in has any effect on the shape of the Phillips curve compared to that of a developed economy.

Results from this study add to the growing body of literature suggesting that the Phillips curve is not relevant in the same way that it was when the relationship was initially discovered by A.W. Phillips. Results from the United States indicate that the Phillips curve no longer remains an inverse relationship with the coefficient for unemployment being 0.103 and significant at the ten percent level. When this variable was lagged the coefficient to 0.0280 and became insignificant, but a positive coefficient for unemployment helps to validate Blanchard (2016) paper where he discusses a gradual flattening of the Phillips curve over time. As can be seen in the summary statistic tables for each of the countries, the sample sizes for each country vary, however they offer some insights into the consistency of the data as well as the stability of the respective economies over time. One example of this is in Table 6 for the United States inflation remaining steady around the Federal Reserve's two percent target with a mean value of 2.15 percent with a standard deviation of 1.10 between 1997 and 2015. This stability is remarkable considering the highs of the .com boom and the lows of the financial crisis that occurred during this time period. It is especially impressive when compared to Colombia, which had a mean value of 4.56 percent with a standard deviation of 1.68 percent for a similar period of time. These comparisons are consistent throughout most of the variables, and are a sign of the developing state of the Colombian economy and the developed and more stable state of the United States economy.

This paper is organized as follows; the second section contains a thorough review of literature on the Phillips curve in the United States as well as work that has been done on the Phillips curve in developing countries. The third section introduces the both models and explains the variables used. The fourth section discusses the dataset and is followed up by the fifth section on results. The sixth section is a discussion of results and policy implications, and is followed by concluding remarks including limitations and areas for extension of the research conducted.

II. Literature Review

This paper organizes the literature into two key arguments. First, economists have argued that over time our inflation expectations have become more anchored therefore inflation does not fluctuate as it once did because it is less dependent on output. The second argument builds on the first focusing less on anchoring tendencies around inflation and expands this exploration to the economic slowdown and the new relationship between output and inflation. Economists can agree that today the Phillips curve is much more flat than it once was with most of the flattening occurring before 1990. This means that the Phillips curve can no longer be evaluated by the same standards it once was. These two points of research are critical to understanding the 'New Normal' Lael Brainard has discussed with regards to the ongoing relationship between output and inflation embodied within the Phillips Curve. Finally, this literature on developed economies, specifically focusing on the United States during its most recent recession, is contrasted to work done on the existence of the Phillips Curve on developing economies.

Inflation Expectations and Anchoring Bias:

Coibion and Gorodnichenko (2015) address key questions economists have been asking about the relevance of the Phillips curve during and after the great recession. The Phillips curve, which stipulates that in times of high unemployment there will be low levels of inflation, has seemingly lost its applicability in developed economies, and the Coibion and Gorodnichenko (2015) paper addresses some potential reasons for this, using United States state level data. During 2008 and 2009 in the midst of the global financial crisis the U.S. unemployment rate skyrocketed reaching a high of 10 percent in October of 2009. However, despite this high rate of unemployment, there was not downward pressure on prices of the same magnitude that the Phillips curve suggests there should have been. In their paper, Coibion and Gorodnichenko (2015) explore hypotheses put forth by economists trying to pinpoint where this lack of disinflation stems from. One suggestion that has been discussed at length by U.S. Federal Reserve Bank presidents is that the Phillips curve has flattened naturally overtime. The authors dismiss this theory partially. They argue that because there were no structural changes in the U.S. economy during the economic crisis and because the changes in unemployment and inflation were not proportionally similar to the flattening of the Phillips curve over time that this is not the primary cause.

One idea they suggest is based on data from the Michigan Survey of Consumers. They find that while experts anchor their inflation expectations on forward guidance from the Federal Reserve and their two percent inflation target that consumers have traditionally higher inflation forecasts that are much more closely tied to food and energy prices, specifically prices paid at the pump. Using panel data to control for different

economic factors they are able to show that consumer inflation expectations based on oil prices was responsible for the missing disinflation during the 2009 financial crisis (Coibion and Gorodnichenko 2015). A critique of this analysis is that, while the data clearly points to consumer price sensitivity at the pump to their elevated inflation expectations, this data is only for Michigan consumers. Additionally, Michigan's economy is centered on the auto industry, therefore consumers in Michigan are likely to be much more aware of the price they are paying for gas than other regions that may be less dependent on the automotive industry and gasoline to fuel their vehicles.

Coibion and Gorodnichenko (2015) extend this analysis further and suggest that consumers are not the only ones susceptible to elevated inflation expectations. They suggest that smaller businesses that do not have economists on staff responsible for projecting inflation expectations are also partially responsible for the missing disinflation pricing their goods to cover their costs and also in conjunction with other observed price increases. They argue that it was not monetary policy from the Federal Reserve that kept the United States economy from spiraling into a period of disinflation, but rather consumers and producers, to some extent, elevated inflation expectations that actually propped up inflation during the economic downturn. Finally, the authors caution that the Federal Reserve cannot count on another hike in oil prices in conjunction with the next crisis and thus we got 'lucky' that consumer's inflation expectations were artificially high. This ultimately helped to temporarily prop up the economy, and they must look for other monetary policy tools to help spark some economic activity and inflation.

Support for the argument that inflation expectations have become more anchored over the years, and therefore plays a larger role in the effect inflation expectations have

on actual inflation comes in Blanchard's (2016) paper. Like Coibion and Gorodnichenko (2015), using the Phillips curve as the foundation for the relationship between unemployment and inflation and the financial crisis as the framework, Blanchard questions why the U.S. economy did not suffer a much greater deflationary period. Paul Krugman noted, "if inflation had responded to the Great Recession and aftermath the way it did in previous slumps we would be deep in deflation by now; we aren't." (Blanchard, 2016). Through empirical analysis of previous economic crisis and the historic relationship between inflation and unemployment, Blanchard (2016) addresses Krugman and others observations offering four possibilities. The two most relevant to other literature are, first, that, inflation expectations have steadily become more anchored which has led to relation between the rate of unemployment and that of inflation rather than a change in inflation. Second, the slope of the Phillips curve, which is, the effect of the unemployment rate on inflation given expected inflation has decreased. However, he notes that most of this decline happened in the 1980s therefore is not directly correlated to the most recent crisis (Blanchard, 2016). The first argument Blanchard makes that inflation has become more anchored over the years agrees with Coibion and Gorodnichenko's (2015) argument. However, while Coibion and Gorodnichenko (2015) argue that the anchoring of inflation expectations comes primarily from consumers and their sensitivity to observed price change, Blanchard argues that the anchoring of inflation expectations comes from economists' long term inflation projections. This could be a biased opinion because these long-term inflation expectations, which are anchored to the Federal Reserve's two percent target, put forth by the Federal Reserve,

which Blanchard is a member of – thus he could be over emphasizing the effectiveness of policy that he has helped to enact.

