



## What has happened to U.S. Inflation? The Effect of Globalization on the Phillip's Curve

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### I. Introduction

In the last decade, U.S. inflation has remained stable at a low level while the unemployment rate has decreased, and GDP growth has increased. These observations contradict the logic behind Okun's law and the Phillips Curve, two fundamental economic concepts in which economists use to determine and forecast the price level. To be exact, Okun's law describes a negative relationship between changes in output and changes in unemployment, whereas the Phillips Curve illustrates the behavior of inflation through an inverse relationship between unemployment and inflation (the rate of change of overall price levels). By connecting Okun's law and the Phillips Curve, one can see how changes in the output lead to changes in inflation levels. Historically, these concepts have explained the behavior of inflation remarkably well; however, in the past decade, there seems to be a breakdown between the concepts and behavior of inflation. Thus, the recent behavior of these economic indicators provokes the following questions: is the linkage between the output gap and unemployment gap broken? Or, is the linkage between unemployment and inflation broken?

#### a. Okun's law

To assess the current inflationary environment, both Okun's law and the Phillips Curve need to be re-evaluated. This paper begins the discussion by examining Okun's law. Arthur Okun (1962) first depicted the relationship between the output gap and unemployment in his seminal paper, "Potential GNP: Its Measurement and Significance." Since labor is required to produce goods and services in the economy; therefore, at the natural level of output, there must be a certain number of workers that need to be employed to reach that output. If a nation's output rises above its potential output, then there is a demand for more workers, thus the unemployment rate decreases below the natural rate of unemployment and vice versa. Labor can come through a variety of forms, such as having employees work longer hours or hiring more workers. Hence, there must be a relationship between the natural rate of unemployment and the natural rate of output. To estimate this relationship, Okun needed to define a measurement for potential output. He believed that potential output should not be measured as the maximum output the economy could produce. Rather, he argued that potential output should be measured at full employment, which is free of inflationary pressure, and often called the level of non-accelerating rate of unemployment (NAIRU). Okun used quarterly data from (1947:Q2 to 1960:Q4) to derive his conclusions about the validity of the relationship and subsequently, his law. More specifically, Okun used the following equation to regress unemployment rate on change in the log of real gross national production,

$$(1) \Delta u_t = \alpha + \beta \Delta y_t + e_t ,$$

where  $u_t$  is the unemployment rate and  $y_t$  is the natural log of output measured with real GNP. This equation is often referred to as the "changes" version of his regressions. Nonetheless, Okun found an empirical relationship between the two variables,  $\alpha = 0.3$  and  $\beta = 0.3$ . In practical terms, a 1- point decrease in the real GNP growth is associated with a 0.3 – percentage point increase in the unemployment rate. By inverting the result, Okun found that when unemployment

falls by 1 percent, GNP rises by 3 percent output (Owyang, Sekhposyan 2012). Okun estimated another equation, linking unemployment to the output gap. Using quarterly data from 1953:Q1 to 1960:Q4:

$$(2) u_t = \alpha + \beta (y_t - y_t^n) + e_t ,$$

where  $y_t^n$  is the time-varying path of potential output and  $(y_t - y_t^n)$  is the output gap; that is, the difference between actual GDP and potential GDP. This equation is referred to as the “levels” version of his law. However, Okun reported that the estimates of the coefficients were  $\alpha = 3.72$  and  $\beta = 0.36$  output (Owyang, Sekhposyan 2012). Therefore, Okun concluded that a, “3-percentage-point negative deviation of output from its trend is associated with a 1-percentage-point increase in the unemployment rate” (Owyang, Sekhposyan 2012).

### **i. The Validity of Okun’s law**

Owyang and Sekhposyan (2012) and Ball, Leigh, and Loungani (2013), each estimates or re-estimates the relationship between output and unemployment in Okun’s law. Owyang and Sekhposyan (2012) study the evidence on instability in Okun’s law and are interested in determining if the three most recent U.S. recessions and the Great Recession has led to a breakdown of the empirical relationship. Nonetheless, the authors use different equations of Okun's law to determine if the relationship between the unemployment and output fluctuations over the business cycle for different time periods. The main result is that the estimated relationship between the unemployment rate and output changes, thus supporting the notation of instability in Okun's law. In addition, it appears that the largest break downs in Okun's coefficient is around recessions, suggesting Okun’s law is highly correlated with the business cycle. Finally, Ball, Leigh, and Loungani (2013) analyze how well Okun’s law has performed in short-run unemployment movements in the United States since 1948 and twenty advanced economies since 1980. They find that the law is both "strong and stable" in most countries and the United States; however, they note that the estimated relationship varies. Although they attribute this variation in the estimated relationship to the "idiosyncratic features of national labor markets,” but not because of differences in employment protection legislation.

### **b. Phillips Curve**

Through economic analysis and past literature, it is reasonable to conclude that Okun’s law has been stable over time; therefore, if the problem is not with Okun’s law, perhaps it is with the Phillips Curve itself. Around the same time as Arthur Okun, A. William Phillips (1958) studied the effects of unemployment and money wage changes in the paper called, “The Relation between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861-1957.” The logic behind the negative relationship is that when unemployment is low and the demand for labor is high, employers have to raise wages to attract the best workers. Conversely, when unemployment is high and the demand for labor is low, employees accept lower wages. If the economy is expanding, unemployment rate is decreasing quickly, employers will raise wages more for workers than they would if the unemployment rate is increasing slowly or not increasing at all. Since wages are a major input cost for businesses, increasing wages leads to higher prices for products in the economy. This curve has importance because government officials and government organizations such as the Federal Reserve take monetary actions based

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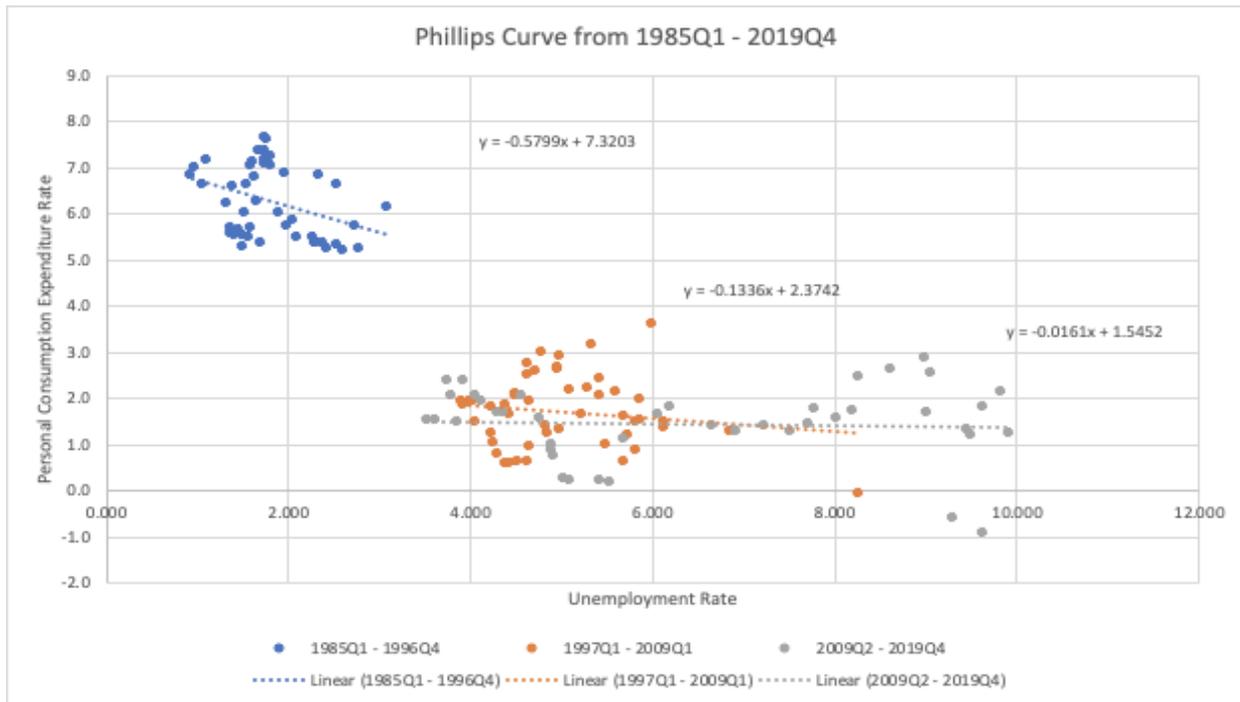
on the theoretical argument of the curve. For example, in the United States, the Federal Reserve Act of 1913 requires the Federal Reserve to promote, “maximum employment, stable prices, and moderate long-term interest rates.” Given the federal mandate, the curve serves as a tool for the central bank to use to forecast inflation, thus accuracy is of most importance. Although, during the 1970s, economists discovered that eventually workers began to comprehend the effects of the curve, so when unemployment is decreasing, the workers expected inflation to increase, so they demanded higher wages. In return, by demanding higher wages, this caused the unemployment rate to increase while inflation increased as well. This period of high unemployment and high inflation, commonly referred to as “stagflation.” Thus, the regression equation for the Expectations-Augmented Phillips Curve is as follows:

