

A Time Series Analysis of Determinants of PCE Inflation in the United States

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Abstract:

This paper investigates the factors contributing to the PCE inflation rate in the United States. The study incorporates economic determinants in a time series analysis to examine the influence of economic variables on the PCE Inflation rate in the United States. The economic variables include the unemployment rate, wages, inflation expectations, the federal funds rate, the money supply, import prices, and the labor force participation rate. The ADF unit root test shows that the first difference is stationary while the Johansen test of cointegration shows that there is cointegration of 7 and that a vector error correction model (VECM) must be run. The results show that there is long run causality among the variables of PCE inflation, output per person, import price of commodities, the labor force participation rate, wages, and GDP. Diagnostics of the VECM show that there is no autocorrelation, and the residuals of the overall model are not normally distributed.

JEL Classification: **E24, E31, C32**

Keywords: **Inflation, Personal Consumption Expenditures**

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1.0 INTRODUCTION

The PCE inflation rate is the measure of price levels that the Federal Reserve observes when analysing the state of the United States Economy and determining what monetary policy actions to perform. The Federal Reserve aims for inflation of 2% which they look to the PCE inflation rate to evaluate if their goal is being achieved. The choice of 2% inflation is to maintain low and stable inflation and was adopted in January 2012. The Fed aims for 2% inflation in order to prevent deflation and to anchor inflation expectations which are an important determinant of actual inflation and thus price stability (St. Louis Fed).

This study aims to enhance understanding of the determinants of PCE inflation in the United States since 2007. From a policy perspective, this analysis is important because the Fed strives to hit 2% inflation as measured by the PCE index and understanding how various economic factors have influenced the rate in the past can give valuable information on future projections of inflation. The relevance of this study is that since the adoption of the 2% inflation target almost 10 years ago, the Fed has often been under target and managed to be at or above the target, measured quarterly, only a few times. It can also be observed that the average PCE inflation rate since April 2007 has been 1.6%. However, due to the importance of the Fed reaching their target, recently, in August 2020 the Fed made adjustments to their “Statement on Longer-Run Goals and Monetary Policy Strategy” that states that “following periods when inflation has been running persistently below 2 percent, appropriate monetary policy will likely aim to achieve inflation moderately above 2 percent for some time.” This change in their statement is important because it also means that they will no longer be engaging in the pre-emptive lifting of the federal funds rate to combat higher inflation and instead will be implementing rate increases only when they see actual evidence of higher inflation. The Fed is aware that they have not been achieving their goal of 2% and so have made necessary changes to the way they engage policy to make up for the low inflation that has been observed since the implementation of the inflation target.

In the past, it was noted that when the unemployment rate reached a low level under the Non-accelerating Inflation Rate of Unemployment (NAIRU) inflation would start to rise and this relationship between inflation and the unemployment rate is described by the Phillips Curve which proposes that inflation and the unemployment rate have a somewhat inverse relationship. But in the past decade, evidence of the Phillips Curve has seemed to have deteriorated or at least the

Phillips Curve doesn't appear to be as relevant as it once might have been. The Fed has noticed this trend as well and so seeks to reach maximum employment without acting out of influence from the Phillips Curve by waiting until they actually see that high inflation because up until the 2020 Covid Pandemic the United States economy was experiencing some of the lowest levels of unemployment with inflation remaining below 2%.

Even more recently in economic and financial news for the 2021 year, there have been discussion around finally seeing inflation above 2% given the recovery from the Covid-19 Pandemic due to increasing numbers of vaccinated people, the fiscal policy stimulus packages that have passed, and the accommodative monetary policy conditions that have remained in place since the start of the Pandemic. And, looking at measures of inflation expectations that have recently come out, most of them are at some of their all time highs, showing that households, businesses, and professional forecasters all expect higher inflation to appear given the conditions that are being seen. It will be interesting to see if and when this comes true and even more so if observing inflation above 2% will remain for some time or just be temporary and once the economy has returned to normal observe if inflation will once again remain below the Fed's target.