Mazumder (2012) serves as one of the biggest motivations for this research, thus my model will closely resemble Mazumder's. This paper critiques Robert Lucas' 1976 paper argues that the Phillips Curve will not hold in the long run because there is no theoretical reason for the Phillips curve's parameters to remain the same despite the regime change. Essentially, as the philosophy of the Federal Reserve changes with the introduction of new Federal Reserve chairs, the changes in monetary policy will cause for structural breaks in the Phillips curve, whose underlying parameters remain unchanged. Lucas' paper is centered on Phelps (1967) and Friedman's (1968) findings that the Phillips curve will not hold in the long run (Mazumder 2012). In his OLS model

$$\pi_t = \mu + \Sigma\alpha_i \pi_{t-i} + \Sigma\beta_i\mu_{t-i} + \Sigma\Upsilon_i Z_{t-i} + \varepsilon_t$$

Mazumder uses the inflation rate and the unemployment gap, real output less nominal, and a supply shock variable that is a CPI for food and energy prices exclusively. Mazumder's findings show that contrary to Friedman, Phelps, and Lucas' findings there are no structural breaks in the Phillips curve during the Volcker, Greenspan, and Bernanke regimes. A key limitation of this paper is that while he shows that there are no structural breaks in the Phillips curve during those three regimes, he offers no reasoning as to why this is, and no critical response to Friedman, Phelps, and Lucas' arguments. Additionally, much of the literature talks about inflation expectations and anchoring bias, and his model does not account for this. The study may now be updated to include data from the Janet Yellen's time as the Fed chairwoman; this would include her unique monetary policy that began in 2014, which focuses primarily on adding to the Fed's

toolkit for addressing future financial crisis. This additional analysis could help to continue to validate, or challenge, Mazumder's (2012) work.

Roberts (2011) model is based on full-information techniques exploring the effects of sticky prices, the resistance to change that prices have despite changes in other economic factors, on inflation expectations. He adds to the previous models that focus solely on sticky New Keynesian models by considering price setting in the future. This consideration is one that has been explored in great detail recently by economists such as Coibion, Gordonichenko (2015), and Blanchard (2016) with their work on the effects inflation expectations have on the Phillips Curve. By exploring future price setting behaviors of firms, one is also considering price adjustments and therefore how consumers perceive inflationary outlooks (Roberts 2011). In his model Roberts (2011), like Coibion and Gordnichenko (2015), use the Michigan Survey of Consumers as well as CPI figures. While his model does not apply closely to my particular area of research, his procedures for standardizing CPI changes on a twelve-month percentage basis as a proxy for inflation is one that I will use when compiling my monthly CPI data.

New Interactions Between Inflation and Output:

Blanchard, Cerutti, and Summers (2015) add to Coibion and Gordonichenko's (2015) work by discussing the continued relationship between inflation and output. They first look at the hysteresis hypothesis that recessions have permanent effects on an economy's level of output relative to its pre-recession trend (2015). In order to do this, the authors first isolate unemployment and inflation numbers over a 50-year period looking specifically at 23 advanced economies. In two-thirds of the recessions studied they find that pre-recession trends of economic growth are greater than post-recession

pointing to the hysteresis hypothesis (Blanchard, Cerutti, Summers 2015). They continue with their research by isolating recessions caused by supply or demand shocks. On the supply side they specifically explore shocks caused by increases in oil prices and financial crisis to check for correlation between different types of shocks and pre and post recession growth rates. In both cases they find that such supply shocks will lead to lower output in the long run (Blanchard et al. 2015).

In order to better understand all the aftereffects of a recession, and perhaps the hysteresis hypothesis that their original findings point to the authors explore output trends before and after recessions. In order to control for booms that often lead to crashes the authors use the trend 2 years prior to the crisis as their proxy for growth trend before a crisis. They use a similar approach to Martin and Wilson (2015) by excluding two years prior to the recession and base the start of the estimated trend at the log real GDP two years prior to the recession (Blanchard, Cerutti, Summers 2015). The thought process for this is sound, as booms leading up to recessions are very clear inorganic growth and cannot be viewed as natural. Therefore, when extrapolating GDP trends into post recession periods, economists are more equipped to accurately forecast growth. Despite this adjustment looking at histogram distributions, all that are positive, despite different supply shocks output after the recession is lower than pre-recession trends. With this information they try to address what could be behind hysteresis and the seemingly permanent slowing of growth in post recession periods? Blanchard, Cerutti, and Summers (2015) suggest that during recessions firms do less research and development in order to save money, which permanently lowers their productivity level had there not been a recession and budget cuts not been necessary. They also propose that recessions

lead to less job creation and even job destruction that would have long-term effects on economic trends. While these hypotheses make sense, it is very difficult to isolate specific variables to empirically test because so many factors are interdependent, which was the reason for specifying the type of supply side recession between oil price hike, financial crisis, or other recession (Blanchard, Cerutti, Summers 2015). Consistent with other papers of his, Blanchard (2016) suggests that another reason for a flatter Phillips curve has been the stabilization of short-run inflation expectations since the 1970s with much of the decline happening before 1990. This is relevant, because while some have argued that the Phillips curve no longer is relevant, as the inflation fluctuations have become much more subtle as a result of targeting the relationship has become less clear cut, but Blanchard, Cerutti, and Summers conclude that, their initial hypothesis, which was that there might no longer be a significant relation between inflation and unemployment, is not supported by the data. While the Phillips curve coefficient is lower than it was up until the early 1990s, it appears to have remained stable since then. (Blanchard, Cerutti, Summers 2015).

One clear policy implication from this paper is that the unemployment gap is having a smaller impact on inflation, whether this is because of inflation targeting or not is still up for debate, but this could explain why the Federal Reserve is so slow to raise interest rates despite reaching full employment. It would be interesting to hear more about preventative monetary policy, or how to better identify bubbles as they are occurring and address the issue. The two year window leading up to a recession seems to be clear cut based on the trends done in the study, however it also seems a bit arbitrary, which could be another critique for this paper.