### **Expectations-Augmented Phillips Curve Equation:**

$$(3) \Delta\pi_t = \beta_0 + \beta_1\Delta\pi^e + \beta_2(y_t - y_t^n)^D + \varepsilon_t$$

where  $\pi_t$  is the change in inflation,  $\pi^e$  is the inflation expectations, and  $(y_t - y_t^n)^D$  is the domestic output.

Nonetheless, since the end of the Great Recession, the performance of the curve has been called into question. As can be seen in *Figure 1*, the chart depicts the historical performance of the Phillips Curve in the United States from 1985Q1 to 1996Q4, 1997Q1 to 2009Q1, and 2009Q2 to 2019Q4. Since 1985, the slope of the Phillips Curve has appeared to be ‘flattening,’ thus calling into question the performance of the curve to forecast inflation. Over time, the slope of the Phillips Curve has been decreasing or rather “flattening,” as can be seen from the slopes in the figure, in particular, in the estimated coefficients. The relationship appears to have disappeared completely since 2009Q2. From the first time period (1985Q1 to 1996Q4) to the second time period (1997Q1 to 2009Q1), the slopes have reduced by more than ½.

**Figure 1: Phillips Curve from 1985Q1 – 2019Q4**

**Note:** The Unemployment rate is from the Bureau of Labor Statistics while the Personal Consumption Expenditure rate is from the U.S. Bureau of Economic Analysis. It is evident that the Phillips Curve has flattened over time. The argument is that after the Great Recession, the Traditional Phillips Curve cannot accurately explain inflation.

The “flattening” of the Phillips Curve can have powerful effects on the economy, such as in the aggregate demand, aggregate supply model, where the aggregate supply curve flattens as well. This flattening of the aggregate supply curve suggests that output and prices are not strongly associated. In a broad perspective, the lack of association with the Phillips Curve suggests that employers do not raise wages in response to a tight labor market anymore. If this statement is true, what is causing either the employers to react this way?

Since Figure 1 provides sufficient evidence that the Phillips Curve can no longer explain the inflation dynamics in the United States, the main explanations are that the Phillips Curve is either dead, ‘missing,’ flattened, or shifted, and data/ measurement issues (Ng, Michael, David Wessel, and Louise Sheiner (2018) and Forbes (2019)). First, the “Phillips Curve is Dead” argument states that the relationship between the unemployment rate and inflation rate no longer exists. In other words, employers do not raise wages in response to a tight labor market anymore and low unemployment does not cause higher inflation. Thus, this argument recommends economists to build new models or use other economic concepts such as the Beveridge Curve. Potential explanations for this argument included globalization and a decrease in worker bargaining power caused by the declining importance of unions. The “Phillips Curve is Missing” explanation believes that the Phillips Curve is alive and well, but some change in the economy is hiding the

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curve. Some of the potential changes are that inflation expectations are well-anchored, the labor market is not tight as it may seem, the Productivity Wage Gap, and e-commerce has led to stable prices through its transparency (Austan D. Goolsbee and Peter J. Klenow (May 2018)). Similarly, the “Phillips Curve is Flatten” argument is that some change has occurred in the economy, thus decreasing the magnitude between the unemployment rate and inflation rate. Some examples of the weakening of the Phillips Curve include, the rise of the ‘sharing economy,’ unions have less power, and a decrease in workers’ bargaining power. In particular, for the worker’ bargaining power, the main idea is that older workers are less likely to switch jobs, so their bargaining power is reduced as there is no longer a threat of older workers leaving the company. Next, the “Phillips Curve has Shifted” suggest that in advanced economies, productivity growth has fallen so the decrease in productivity growth leads to a decrease in wage growth as productivity partly explains workers’ wages. Finally, the “Data and Measurement Explanation” questions the validity of variables such as the unemployment rate. In the United States, workers who have withdrawn from the labor force, also known as “discouraged workers,” are not accounted for in the unemployment rate. Therefore, there is less pressure on employers to raise wages despite the low employment rate because of discouraged workers.

This paper explores globalization and inflation expectations are well anchored. In particular, this paper investigates whether the traditional theoretical model of the Phillips Curve can still accurately display the relationship between the unemployment rate and the inflation. If not, this paper studies the impact of globalization and inflation expectations on the inflation dynamics in the United States. In the traditional model, when unemployment is low, firms must raise wages to attract workers (so the bargaining power of the worker increases). On the contrary, this paper focuses on the idea that globalization has changed this logic of the traditional model.

### **II. Research Hypothesis:**

Because the literature review suggest Okun’s law has remained stable over time, this paper attempts to explain recent behavior of inflation by further augmenting the “expectations-augmented Phillips Curve” to include global variables such as exchange rate, world output gap, world commodity prices, openness to trade, and inward FDI, and outward FDI.

### **III. Literature Review:**

The literature review can be broken down into two categories: Phillip’s Curve and Okun’s Law. The former serves as a representation of how economists have addressed the Phillips, whereas the latter provides a background of Okun’s law since its inception.

#### **a. Updates to the Phillips Curve**

Forbes (2019), Zhang (2016), Auer, Borio, and Filardo (2017), and Murphy (2019) each provide their unique analysis of the Phillips Curve. Forbes (2019) argues that as the world has become globalized, the relationship between unemployment and inflation has weakened because of the increase in world trade, which causes domestic firms to lower their prices to compete with foreign companies. In addition, the integration of global markets indicates that there is a change in effect of domestic inflation. For example, the Consumer Price Index, a measure of prices in a consumer’s basket, changes more with global economic indicators than domestic indicators. This

result is because the increase in trade integration translates to a higher share of price indices for imports. Then, these prices are associated with changes in global demand and supply. Forbes then continues by adding that the “fact that emerging markets now have a greater heft in the global economy. So, shifts in demand in emerging markets increasingly drives shifts in commodity prices.” In summary, Forbes suggests that domestic prices have been influenced by, “increased trade flows, emerging markets, and ease of using global supply chains.”