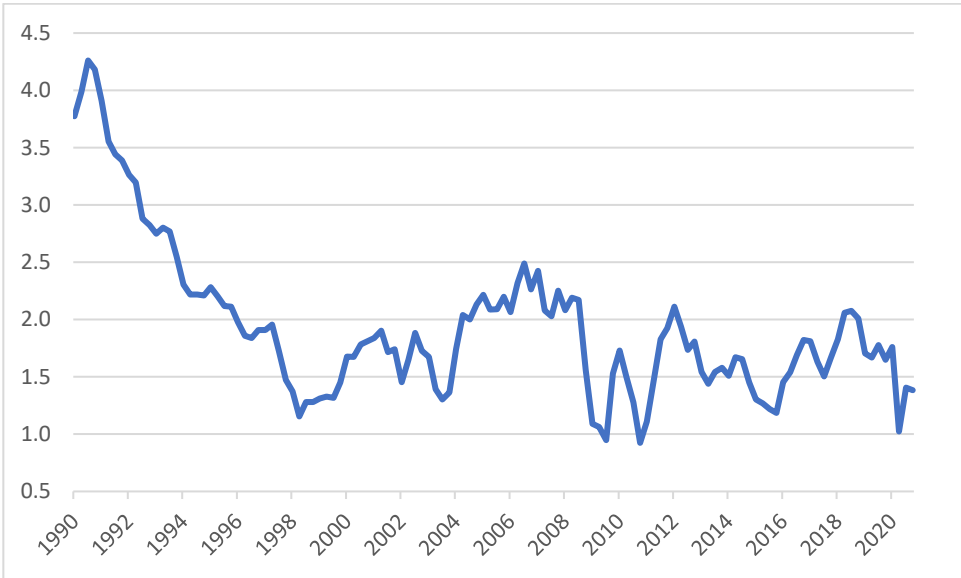
This paper was guided by three research objectives that differ from other studies: First it investigates various economic variables that were observed in multiple papers that sought to analyze determinants of inflation; Second, it analyzes inflation only in the United States and in the time period of April 2007 to October 2020; Last, it analyzes these economic variables in a time series analysis using a vector error correction model. This paper aims to explore multiple variables discussed in other research papers and bring them together to analyze how these variables influenced the PCE inflation rate seen since April 2007, right before the Great Recession and up until current times.

The rest of the paper is organized as follows: Section 2 gives a brief literature review. Section 3 outlines the empirical model. Data and estimation methodology are discussed in section 4. Finally, section 5 presents and discusses the empirical results. This is followed by a conclusion in section 6.

2.0 PCE Inflation Before and After the 2007-08 Recession

Figure 1 shows the United States PCE Inflation rate from 1990 – 2020. There has clearly been a downward trend observed over the past three decades as PCE inflation has reached lower and lower highs, and has appeared to somewhat stabilize, not having reached the highs of the early 90’s. It can also be observed how inflation has acted through this period which contains three recessions and the current one caused by the Covid-19 pandemic.

Figure 1: PCE Inflation 1990 - 2020

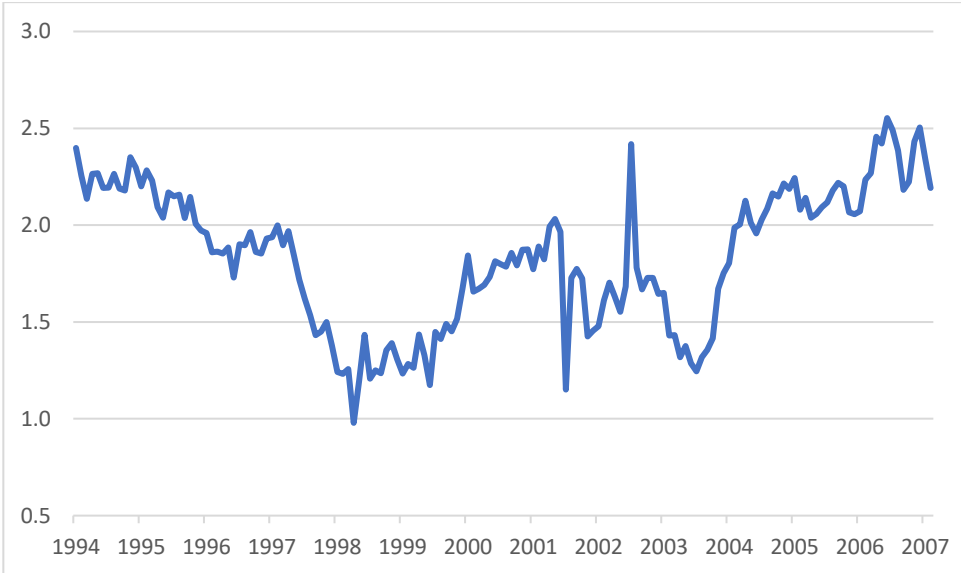


Source: U.S Bureau of Economic Analysis

Figure 2 shows the PCE inflation rate from 1994 to 2007, the 13 years leading up to the Great Recession, while Figure 3 shows the PCE inflation rate 13 years after the Great Recession, from 2007 – 2020. A notable difference between these two figures is that PCE inflation tended to be higher before the recession than after the recession. It can also be seen that there were more times in the 13-year period before the recession where inflation was above 2%, especially from 2004 on leading up to the recession. PCE inflation from 1994 to 2007 had a slightly larger range of 1.6 variation with a high of about 2.6% and a low of 1.0%, while PCE inflation from 2007 –