Many central bankers in the U.S. have proposed theories as to why the nature of the Phillips curve has changed over time, and furthermore why the relationship between productivity, and potential output may have been changed due to the Great Recession. Fernald (2014) proposes his own set of ideas for this noticeable economic slowdown that adds robustness to other literature reviewed in his paper. He centers his argument on the observation of Total Factor Productivity (TFP) defined as the amount of output that is not the direct result of labor and other inputs. Framing his argument based on a quote by Ben Bernanke in 2014 that associates disappointing productivity growth with slower economic growth in the post financial crisis period. He adds to this by arguing that the slowdown leading up to and after the Great Recession was due to the slowdown in sectors that produced and use information technology intensively (Fernald 2014). He argues that the general productivity slowdown was not due to the housing or financial bubbles often associated with the Great Recession, but rather the slowdown experienced in IT intensive industries. Examples of this would be innovations in the early 2000s that helped business streamline inventory control and supply chains as microprocessors became more efficient. He points to this slowdown occurring well before the Great Recession as further proof of this argument.

Taken at face value Fernald's methods do not closely apply to my study, but his research adds robustness to questions surrounding the relationship between output, unemployment, and productivity. Much has been written about a productivity slowdown and the technology boom, but this paper takes a closer look and gives real-world examples and implications for this slowdown in productivity along with helping to

reinforce Blanchard, Summers, and Cerutti's (2015) case for reduction in innovation during times of crisis helping to contribute to a perpetually lower level of TFP.

Like the U.S., many economists in the European Union and the Eurozone have noticed structural changes in the Phillips curve surrounding the lack of influence output has on inflationary pressures. In a working paper for the IMF, Andrle, Bruha, and Solmaz (2013) argue that there remains a relationship between inflation and output. By isolating different factors contributing to inflation via a trimmed mean CPI, a weighted median inflation, and a CPI excluding food and energy prices, much like Mazumder (2012) and others have used, they find that inflation and output move together with the business cycle with a roughly one month lag. They are slower to dismiss the relevance of the Phillips curve, and argue that because of its close correlation to the business cycle in the Euro area that demand factors will play a large factor into future comovements between inflation and output. This paper closely mirrors much of the work done by economists exploring the Phillips curve's continued relevance, or lack thereof, in the U.S utilizing CPI less food and energy prices as one measure of inflationary pressures. They deviate from previously reviewed literature exploring different contributing factors for inflation. They draw a correlation between the role demand shifts play in the business cycle, and use this as the basis for exploring ways in which the business cycle influences the comovement of inflation and output. While this is an interesting argument, there has not been additional literature about the link between demand shocks' effects on the Phillips curve in the U.S. thus it is difficult to draw further policy implications from their work. It would, however, be interesting to use their approach of dissecting different

inflationary factors and apply it to anchoring biases and targeting as an added layer to the Coibion and Gordonichenko (2015) exploration of consumer inflation outlook bias.

Phillips Curve in Developing Economies:

Compared to large developed countries that have countless capital inflows and outflows, smaller developing countries offer much different characteristics of the Phillips curve as the interaction between output, unemployment, and inflation is much different. One such open developing economy that has been studied is the Dominican Republic. In her paper Cruz-Rodriguez (2008) shows empirical evidence using data from the Central Bank of the Dominican Republic of the Phillips curve's existence in developing open economies. Using a traditional framework where actual inflation is on the left side of the equation and expected inflation, real, and natural unemployment are on the right along with a supply shock variable, oil prices as many others use, Cruz-Rodriguez (2008) is able to show a positive and significant co-movement between the output gap and inflation. Furthermore, she is able to identify that the Dominican Republic's Phillips curve is characterized by strong excess demand while inflation is negatively correlated with the unemployment gap. Cruz-Rodriguez (2008) suggests that results indicate that supply factors play the biggest role in determining the inflation rate (Cruz-Rodriguez 2008). To be able to identify exact supply side changes and their effects on inflation is one major advantage of exploring developing economies within the context of the Phillips curve. Furthermore, her findings are in line with other economists that suggest that supply side shocks do have a significant impact on inflation, and more specifically, the findings are in line with Coibion and Gorodnichenko (2015) who were able to associate anchoring biases of prices paid at the pump with upward inflationary pressures.

Dammak and Boujelbene (2009) conduct a study on the presence of the Phillips curve in Tunisia did another very similar study to Cruz-Rodriguez. As an emerging economy, Tunisia has struggled from perpetual high unemployment and moderate inflation due to restrictive monetary policy (Boujelbene & Dammak 2009). In addition they note that some of the inflationary waves are due to variations of production costs that reflects consumption heavily influenced by the exchange rate (Boujelbene & Dammak 2009). In their model they use nominal wage growth rate, the unemployment rate, the expected inflation rate and the labor productivity growth rate and show that, despite what some economists have claimed, that the Phillips curve remains relevant in emerging economies. They suggest an area of further research would be to examine other developing African and Asian countries that have different social and economic backgrounds. While this research is certainly relevant, limitations in studies on developing economies arise due to the lack of perfect information. One characteristic of developed economies is that there are checks and balances and there is generally less corruption in developed economies. This corruption can cause skewed or manipulated inflation and unemployment numbers that are meant to paint a better economic picture than actually exists. This shows that the continued study of the Phillips curve within the context of emerging markets is an important area to go further to identify specifically different supply and demand factors that could effect the co-movement of inflation and output.

Conclusion:

Consensus amongst economists seems to be that the relationship between output and unemployment still exists, just not in the way it did when A.W. Phillips first made

his discovery. Furthermore, while there seems to be consensus for some of the reasons for this structural shift, such as anchoring of inflation expectations leading to a flattening of the Phillips curve in, addition to supply shock factors and a decrease in output's influence on inflationary pressures there remains debate on the exact reasons. Economists such as Coibion and Gorodnichenko (2012) seem to believe that the flattening and missing disinflation during the Great Recession is do primarily to consumers anchoring of inflation expectations in everyday goods like fuel prices; while Blanchard (2015), and others at the Federal Reserve believe this is more due to the Fed's dual mandate and the two percent inflation target dating back to the 1970s. In addition to the debate of what exactly is behind the missing disinflation surrounding the most recent financial crisis, many economists have debated the new relationship between output and inflation in relation to the productivity slowdown. This information is helpful because understanding that the productivity slowdown predated the crisis helps to dissolve the argument that slow growth currently being experienced is a direct result of the crisis. Furthermore, the more lose inverse relationship between output and inflation helps to explain the Fed's slow response to full employment and why certain FOMC members are less concerned about a sudden spike inflation despite the output gap being nearly completely closed.