Zhang (2016) attempts to address the relationship between the inflation rate and unemployment in China. Since, 1994, inflation in China has been relatively low and stable, with a few periods of deflation. Zhang proves evidence that after 1994, the world output gap played a significant role in affecting domestic inflation. This, in turn, highlighted that the structure of inflation dynamics has changed. In general, Zhang finds evidence that the globalization of the Chinese economy has changed the behavior of inflation dynamics. Meanwhile, Auer, Borio, and Filardo (2017) explains how global value chains provide evidence that the world output gap influences domestic inflation. In particular, their results support the hypothesis that as the global value chains become more related through both direct and indirect competition, domestic inflation becomes more sensitive to the global output gap. Global value chains have increased cross-border competition through price pressures from inputs that are imported at all stages of the production process. In addition, this presence of global value chains can impact the decision of central banks as they attempt to manage their inflation within their economy.

Nonetheless, Murphy (2019) explores why the inflation rate remained low while the unemployment rate declined, and labor markets tightened. His paper corroborates the hypothesis that the relationship between unemployment and inflation (Phillips Curve) has been lessening and appears to be close to zero. To corroborate his claims, Murphy’s equation modifies the Phillips Curve by allowing its slope to vary, “continuously through time consistent with theories of price-setting behavior when prices are costly to adjust and when information is costly to obtain or process.” The regression results show that account for time variation in the traditional Phillips Curve explains recent inflation patterns. He then specifies that, “by adapting the Phillips curve to allow for time-variation in its slope, the behavior of inflation is explained without resorting to anchored expectations, alternative measures of slack or survey measures of expected inflation.” Thus, Murphy reaches the conclusion that time variation has played a role in the recent behavior of inflation.

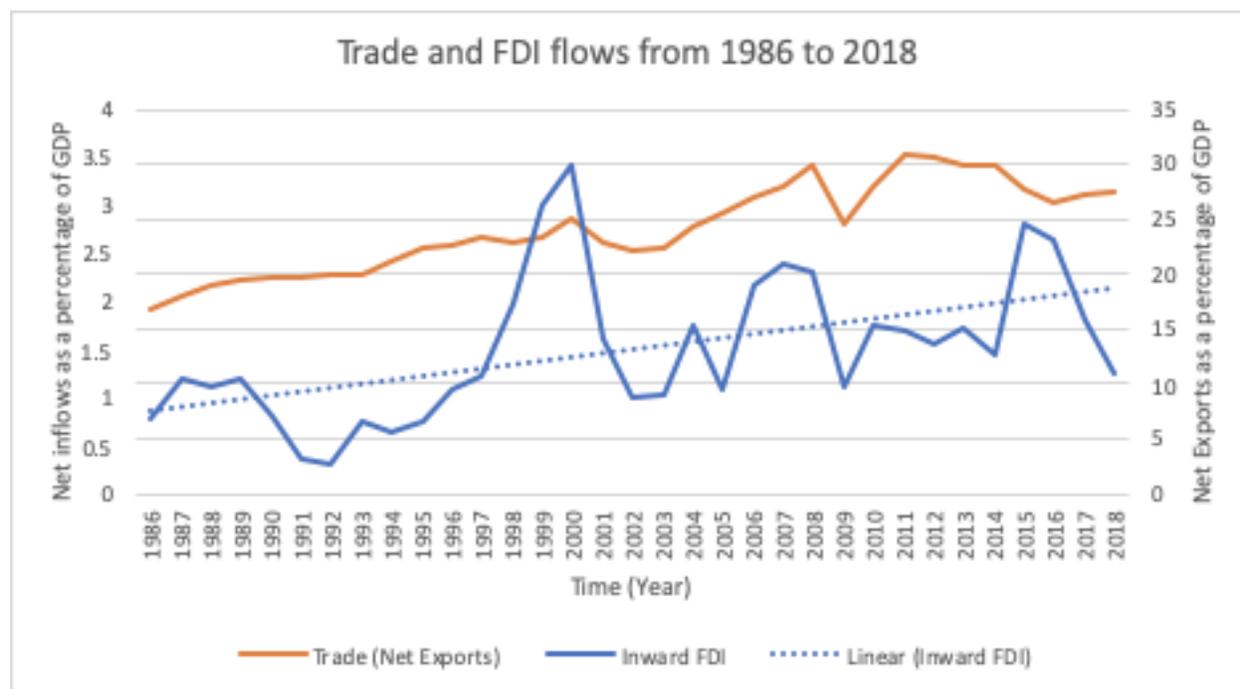
#### **IV. Economic Theory**

Globalization is the process of international integration through the exchange of products, technology, information, and jobs across global economies. This global spread can be visualized through the increase of world trade. Since 1970, world trade as a percentage of world GDP was 26.7%. However, in 2018, world trade increased to 58.4% (World Bank). Similarly, during this period of globalization, the rise of multinational corporations has increased the magnitude of foreign direct investment flows. Multinational corporations are defined as corporations that engage in foreign direct investment. Additionally, Foreign Direct Investment is classified as corporations that have a productive asset, such as plants, factories, or R&D, in a country other than its residence, with an effective voice in the management of those productive assets. Therefore, very similarly to trade flow, FDI inflows have increased over time, as can be seen in Figure 2. In the United States, since 1986, international integration has increased over time, from

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18% of GDP to 29% of GDP. The graph suggests that these flows have made the United States more connected with global markets for goods and services. As the United States becomes more internationally integrated, the supply and demand for global imports influence U.S. price levels. In particular, imports are included in the Consumer Price Index, so this measure of inflation can be affected by increasing global prices (U.S. Bureau of Labor Statistics (2020)). In these globalized industries, the demand for final goods and services inhibits the domestic firms from deciding their own prices because the demand curve no longer reflects the demand for the domestic country, but rather for the world's demand. As a domestic country becomes internationally integrated, there is an overall increase in competition, which can be seen through the real effective exchange rate decreasing over time. Naturally, when global imports rise, domestic inflation is more correlated with global prices because imported goods have a share of the basket of goods used to calculate inflation.