Colombia is a country that boasts a lot of potential for study within the context of the Phillips curve. They were one of the first countries whose central bank introduced formalized inflation targeting in 1991. At first glance it appears that inflation targeting has been successful when in 1997 inflation dipped into the single digits (Gomez et. al. 2003). Gomez, Uribe, and Vargas (2003) suggest that this initial research is just the

beginning and more macroeconomic evaluation must be done. By applying the Phillips curve to the Colombian economy I hope to add to the growing amount of literature on not just the Phillips curve generally, but the unique characteristics of the Phillips curve in developing countries. Finally, by comparing differences between developing economies to developed ones like the U.S., it may to identify further nuances stemming from recessions and the interaction of output and inflation.

III. Methodology

One equation for the Phillips curve that can be found in every macro textbook is the adaptive expectations Phillips curve which is written as

$$\pi_t = f(\pi_{t-1}, U_t - U^*)$$

where π_t is inflation in time period t written as a function of inflation in the previous time period, U_t is the unemployment rate, and U* is the nominal rate of unemployment as set by a country's central bank. This equation is helpful because it captures, in simple terms, the fundamental relationship between inflation and unemployment without adding any other variables. However, due to the complexities of economies today, it is no longer possible to isolate these two variables and study their relationship exclusively. It is unrealistic to assume that a downward trend in the output gap created by a decrease in the number of people unemployed is the sole contributor to an increase in inflation. Furthermore, many economists are noticing that low unemployment is not causing inflation the way Phillips once hypothesized. Rather we are experiencing, particularly in the post financial crisis period, that perpetually low inflation and unemployment. This leads us to the model used for this particular research comparing the Phillips curve from a

developing economy, Colombia, to that of developed economies in the United States and Japan.

Building on and merging work done by Cruz-Rodriguez (2008), Mazumder (2012), and Coibion and Gorodnichenko (2015) the model for this research is:

$$\pi_t = \alpha + \beta_1 Unemployment_t + \beta_2 LNCPI_t + \beta_3 GDP_t + \beta_4 IndustrialProductivity_t + \varepsilon_t$$

where π_t is inflation in a given time period, α is a constant term $\beta_1 Unemployment_t$ is the measure of unemployment using seasonally adjusted core consumer price index, as is common practice amongst economists, (CPI) prices from the given countries in a given time period, $\beta_2 LNCPI_t$ which is the natural log of the CPI which helps to soften the growth of the CPI over time, a technique used by Fernald (2014) when dealing with changes in productivity and output, $\beta_3 GDP_t$ which is the annual GDP for each of the countries in a given time period, $\beta_4 Industrial\ Productivity_t$ is the measure of a country's industrial productivity which was included to address the slowing of general productivity that has been noted by various economists, this term was used because it was the only productivity value that was consistent for each of the countries chosen in this study, and finally an error term ε_t. Because the GDP and industrial productivity variables are both annual and the CPI, unemployment, and inflation variables are monthly, the latter were aggregated into yearly averages. This caused for a significant decrease in the number of observations for each country, thus I created a second model that omits GDP and industrial productivity to test the relationship with a more robust sample size. The second model looks like this:

$$\pi_t = \alpha + \beta_1 Unemployment_t + \beta_2 LNCPI_t + \varepsilon_t$$

where inflation, unemployment, and LNCPI are all at the monthly level. All regressions and graphs were made using basic STATA OLS regressions.

In their models, Cruz-Rodriguez (2008), Mazumder (2012), and Coibion and Gorodnichenko (2015) add various variables to their model in order to account for different shocks and contributing factors such as Coibion and Gorodnichenko (2015) who use a food and energy basket of goods to account for supply side shocks. Because my research is focused more on the general Phillips curve and comparing developed and developing economies, I chose to instead use GDP as a measure of general economic health. Additionally, members of the U.S. Federal Reserve Open Market Committee (FOMC) have talked extensively about a slowdown in worker productivity, so industrial productivity was added to the model in order to help capture some of this slowdown.

In addition to the variables listed above, a lag function was added to the model. The lagged variables may be identified by the L. prior to the variable name in the results tables. The lag was added in an effort to help account for sticky prices that have been discussed by economists such as Blanchard (2016) amongst others. The rational behind this is that changes in unemployment and inflation take time to effect other factors in the economy. By lagging variables behind inflation it helps make the model more realistic as a change in inflation in time period *t* will have an effect on unemployment, CPI, GDP, etc. in future time periods.

IV. Data

The data compiled in the dataset was drawn from Data Planet. Each dataset was downloaded into Excel to be cleaned. The unemployment data was taken as a percentage as reported by the country's central bank in monthly increments for each of the three countries. The same procedure was used with the core CPI metric. After being downloaded into Excel, a separate spreadsheet was created for each country, and the

unemployment and CPI figures were paired from January 1997 to December 2016. The formula for generating monthly inflation figures is as follows $((CPI-CPI_{t-1})/CPI_{t-1})*100$ where the current CPI period is subtracted from the previous then divided by the pervious period before being multiplied by 100 to be made into a percentage. This procedure yielded the inflation variable. Next, in order to help smooth the data the natural log of the seasonally adjusted core CPI data was taken with a simple LN formula in excel giving the LNCPI variable. A similar approach to the inflation and CPI data was used to gather GDP and industrial productivity.

The datasets were downloaded for each country and then cleaned and matched with the caveat being that instead of being in monthly intervals there were taken yearly. Because of this, a duplicate spreadsheet was created for each country where unemployment and inflation were aggregated using 12-month averages to give values at the annual level. These values were then matched and added to the dataset with yearly GDP and productivity data. There were two separate datasets that correlated with both models described in the methodology section, first at the yearly level a dataset with unemployment, inflation, LNCPI, GDP, and industrial productivity – this dataset had 14 observations for Colombia spanning 2001 to 2015, and 19 observations for Japan and the U.S. spanning 1997 to 2016. While the variables in this model are more robust, the dataset was limited by GDP and productivity only being available on the yearly level, thus the second model was introduced to offer a more robust dataset. The second model featured inflation, unemployment, and LNCPI all at the monthly level. This allowed for the number of observations for Colombia to increase from 14 to 184 and for the U.S. and Japan from 19 to 828 and 233 respectively. The summary statistic tables show, as would

be assumed, the datasets for the United States and Japan are more robust and feature smaller standard deviations amongst variables. This is likely due to the stability and organization of the more developed economies in both Japan and the US. This data consistency, or lack thereof is one limitation to this study. Further summary statistics can be seen in tables 2,4, and 6 for Colombia, Japan, and the United States respectively.

V. Results

The results section is organized as follows: Section A. will discuss results from Table 1, Section B. will discuss results from Table 3, and Section C. will discuss results from Table 6. Section D. will compare results from each of the three different sections. Finally, Section E. will draw conclusions between the effects of different central bank mandates and policies on the Phillips curve in those countries.

A. Table 1 contains the results from the Colombian regressions. Column 1 lists the results from the second model that utilized monthly data, while column 2 lists the results from the first model that utilized annual data. The variables with the L. prior to the variable name indicate that the variable had been lagged. This is case for Japan and the United States as well as Colombia. For Colombia, the monthly data yielded the most significant results.

   When comparing results from the normal regression to the lagged regression many variables remained significant, which is unique to Colombia. A negative coefficient for unemployment of -0.0235 was significant at the ten percent level, but became significant and positive at the one percent level when it was lagged. The opposite happened for the core CPI variable where it was first positive, then when lagged became negative. Although the results

here are statistically significant, the change in the signs of the coefficients makes interpretation difficult. A similar pattern arose for the regression utilizing the annual data. The results in the second column show that the only significant variable was the CPI variable, however when it was not lagged the coefficient was positive, and when it was lagged it became negative. Both were significant at the 1% level.

One thing that was consistent was the positive sign for the lagged unemployment coefficient. It must be noted that the lagged unemployment variable using the yearly data was not significant, however it was significant at the 5% level for the monthly data. These results do offer some potential conclusions that are reinforced by Graph 1. The scatterplot, which was created using the yearly unemployment and inflation data shows a positive trend that is consistent with the positive unemployment coefficient. As inflation increases, so too does unemployment, which is a direct contradiction of what the Phillips curve suggests should be the case when looking at the interaction between inflation and unemployment.

The pattern of the coefficient sign changing from positive to negative indicates that there may be an issue with the data that was used in the regression, which is also a limitation of this study. As is the case with many developing economies the data is inconsistent. Furthermore, Table 2 shows the summary statistics that describe the Colombian dataset, and when compared to the other countries, Japan and the United States, it is evident that the data is simply not the same quality. Not only does Colombia have the

smallest sample size, but , generally speaking, it also has the largest standard deviation for each of the variables indicating large variability in the data. As more data becomes available for Colombia better studies may be conducted that could yield consistent results.

B. Table 3 contains the results from Japan. Compared to the Colombian results, the outputs from the Japan regressions are much more consistent. The only results that were significant are the results for CPI, however they are significant in both the yearly data as well as the monthly and all four are significant at the 1% level. The CPI variable was used to create the inflation variable, so while the two are different, they are definitely related. It is important to note that in both models the CPI coefficient is negative and remains negative for both the normal and lagged regression. Because the Phillips curve focuses on inflation and unemployment it is difficult to draw conclusions from the CPI variable, especially because it was used to create the inflation variable, but a negative sign for the CPI coefficient indicates that as inflation rises CPI will decrease which is a reasonable assumption.

Another interesting finding is that for both unemployment and lagged unemployment the sign before the coefficient is negative. Although none of the results are significant, this indicates that as inflation increases unemployment will fall which is consistent with the Phillips curve relationship. It is also consistent with the scatterplot created for Japan in Graph 2. The scatterplot shows a negative correlation between inflation and

unemployment between 1997 and 2015, which is consistent with findings from other economists who have plotted the Phillips curve for Japan.

C. Some interesting conclusions can be drawn from the United States results in Table 5. It was originally hypothesized that there were consistencies between the Phillips curve in economies that were in a similar developmental stages; in the case of the United States and Japan, both economies are advanced and developed. However, this is not the case. Analyzing the data in the second column, the coefficient for unemployment is positive and significant at the 10% level. Unfortunately, when lagged this variable becomes smaller and loses its significance, but it remains positive. This is a sign, much like Blanchard (2016) suggests, that the Phillips curve has undergone significant change. The non-lagged unemployment variable indicates that there is a comovement between unemployment and inflation in the United States, which would signal some key policy implications at the Federal Reserve. Much like the unemployment coefficient suggests, the graph of the Phillips curve for the United States appears to have a slightly positive trend.

D. The purpose of this study is to help draw conclusions on characteristics of the current state of the Phillips curve in different countries and whether the Phillips curve remains relevant today. Based on the results, it is difficult to draw concrete conclusions, however, there are common trends between countries. When comparing lagged and non-lagged results there seemed to be only small increases and decreases in the magnitude of the coefficient.

With more time and further studies further lag periods should be added to see what effects, if any, they have on the coefficients. Additionally, the CPI variable seemed to be the most consistently significant variable. While the sign varied for each of the studied countries, this indicates that CPI has the greatest effect on inflation, which is consistent with economic theory because the price a consumer pays for their basket of goods will have large effects on both perceived and actual inflation. This topic is discussed extensively by Coibion and Gorodnichenko (2015) using the Michigan Survey of Consumers.

E. Results indicate that the Phillips curve is unique to each individual economy, and while there are likely countless reasons for this, one that must be addressed is the effect of central bank policy and mandates. While central banks generally have the same objectives it is possible that each bank has slightly different variations of objectives, and furthermore, have different ways of implementing them. Due to these differences, the shape and characteristics of the Phillips curve are unique for each country.

The Colombian central bank, Banco de la Republica – Colombia, states on their website that their primary objective is to reach and maintain a low and stable inflation rate in order to achieve long run GDP growth. In order to do this they adjust their market interest rates, much like the Federal Reserve in the United States, as well as manipulating their exchange rate[1]. These goals and practices are evident in the shape of the Colombian Phillips curve, but even more so in the summary statistics in Table 2. Looking at the

[1] "Banco de la Republica – Colombia (http://www.banrep.gov.co/en/temas-a/5838)

inflation data, it is evident that Colombia struggles to keep inflation in check which then effects price stability and then GDP growth. Compared to the United States and Japan, Colombia's inflation numbers are much higher with a larger standard deviation. Despite this, the raw data indicates a downward trend in inflation in recent years indicating that Colombian monetary policy is taking hold.