**Figure 2: US Trade and FDI Inflows from 1986- 2018**



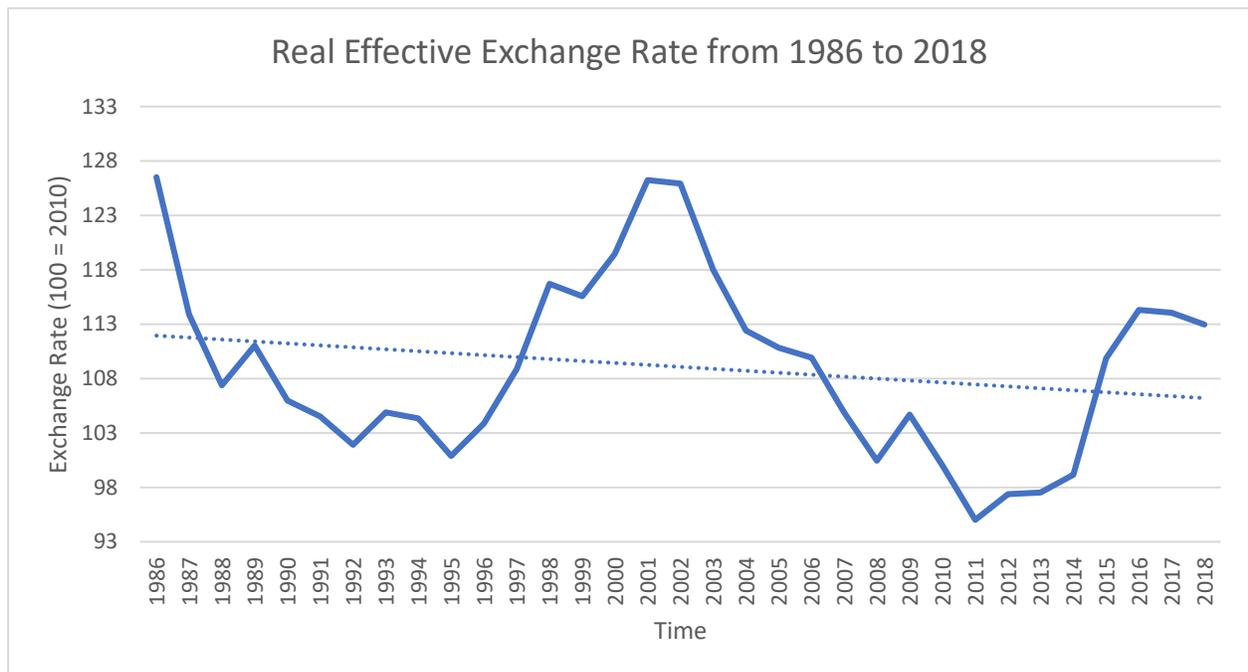
Note: This graph depicts U.S. trade and U.S. FDI flows from 1986 to 2018.

In the United States, the growth of multinational corporations force domestic firms to compete with multinational corporations for lower input prices during the production process. These lower input prices translates to lower prices of final goods; however, to access the claim that competition between the multinational corporations and domestic firms have changed over time, this paper uses the real affection change rate. This rate is a measure of the value of a specific currency against a weighted average of several foreign currencies, all divided by a price deflator or an index of costs. *Figure 4* shows the real exchange rate from 1986 to 2018 for the United

States. Generally, in context of trade, the graph suggests that as the United States real effective rate decreases, the price of domestic goods and services become relatively inexpensive for foreign consumers. Due to this, foreign consumers can purchase more goods and services from the United States. In addition, the graph depicts a general trendline to further add evidence that the United States' competition has grown steadily since 1986. Despite the fact that competition has grown slowly, this unfaltering growth does not suggest why multinational corporations conduct foreign direct investment into or out of the United States.

**Figure 4: Real Effective Exchange Rate from 1986 – 2018**

Note: This graph shows the real effective exchange rate from 1986 to 2018. It shows how there has been an increase in competition in the United States. This increase in competition influences a firm's ability to set prices.



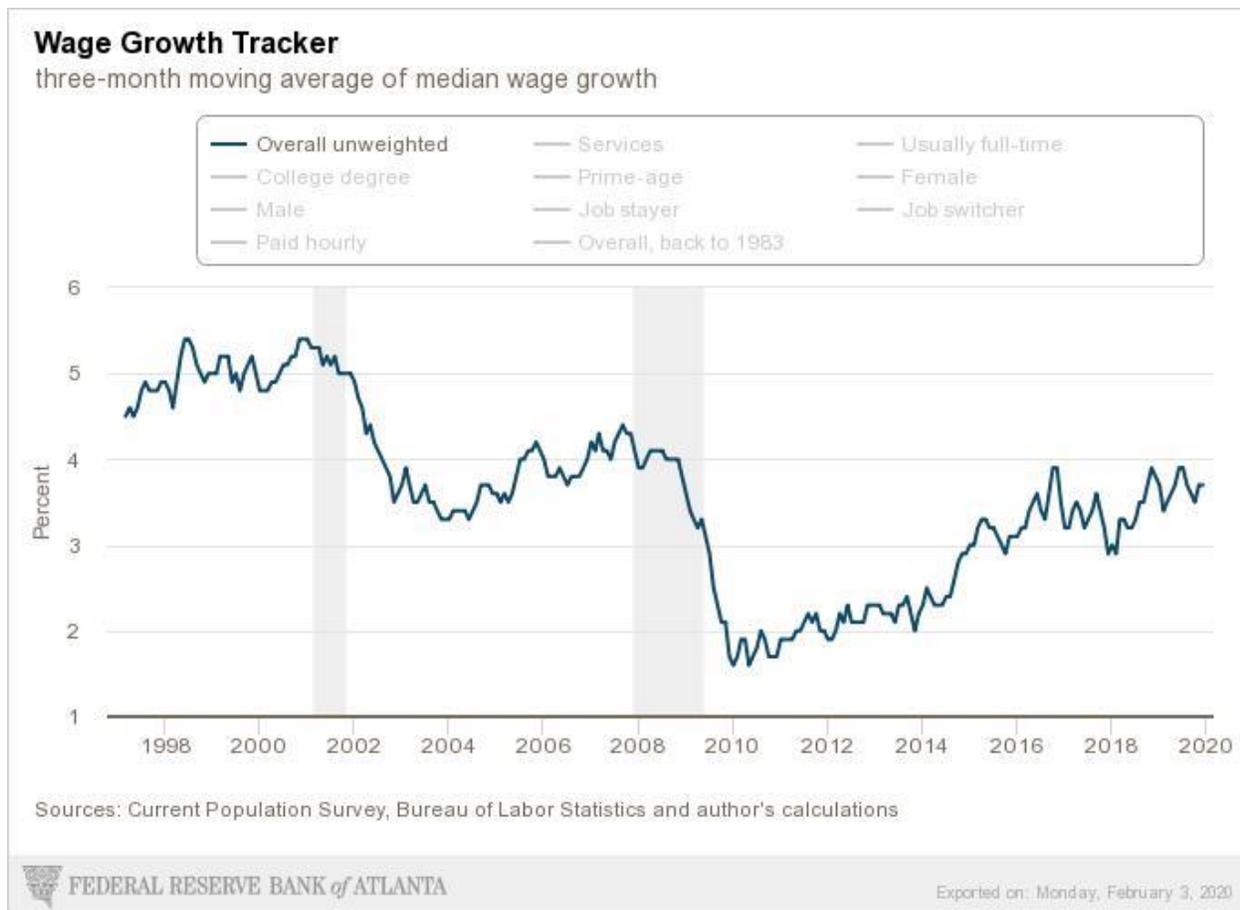
One of the reasons for multinational corporations to conduct foreign direct investment is vertical specialization. Multinational corporations establish a productive asset in a foreign country rather than remain in their domestic country because the corporations want to exploit a comparative advantage, such as making a specific product more efficiently or at a lower cost. In the FDI literature, this exploitation is referred to as vertical specialization, which allows multinational corporations to reduce the cost of their final good as the firms can fragmentation the production process. Therefore, as the growth of multinational corporations into the United States increases, these firms bring cheaper prices for final goods because of the reduction in the cost of input prices. Oftentimes, natural resources and commodities are used in the production process for

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many final goods; therefore, as commodity prices decrease, the price of the final good decreases as well.

As the prices of final goods become cheaper, domestic firms' loss their ability to raise wages for workers and set their prices for their final goods. The presence of multinational corporations deters domestic firms from increasing their wages to attract workers because the domestic firms have to compete with the multinational corporations for final prices. *Figure 5* shows powerlessness of domestic firms to raise wages in the face of competition. Therefore, as inward FDI has increased, multinational corporations have put downward pressure on domestic firms to reduce the cost of their goods. The combination of decreasing the prices of inputs during the production process and increasing competition has motivated domestic firms to stay vigilant by aligning their costs to the global variables. Some of these variables include world output and exchange rates.