The Bank of Japan (BOJ) has a slightly different mandate compared to Colombia, partially because their economy is more established. The BOJ simply states that they target long-term price stability because they believe that price stability lays the foundation for economic activity. They implement this monetary policy similar to other central banks by adjusting interest rates ultimately targeting a 2% inflation rate like the United States Federal Reserve[2]. It is clear by analyzing the summary statistics in Table 4 that the BOJ has fallen short in their mandate targeting a 2% inflation rate. Inflation in Japan, which has lingered around zero, could be one of the primary factors of their Phillips curve maintaining a negative relationship shown in graph 2. Because there has not been much of a change in inflation and unemployment has hovered between three and five percent there have not been enough variability to affect the Phillips curve and change the relationship between unemployment and inflation positive.

Lastly, the United States Federal Reserve is tasked with a mandate of maximizing employment, maintaining stable prices, all while moderating

[2] Bank of Japan (https://www.boj.or.jp/en/mopo/outline/index.htm/)

long-term interest rates. They do this via their dual mandate targeting an inflation rate of two percent and a nominal unemployment rate of 4.7 percent. Like the other central banks, the Fed uses the Federal Funds rate of interest as their primary tool[3]. In addition to the Federal Funds rate the Fed also began quantitative easing, an asset buying program, in the wake of the financial crisis to help further stimulate the economy with the objective of elevating mid and long term bond yields. This unique monetary policy tool had never been used before, but could be one of the contributing factors for the Phillips curve changing from a negative relationship to a comovement.

VI. Discussion

A lot of research and discussion has gone into the development of the Phillips curve and whether the negative relationship between output and unemployment still exists. A significant positive coefficient for the United States helps to confirm what many economists at the Federal Reserve have suspected and alluded to in speeches given about the new normal economic outlook within the United States economy. The gradual flattening of the Phillips curve has been well documented and can clearly be seen when plotted on a chart, but the findings of this research and by others indicates a shift beyond just a flattening. No longer is it possible to observe a downward sloping linear relationship – rather the results indicate that the interaction has tipped beyond an inverse relationship and is now positive; that is, we can expect inflation and unemployment within the United States to move together. If this is true, it is now important to address

[3] United States Federal Reserve (https://www.federalreserve.gov/monetarypolicy.htm)

policy implications stemming from this as well as what exactly may have caused such a monumental shift.

For the first time in nearly five years inflation in the United States has risen above the two percent target. Other headlines in major news outlets indicate that jobless claims have risen slightly as well in the first quarter of 2017, which could be reflective of the comovement between inflation and unemployment. In order to temper inflationary pressures, the Federal Reserve has begun slowly raising the Federal Funds rate of interest, and has indicated that they will continue to do so, signaling to investors and markets that there is going to be a shift away from the free money period that helped to speed up the recovery process in the wake of the financial crisis. Only time will tell if this trend will continue and if the positive relationship becomes stronger, or if other shocks cause the Phillips curve to begin to tilt back toward the inverse relationship that used to exist. However, should the relationship remain positive, changes inside the Federal Reserve and how they conduct monetary policy will be worth monitoring. For so long members at the Fed have understood that as unemployment decreases inflation will increase, and monetary hawks have used this argument to help support their argument to raise the Fed Funds rate of interest. Yet, this thought process will now be challenged as this relationship is better understood with time and more data and analysis is done.

While the original intent was to compare the state of the Phillips curve in developed and developing economies, it is important to juxtapose what is happening with the Phillips curve in the United States to what is occurring with it in Japan. While it was originally hypothesized that similar characteristics between developed and developing economy's Phillips curves would arise – the Japanese coefficient being negative while

the United States sign is positive is significant. Economists have discussed the aging labor force in Japan being a major factor for the shift in the economic outlook suggesting that the younger generation will not be able to support the generations before them. Despite these predictions, it appears that it has not yet had an effect on the Phillips curve. While the coefficient isn't very large, the sign remains negative for unemployment indicating that the inverse relationship remains. As time presses on, it will be important to monitor the Phillips curve relationship to see whether certain economic factors, such as the aging workforce or another unforeseen economic shock are the reason for the change. However, based on what is occurring in the United States and other advanced economies it would not be surprising if the Phillips curve became obsolete in Japan as it has in the United States.

Colombia's results are more difficult to draw conclusions from than the other two countries. Some may have to do with the lack of consistency within the data itself that effects the robustness of the sample size, but that's not to discount the significant results that were gathered. In the second model the CPI variable being significant and positive seems logical. As inflationary pressures increase driving prices of goods and services up, it would make sense that CPI would trend in the same direction as inflation. That is because CPI is a price paid for a basket of goods purchased by a consumer, thus as inflation increases so too should CPI. In the other model, however the significant result for the Variable GDP is logical because it is indicating that as inflation increases GDP will decrease. This is reasonable to assume because inflation often leads to instability within an economy, especially one that does not have all of the sophisticated controls and oversight to help control inflation, and that instability negatively affects GDP. Like any

data from developing countries it is important to consider data points that may be biased or outright incorrect, thus leading to inconsistent and confusing results. It will take more time and a more stable political and economic environment before meaningful and significant results may be gathered from Colombia on a regular basis.

VII. Conclusion

With the global economy largely recovered from the depths of the financial crisis, now is the time for central bankers to begin reshaping their monetary policy to fit the new economic outlook. This includes, as United States Federal Reserve President Janet Yellen has discussed, adding tools to their toolbox to help combat the next economic crisis. They have signaled that the first move will be to move the Federal Funds rate of interest away from the zero lower bound through small incremental increases over the coming quarters. These discussions about monetary policy and the zero lower bound are especially relevant when discussing the Phillips curve because the Federal Funds rate of interest is the Federal Reserve's primary way to control inflation. However, just because it is their primary tool, it does not mean that it is always effective. Traditionally, the Federal Reserve has also kept a close eye on the output gap, as the Phillips curve suggests, because the traditional belief has been that as the output gap shrinks it puts upward pressure on inflation.

The findings this research suggests are in agreement with work done by other economists that, within the United States, the Phillips curve is no longer relevant in the way it once was. It is premature to declare that the Phillips curve is no longer relevant at all, it is just important to define what this new relationship is, and what it means. The relationship between inflation and unemployment is no longer an inverse relationship,

rather research shows that the two now mover together on varying magnitudes. That is, for every one basis point change in inflation you can expect a 0.6249 change in unemployment, in the same direction. As this understanding becomes more ingrained in economists thought processes in the United States and abroad they will be able to better shape monetary policy, and economies will be able to reap the benefits of a more accurate and refined models and policy. The challenge will be replacing the old thought process with the new one.