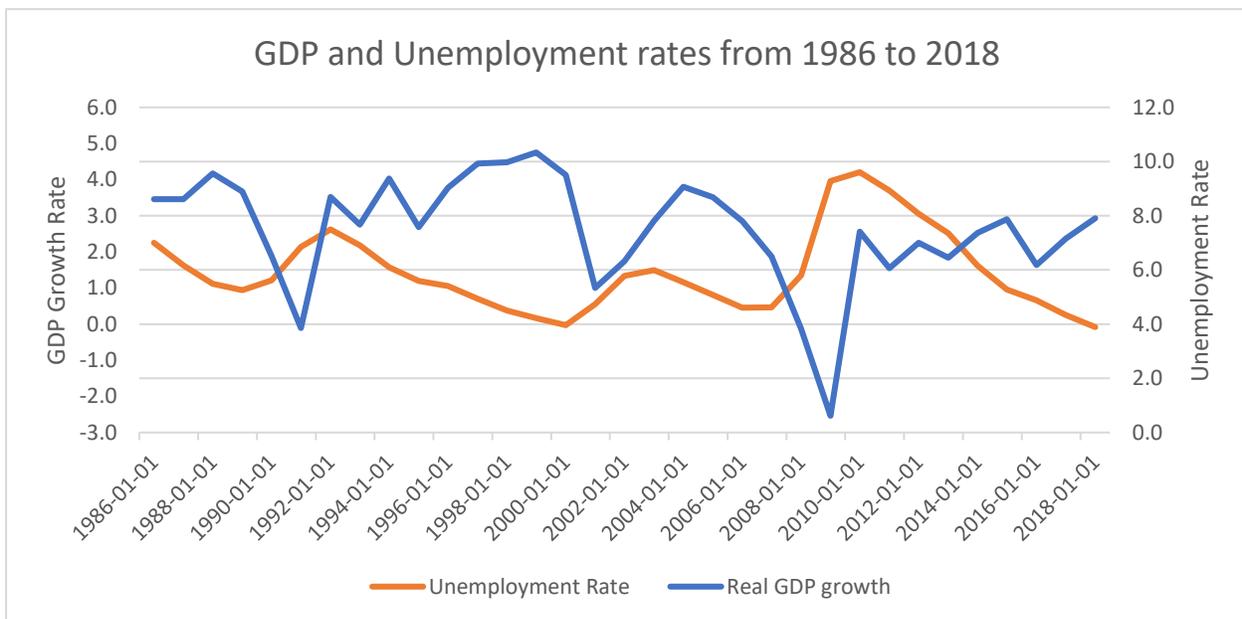
**Figure 5: Median Wage Growth from 1996 - 2018**



Note: This graph is from the Federal Reserve Bank of Atlanta. However, the graph shows the median wage growth and its recent movements. From the graph, it is clear that the wage growth has been slow-moving, thus suggesting that domestic firms have lost their control to raise wages despite low unemployment.

The United States global and domestic markets become increasingly aligned as they become more connected. This suggests that domestic price levels are influenced by global markets. As multinational corporations and domestic firms decrease their price of inputs, supply and demand models states that this decrease in the cost of production shifts the supply curve to the right. Moreover, a shift in the supply curve causes the price of the final good decreases as well. Although, as the United States economy becomes internationally integrated, the total output increases as the good becomes cheaper thus, more available to consumers in the economy and the world. In addition, Okun’s law advises that as output increases, unemployment decreases. *Figure 6* illustrates the relationship between output and unemployment is still alive as when there is an increase in GDP growth, unemployment appears to decrease and vice versa. This relationship sparks this paper’s ambition to re-estimate Okun’s law. Nonetheless, the output rises as unemployment falls; however, the price levels seem to be decreasing as well. This relationship between unemployment and price levels contradict the original logic behind the Phillips Curve.

**Figure 6: GDP and Unemployment Rates from 1986 - 2018**



Note: This graph illustrates the empirical relationship between output and unemployment rate. It appears that when one rate increases, the other decreases, which provides some evidence that Okun’s law is still alive.

The rise of multinational corporations has influenced inflation to be stable at low prices through Okun’s law because these corporations inspire prices of inputs to fall as well as the price of the final good. As the number of multinational corporations increased, the price of inputs to final goods decreased. Furthermore, as the price of inputs decreases, the supply for the final good increases as firms can produce more final goods cheaper, thus resulting in a decrease in the price

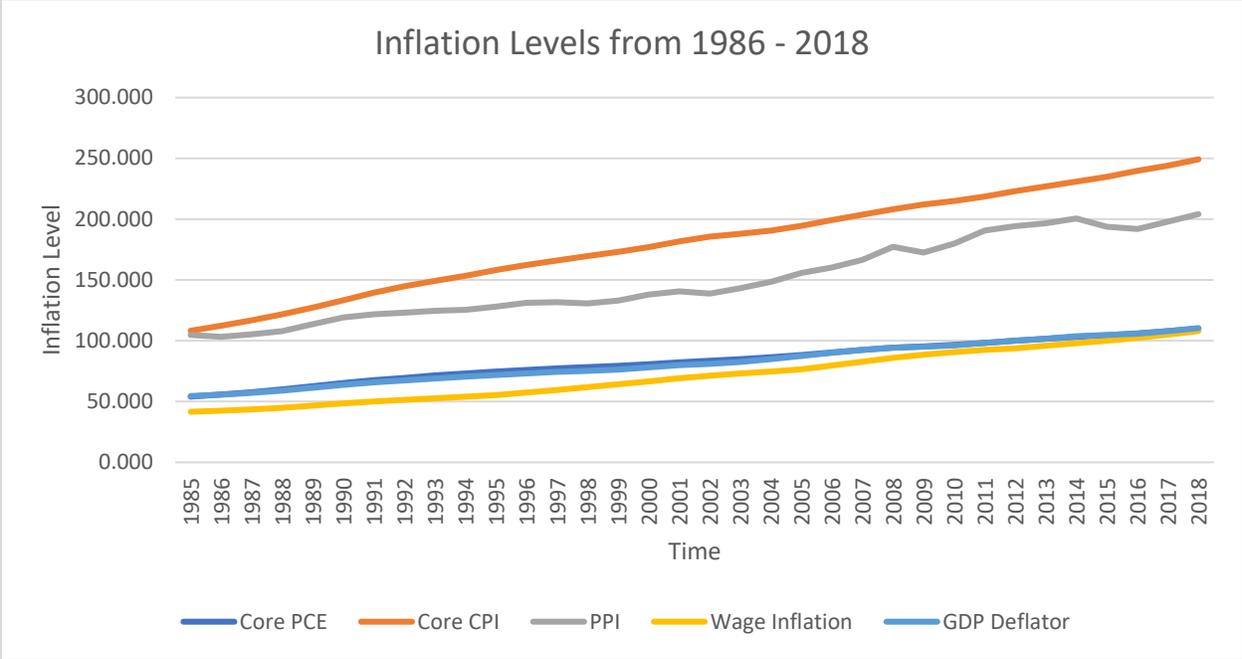
of the final good. The rise of multinational corporations leads to more competition between individual firms. These multinational corporations fragment the production process into smaller production tasks. These tasks are required to be completed in countries that yield a comparative advantage; however, in the aggregate, prices for all final goods and services decrease and the total output increases as goods and services become more readily available for consumers. Okun's law suggests an increase in the change of output leads to a decrease in the change in unemployment. Finally, because the change in the price level is decreasing, then the inflation rate must be decreasing.

### **V. Methodology & Explanation of Variables**

This paper attempts to explain the lack of inflation in the United States by augmenting the Phillips Curve to include variables that account for the rise of global trade. Traditionally, the Phillips Curve regression equation includes either lagged inflation or inflation expectations and the domestic output gap (actual output minus potential output). On the contrary, this paper claims that the Phillips Curve has to be augmented to control for global variables such as trade openness, inward and outward FDI, import commodity prices, exchange rates, and the world output gap. Once these variables are incorporated into the regression equation, this paper hypothesizes that these variables will be able to explain the current behavior of the inflation rate.

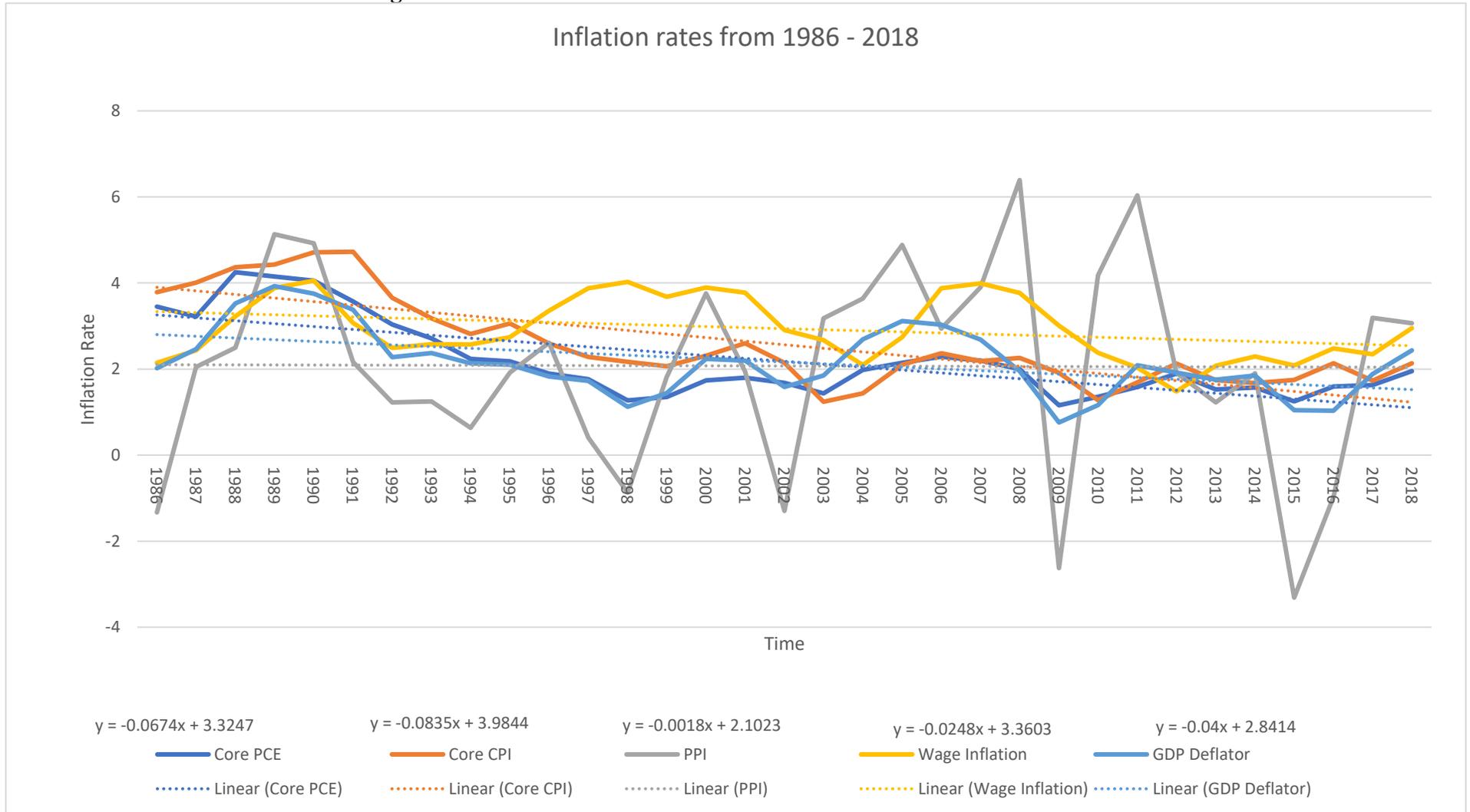
To measure the inflation rate, this paper uses five different measures of inflation: Core CPI, GDP Deflator, Core PCE inflation, Wage Inflation, and PPI, where each measure provides a different context into the economy such as information regarding consumers, producers, and businesses. Each of these measures can provide a different perspective of the trends of trade and vertical specialization through multinational corporations on inflation in the United States. More importantly, in *Figure 7*, each measure of the inflation level is measured over the period. However, the graph shows the inflation rate for each measure over the sample period. These graphs add more context to their movements and changes over time. *Figure 8* portrays the inflation rate for each measure over the entire sample period. PPI rate varies greatly while the other measures appear to fluctuate less. However, it is important to note that every measure of inflation has a negative trendline. This suggests that since 1986, the inflation rates have decreased over the entire period.

Figure 7: Inflation Levels for each of the five measures from 1986 - 2018



Note: This graph shows the levels of inflation from 1986 to 2018.

**Figure 8: Inflation Rates for each of the five measures from 1986 - 2018**



Note: This graph depicts the inflation rate from 1986 to 2018. PPI varies while the other measures seem to fluctuate less. However, there appears to be a negative trend for the entire period. Although, the coefficients are small.

The Core Price Index is the average change in prices over time that consumers pay for a basket of goods and services excluding the food and energy prices due to volatility in prices. Meanwhile, GDP Deflator is the price level of all domestically produced final goods and services in an economy. In comparison, the GDP deflator measures the price level of all goods and services that are produced domestically or within the economy, whereas the CPI measures the price level of all goods and services that are bought by consumers within the economy. Each of these measures has its limitations, for example, the GDP deflator does not account for changes in the price of imported goods and the CPI does not account for changes in the price of exported goods. In addition, their methods of calculations are different. The GDP deflator changes dynamically, whereas the market basket that calculates the CPI has to be updated periodically. The next measurement of inflation is the Producer Price Index (PPI). This index measures the average prices received by producers of domestically produced goods and services. In comparison to CPI, this index forms the perspective of sellers while the CPI depicts the perspective of buyers. The fourth measurement of inflation is the Personal Consumption Expenditures Price Index (PCE inflation rate) which measures the price changes for household goods and services. The primary difference between the PCE index and CPI is that the PCE index uses data collected from the GDP report and business sales reports, whereas the CPI is taken from household surveys made by the Bureau of Labor Statistics. It is also important to note that the Federal Reserve uses this variable to measure the inflation rate. Finally, the last measurement of inflation is Wage Inflation. This inflation rate refers to the general increase in the amount people earn over time. More importantly, the Core CPI and PPI data are collected from the U.S. Bureau of Labor Statistics, whereas the PCE inflation and GDP Deflator are collected from the U.S. Bureau of Economic Analysis. Privately hourly earnings, the proxy for Wage Inflation, is obtained from the OECD statistics. In addition, all of the measures of inflation are measured in annual terms, range in time from 1986 – 2018, and are in the units of a percentage change. This is imperative because the nature of this research uses time-series data. It is evident that inflation is nonstationary, therefore, this paper accounts for this nonstationary by taking the difference in the previous year. This removal helps take out the trend of inflation over time and narrows the scope of the change in inflation.