As has been discussed earlier, the limitations of this study are based on the validity of the dataset. Because it was compiled using multiple central bank sources and it uses data from different time periods there are inconsistencies that effect the results. These limitations are evident in the results tables where certain variables have coefficients of 0, or are altogether omitted. In order to address this one common dataset would need to be compiled focusing on one specific time period and over one time interval such as yearly data, quarterly data, or monthly data. Additionally, another limitation is the lag variable. Due to time constraints only one lag was added, but it is possible that further lags would lead to more significant changes and results amongst some of the variables.

It is also important to note that further research must be done to better understand what economic factors are having the biggest impact on inflation and unemployment. Certainly an aging workforce and a productivity slowdown have been discussed as being the cause for economic disruptions such as secular stagnation, however further work needs to be done to not just validate these suggestions, but also gage the magnitude of their effects.

Table 1: Colombia Results

VARIABLES	(1) Monthly Inflation	(2) YRInflation
YRUnemployment		0.0684
		(0.166)
YRCPI		1.056***
		(0.111)
GDP		0
		(0)
IndustrialProductivity		-0
		(0)
L.YRInflation		-0.0507
		(0.168)
L.YRUnemployment		0.0712
		(0.226)
L.YRCPI		-1.144***
		(0.107)
L.GDP		0
		(0)
L.IndustrialProductivity		0
		(0)
Unemployment	-0.0235*	
	(0.0129)	
CoreCPI	1.012***	
	(0.0166)	
L.Inflation	-0.0108	
	(0.0163)	
L.Unemployment	0.0308**	
	(0.0129)	
L.CoreCPI	-1.016***	
	(0.0166)	
Constant	0.351***	5.640
	(0.0881)	(4.944)
Observations	184	14
R-squared	0.972	0.997

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2: Colombia Summary Statistics

VARIABLES	(1) Observations	(2) Mean	(3) Std. Dev	(4) Min	(5) Max
YR Inflation	14	4.59	1.68	2.01	7.13
YR Unemployment	15	11.85	2.01	8.95	15.44
YR CPI	15	92.26	17.49	63.59	118.98
YR GDP	15	2.30e12	1.07e12	9.47e11	3.80e12
YR Industrial Productivity	15	9.05e10	1.07e10	7.36e10	1.01e11
Inflation	184	0.39	0.23	-0.12	1.01
Unemployment	185	11.78	2.00	8.67	16.24
LNCPI	185	93.17	17.64	61.34	127.49

Table 3: Japan Results

VARIABLES	(1) Monthly Inflation	(2) YRInflation
YRUnemployment		-0.0176
		(0.0271)
YRCPI		-1.012***
		(0.0114)
GDP		0*
		(0)
IndustrialProductivity		-0*
		(0)
L.YRInflation		-0.0180
		(0.0112)
L.YRUnemployment		-0.0112
		(0.0183)
L.YRCPI		-1.010***
		(0.0103)
L.GDP		-0
		(0)
L.IndustrialProductivity		0
		(0)
Unemployment	-0.0024	
	(0.0048)	
CoreCPI	-0.9788***	
	(0.0018)	
L.Inflation	-0.00073	
	(0.0018)	
L.Unemployment	-0.0018	
	(0.0048)	
L.CoreCPI	-0.9787***	
	(0.0018)	
Constant	-0.0060	-0.467*
	(0.0243)	(0.239)
Observations	233	18
R-squared	0.993	1.000

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Japan Summary Statistics

VARIABLES	(1) Observations	(2) Mean	(3) Std. Dev	(4) Min	(5) Max
YR Inflation	18	-0.24	0.76	-1.26	1.83
YR Unemployment	19	4.41	0.61	3.37	5.37
YR CPI	19	102.03	2.59	97.89	105.95
YR GDP	19	4.97e14	1.51e13	4.71e14	5.24e14
YR Industrial Productivity	19	1.54e12	9.70e10	1.33e12	1.74e12
Inflation	233	-0.01	0.34	-0.88	2.05
Unemployment	234	4.37	0.64	3.11	5.52
LNCPI	234	4.62	0.02	4.58	4.67

Table 5: United States of America Results

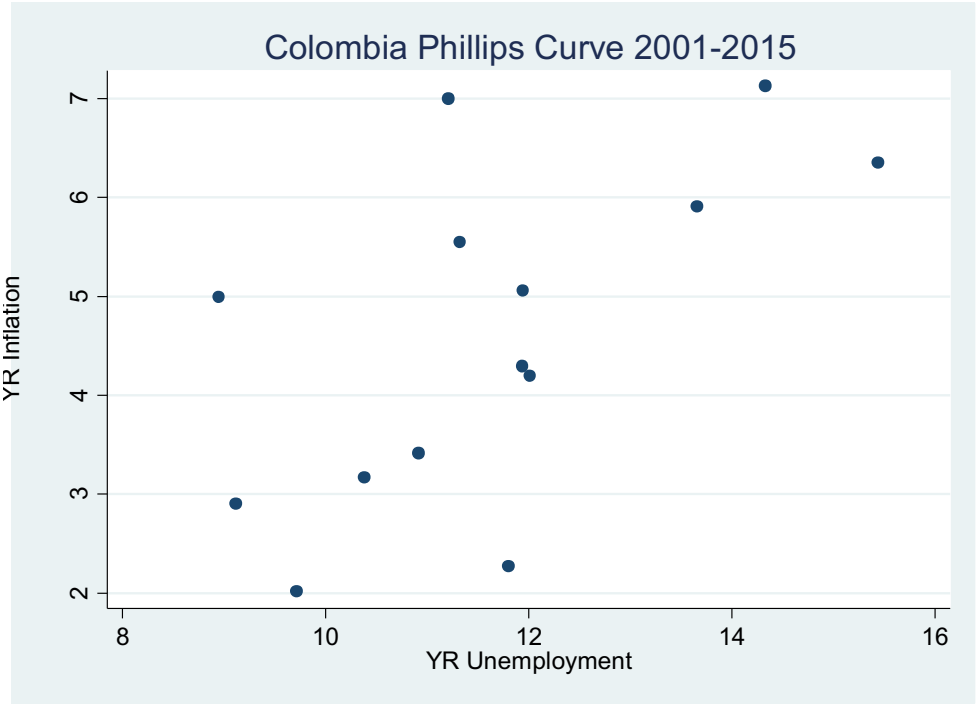
VARIABLES	(1) Monthly Inflation	(2) YRInflation
YRUnemployment		0.103*
		(0.0546)
YRCPI		0.477***
		(0.0253)
GDP		0
		(0)
IndustrialProductivity		-0
		(0)
L.YRInflation		-0.00955
		(0.0444)
L.YRUnemployment		0.0280
		(0.0795)
L.YRCPI		-0.499***
		(0.0249)
L.GDP		-0
		(0)
L.IndustrialProductivity		0
		(0)
Unemployment	0.0431	
	(0.0303)	
CoreCPI	0.579***	
	(0.0189)	
L.Inflation	0.306***	
	(0.0213)	
L.Unemployment	0.0465	
	(0.0303)	
L.CoreCPI	0.581***	
	(0.0189)	
Constant	0.154***	6.150
	(0.0242)	(4.090)
Observations	828	19
R-squared	0.705	0.997