To control for factors affecting inflation, this paper includes inflation expectations, domestic slack, world slack, exchange rate, commodity prices, inward FDI, outward FDI, openness to trade, and time dummy into the regression equation. The main independent variable is FDI inward and outward; however, import commodity measures input prices, whereas the exchange rate serves as a proxy for competition, the openness to trade measures how the United States has trade as a percentage of GDP, and finally, the dummy variable captures the changes in the inflation rate since the end of the Great Recession. Forbes (2019) and Zhang (2016) suggest that world slack and inflation expectations are statistically significant in explaining the current inflation dynamics in the United States, therefore, this paper includes these variables as well.

The inflation expectation variable is measured from the University of Michigan's Survey of Consumers, whereas the domestic and world output gap, is obtained from the OECD Statistics. The OECD Statistics defines the output gap as the difference between the actual and potential gross domestic product as a percent of potential GDP. It is important to note that the world output gap has only the OECD countries because it is impossible to obtain data for the entire world. Therefore, using the OECD countries is the best proxy for the world. However, these

variables are the basic components of the Phillips Curve. Moreover, exchange rates are defined as the real effective exchange rate, which is also obtained through the OECD Statistics. The OECD Statistics defines the variable as, “the nominal effective exchange rate (a measure of the value of a currency against a weighted average of several foreign currencies) divided by a price deflator or index of costs.” This variable is able to take into account the price level differences between trading partners, so movements in variable provide an indication of the evolution of a country’s aggregate external price competitiveness. Commodity prices are defined as import price index (of all commodities), which is obtained by the U.S. Bureau of Labor Statistics. This variable serves as the best approximation for the price of inputs because commodities are typically used as inputs in the production process. Next, FDI is measured in two different ways: inward and outward. The data is collected from the International Monetary Fund and the World Bank. These flows serve as the best approximation for the rise of multinational corporations and their activity. Next, the openness to trade variable is the net exports as a percentage as reported by the U.S. Bureau of Economic Analysis. Similar to FDI flows, this variable represents the increase in the U.S. and foreign goods interchanging countries. Lastly, the regression equation controls for a time dummy variable, which takes the value of 0 before 2009 and 1 after 2009. This variable is to account for the behavior of inflation after the Great Recession. It is important to note that all of the variables are from 1986 through 2018 and measured annually.

### VI. Empirical Model

The regression equations are as follows:

#### Expectations-Augmented Phillips Curve Equation:

$$\Delta\pi_t = \beta_0 + \beta_1\Delta\pi^e + \beta_2(y_t - y_t^n)^D + \varepsilon_t$$

where  $\pi_t$  is the change in inflation,  $\pi^e$  is the inflation expectations, and  $(y_t - y_t^n)^D$  is the domestic output.

#### Augmented Expectations-Augmented Phillips Curve Equation:

$$\Delta\pi_t = \beta_0 + \beta_1\Delta\pi^e + \beta_2(y_t - y_t^n)^W + \beta_3\Delta\text{LN}(\text{Exchange Rate}) + \beta_4\Delta\text{LN}(\text{Import Commodity Index}) + \beta_5\text{Inward FDI} + \beta_6\text{Outward FDI} + \beta_7\text{Openness to Trade} + \beta_8\text{time dummy} + \varepsilon_t$$

where  $\pi_t$  is the change in inflation,  $\pi^e$  is the inflation expectations, and  $(y_t - y_t^n)^W$  is the world output. The augmented Phillips Curve uses the time period from 1986-2018.

Notably, every regression is tested and corrected for multicollinearity and serial correlation. The detection for multicollinearity uses the simple correlation tables and the high variance inflation factors. For the correlation tables, values that are above or below 0.80/-0.80 are cause for concern in regards to multicollinearity. In addition, this paper also uses high variance inflation factors with the general rule that if the vif is greater than 5 then the multicollinearity is severe. When multicollinearity is detected, this paper either dropped a redundant variable or did nothing because there is natural collinearity between the variables. However, this paper also tests for serial correlation. The detection method for serial correlation is the Lagrange Multiplier test. With time-series data, each regression is tested for 1 or 2 lags due to the loss of degrees of freedom with more lags. If serial correlation is detected, the remedy for this issue is the Newey-West Standard Errors.

## VII. Results

The results of the regression analysis are stated in *Table 1 and 2*. *Table 1* explains how well the traditional model of the Phillips Curve holds from 1986 to 2018 with the different measures of inflation. For Core CPI, 11.95% of the variation in Core CPI can be explained through the model. In addition, the F-statistic suggests that there are no significant variables within the model, as can be seen through the lack of statistically significant variables. Thus, the traditional model cannot explain the Core CPI rate.

For Wage Inflation, 26.52% of the variation in Core CPI can be explained through the model. However, in regards to the F-test, I rejected the null hypothesis that all of the coefficients are equal to 0. Therefore, I conclude that at least one of the predictors is important in predicting the inflation rate. In particular, the Domestic Output Gap is statistically significant and the coefficient is positive. For each additional increase in the Domestic Output Gap, I estimate that the Wage Inflation to increase by 0.13% when all the other predictors are held constant.

For PCE Inflation, PPI, and GDP Deflator, the  $R^2$  varies from 0.3284, 0.4589, and 0.3872, respectively. Likewise, the F-test concluded that there is at least one of the predictors is important in predicting the inflation rate. In addition, for these regressions, the Inflation Expectations are statistically significant and positive. However, it is important to note that the size of the coefficient is highest for PPI. Nonetheless, for every additional increase in the Inflation Expectations, I estimate that the PCE Inflation, PPI, and GDP Deflator to increase by 0.41%, 4.41%, and 0.73%, respectively. Finally, the regression has a presence of serial correlation of order 2 as I rejected the null hypothesis of the Lagrange Multiplier test. To correct this econometric issue, I used the Newey-West Standard Error to correct the standard errors.

**TABLE 1.**  
**REGRESSION RESULTS**

	<b>CORE CPI</b>	<b>WAGE INFLATION</b>	<b>CORE PCE</b>	<b>PPI</b>	<b>GDP DEFLATOR</b>
<b>Intercept</b>	-0.005 (0.082)	0.146 (0.095)	-0.025 (0.063)	0.137 (0.233)	0.033 (0.094)
<b>Delta Inflation Expectations</b>	0.171 (0.165)	0.149 (0.191)	0.411 (0.128)***	4.412 (0.747)** *	0.727 (0.19)***
<b>Domestic Output Gap</b>	0.048 (0.039)	0.121 (0.046)**	0.021 (0.031)	0.0002 (0.017)	0.02 (0.045)
<b>R<sup>2</sup></b>	0.1195	0.2652	0.3284	0.4589	0.3872
<b>N</b>	32	32	32	32	32

Note: Standard Errors in parentheses (PPI has Newey-West Standard Errors)

\* Denotes significance at the 90% confidence level.

\*\* Denotes significance at the 95% confidence level.

\*\*\* Denotes significance at the 99% confidence level

Note: The following regression table uses regression equation (3) on the different measures of inflation. The purpose of this regression is to test the traditional model of the Phillips Curve.

Based on the evidence from the regression results, there is evidence that supports the hypothesis that the traditional model of the Phillips Curve can no longer explain the inflation rate. The model is explained poorly as the  $R^2$  is very weak especially considering the data set is time-series. In addition, there are very few statistically significant variables, therefore, this paper believes the traditional model is not fully specified. Thus, by augmenting the Phillips Curve, it is hypothesized that the model will be better explained.

*Table 2* describes the regression results for the augmented Phillips Curve equations. The results from the regression suggest that the augmented Phillips Curve does not appear to be a better model than the traditional model. In general, the  $R^2$  for each measure of inflation has increased, although, this outcome has the possibility of simply being affected by adding more variables to the regression equation. Additionally, within each regression, there is a lack of evidence to support the model.

In particular, for the Core CPI regression, there is evidence to support the general hypothesis of the paper. In fact, there are two statistically significant and positive variables, Outward FDI and Import Commodity Price, which provide meaningful context to the inflation behavior. For every additional increase in Outward FDI, I expect Core CPI to decrease by 0.25% when holding other predictors constant. Likewise, for every additional increase in Import Commodity Price, I expect Core CPI to decrease by 0.03% when holding the other predictors constant. However, these interpretations suggest that outward FDI is negatively correlated with the average prices paid by

consumers. Compared to the hypothesis, these results provide a convincing argument. In the United States, multinational corporations conduct outward FDI to fragment the production process into small production tasks. This investment allows the corporations to complete tasks in different countries where they can exploit a comparative advantage in other countries. As this strategy occurs, the price of inputs to final goods decreases because of the comparative advantage. Furthermore, as the price of inputs decreases, the supply for the final good increases as firms can produce more final goods cheaper, thus resulting in a decrease in the price of the final good. However, in the aggregate, the change in the price level is decreasing, then the inflation rate must be decreasing. Therefore, the negative correlation between Outward FDI and CPI and Import Commodity Price and CPI gives some support to the hypothesis.

Moreover, for the Wage Inflation regression, there is only one statistically significant variable, Outward FDI. The findings suggest that for every additional increase in the Outward FDI, I expect the Wage Inflation to decrease by 0.30% when holding the other predictors constant. Naturally, this negative correlation makes logical sense as when multinational corporations conduct outward FDI, these corporations fragment the production process, thus they are able to produce the final good cheaper. In the aggregate, this cheaper final good translates to cheaper prices. However, it is important to note that Import Commodity Price is not statistically significant, therefore, this paper cannot comment on the reason for the decrease in the price as outward FDI increases.

Next, for Core PCE, Inflation Expectations is the only statistically significant variable. In particular, for every additional increase in the Inflation Expectation, I expect the Core PCE to increase by 0.43% when holding the other predictors constant. Naturally, as consumers anticipate greater inflation in the future, their inflation expectations increase. Therefore, this positive correlation is self-fulfilling. Consumers expect more inflation, therefore, they adjust sentiments so prices increase.

**TABLE 2. REGRESSION RESULTS**

	<b>CORE CPI</b>	<b>WAGE INFLATION</b>	<b>CORE PCE</b>	<b>PPI</b>	<b>GDP DEFLA TOR</b>
<b>Intercept</b>	-0.723 (0.692)	-0.299 (0.922)	0.009 (0.663)	2.8 (2.538)	1.28 (0.905)
<b>Delta Inflation Expectations</b>	0.263 (0.216)	0.369 (0.288)	0.429 (0.181)**	1.017 (0.963)	0.725 (0.283)**
<b>World Output Gap</b>	0.059 (0.071)	0.101 (0.095)	0.057 (0.048)	0.317 (0.271)	0.061 (0.093)
<b>Delta Real Effective Exchange Rate</b>	-2.763 (2.358)	1.788 (3.141)	-1.703 (2.012)	2.455 (10.045)	-1.751 (3.084)
<b>Delta Import Commodity Price</b>	-0.03 (0.014)**	-0.012 (0.019)	-0.012 (0.017)	0.343 (0.037)***	0.001 (0.018)
<b>Inward FDI</b>	0.254 (0.154)	0.091 (0.205)	0.168 (0.121)	-0.225 (0.597)	0.143 (0.202)
<b>Outward FDI</b>	-0.252 (0.125)*	-0.301 (0.167)*	-0.08 (0.094)	0.318 (0.507)	-0.032 (0.164)
<b>Openness to Trade</b>	0.029 (0.034)	0.031 (0.046)	-0.01 (0.031)	-0.125 (0.113)	-0.066 (0.374)
<b>Time Dummy</b>	0.082 (0.286)	-0.027 (0.38)	0.308 (0.233)	1.254 (1.07)	0.687 (0.347)*
R <sup>2</sup>	0.4546	0.3967	0.4916	0.8211	0.5107
N	32	32	32	32	32

Note: Standard Errors in parentheses (PPI is Newey-West Standard Error)

\* 90% confidence level, \*\* 95% confidence level, and \*\*\* 99% confidence level

Note: The regression table uses regression equation (4) on the different measures of inflation. The purpose of this regression is to test the augmented model of the Phillips Curve.

Following Core PCE, the PPI regression has only one statistically significant variable, Import Commodity Price. For every additional increase in the Import Commodity Price, I expect the PPI to increase by 0.34% when holding the other predictors constant. Intuitively, these results make sense as input prices increases, the cost of production increases, so the average price received by producers increases. However, the theoretical argument assumed the cause of the decrease in input prices is a result of globalization. This does not appear to be so. Lastly, the regression has a presence of serial correlation of order 2 as I rejected the null hypothesis of the Lagrange

Multiplier test. To correct this econometric issue, I used the Newey-West Standard Error to correct the standard errors.

Finally, for the GDP Deflator regression, there are two statistically significant and positive variables, Time Dummy and Inflation Expectations. These findings suggest that for every additional increase in the Inflation Expectations, I expect the GDP Deflator to increase by 0.73% when holding other predictors constant. Likewise, holding the other predictors constant, from 2009-2018, the GDP Deflator increased by 0.69% compared to the sample period of 1986-2008. In context, these results provide some insights into the price level of all goods and services that are produced domestically or within the economy. Similar to Core PCE, it appears that as consumers anticipate greater inflation in the future, their inflation expectations increase. Therefore, this positive correlation is self-fulfilling. Consumers expect more inflation, therefore, they adjust sentiments so prices increase. In addition, there is evidence to support that after the Great Recession, the price level of all goods and services that are produced domestically or within the economy seems to increase by 0.69%, holding the other predictors constant.

## VIII. Conclusion

In the last decade, the price levels in the U.S. have been relatively low, yet stable. Macroeconomics suggests that Okun's law and the Phillips curve can explain the influences of inflation. The validity of each concept has been called into question; however, this paper uses the literature review to conclude that the linkage between the output gap and the unemployment gap has been stable. In contrast, this paper explores the linkage between unemployment and inflation through globalization. Ultimately, this paper finds little support for the theory that globalization has influenced domestic prices. The regression results are not convincing enough to determine if globalization has impacted the inflation dynamics. Forbes (2019) and Zhang (2016) suggests that world output is more relevant than domestic output, however, this paper finds that the world output seems not to be relevant to explaining the U.S. inflation dynamics due to lack of statistical support. Moreover, Outward FDI seems to be more negatively correlated with inflation dynamics, whereas Inward FDI does not play a role. Openness to trade seems to be irrelevant as well; however, the research could provide more conclusive results if the sample size also increased, such as using quarterly data instead of annual.

Further research should focus on data in the sector or industry level. This paper uses aggregate data, whereas observing at disaggregate data or sectoral might have more explanatory power. FDI flows by sector could provide more evidence for the recent behavior of inflation. Thus, one recommendation of this paper is to observe data at the sector level.

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