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

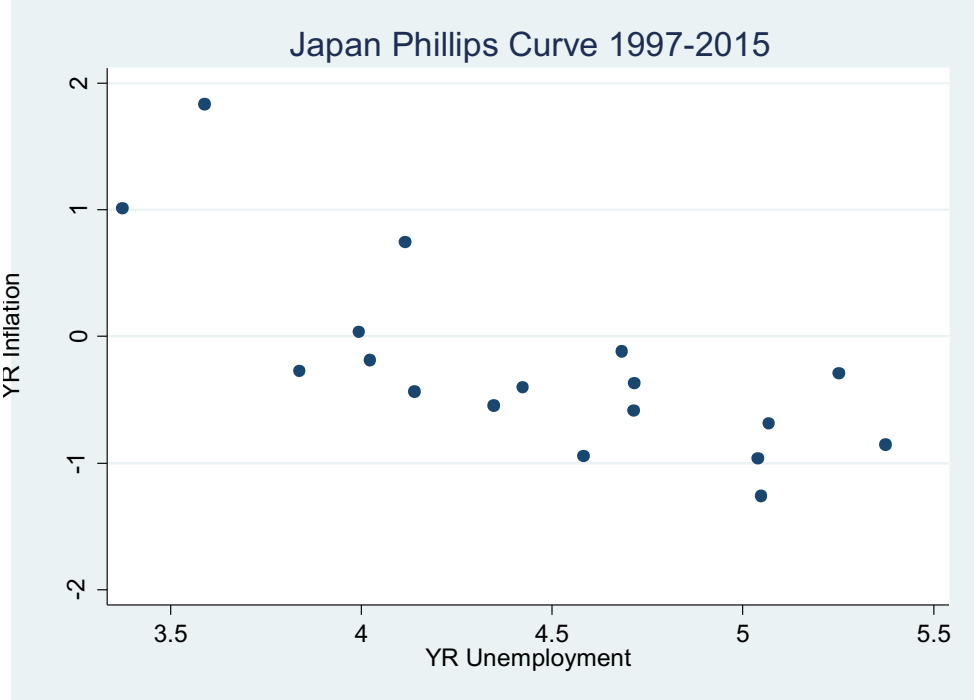
Table 6: United States of America Summary Statistics

VARIABLES	(1) Observations	(2) Mean	(3) Std. Dev	(4) Min	(5) Max
YR Inflation	19	2.15	1.10	-0.32	3.81
YR Unemployment	20	5.97	1.74	3.97	9.61
YR CPI	20	202.27	26.92	160.53	240.01
YR GDP	20	1.31e14	2.96e13	8.61e13	1.80e14
YR Industrial Productivity	20	3.08e12	2.73e11	2.24e12	3.39e12
Inflation	828	0.28	0.34	-1.77	1.81
Unemployment	829	5.01	1.64	2.5	10.8
LNCPI	829	4.35	0.82	3.16	5.50

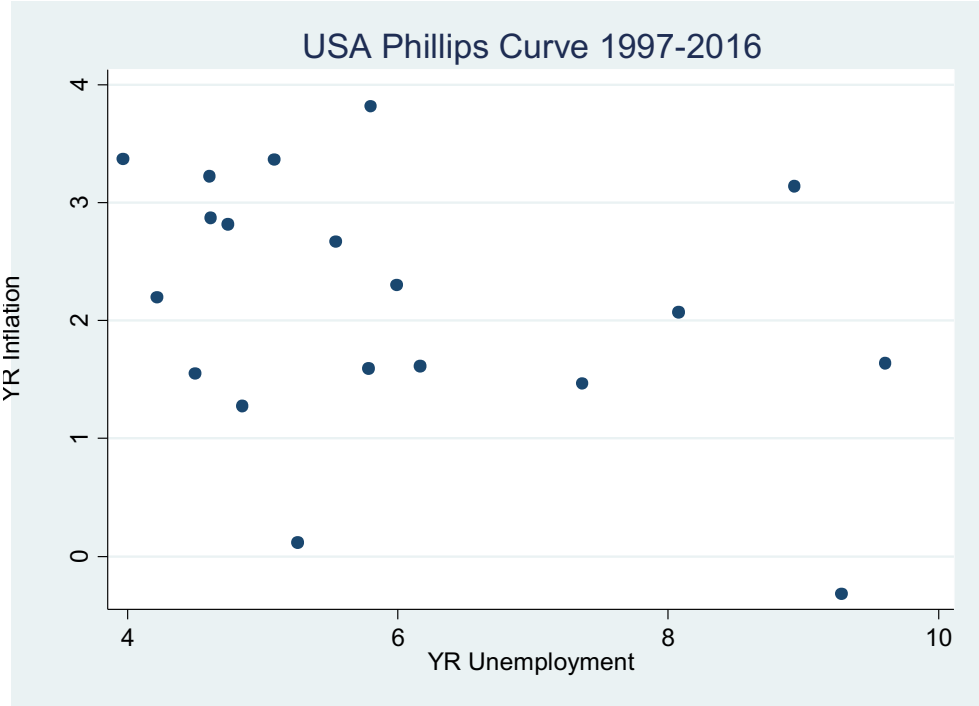
Graph 1: Colombia



Graph 2: Japan



Graph 3: United States of America



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