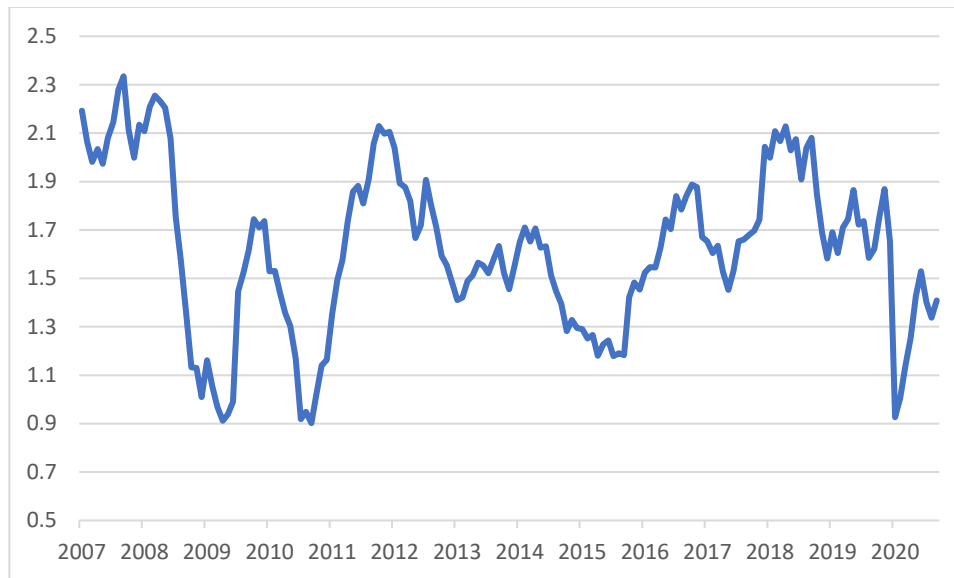
2020 has a range of 1.4 variation, with a high of 2.3% and a low of 0.9%. Here it can be seen that inflation tended to be higher in the period before the Great Recession than after, which on average is a 0.2% difference where the average PCE inflation rate before the recession was 1.8% while after the average was 1.6%. It is also interesting to note that in January 2012 the Federal Reserve announced the inflation target of 2%, and with that the average PCE inflation since implementation has still only been 1.6%. But, as will be discussed later, recently there has implemented some new framework about monetary policy in regard to their longer-run goals and strategy.

Figure 2: PCE Inflation 1994 – 2007



Source: U.S Bureau of Economic Analysis

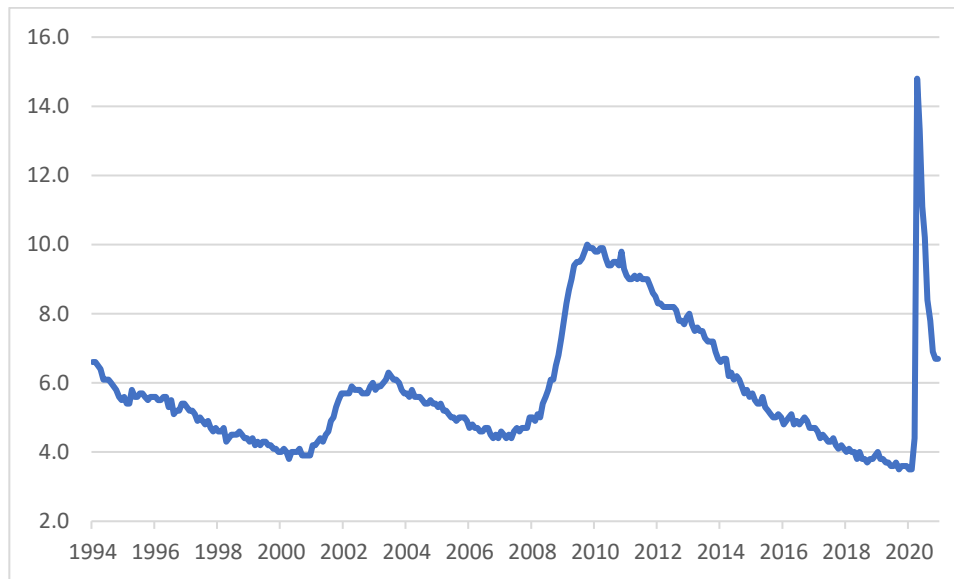
Figure 3: PCE Inflation 2007 – 2020



Source: U.S Bureau of Economic Analysis

Being aware of the dynamics of the Phillips curve, one would expect to see higher inflation when the unemployment rate is low, and lower inflation when the unemployment is high. This relationship makes it important to observe the unemployment rate and its trend overtime as it can influence the inflation trend. Looking at the time period of the U3 unemployment rate from 1994 to 2020 in Figure 4 shows that the unemployment rate is sort of cyclical where it trends downwards to a low and generally during and after a recession rises, peaks, and eventually moves down again. What is interesting to note in this graph is that during this time period after each recession the unemployment rate reached a new high but of course would eventually reach a general low again. Following the Great Recession the unemployment rate reached 10% and throughout the recovery trended downwards in the decade after to eventually reaching lows right before the Covid-19 Pandemic. The unemployment rate reached a low of 3.5% and remained around there up until March 2020 when the Pandemic started but what was noticeable when the unemployment rate was at these lows is that the economy wasn't actually seeing high inflation or even 2% inflation for that matter. This observation may show how the Phillips Curve may no longer be as relevant and/or other dynamics are also at play.

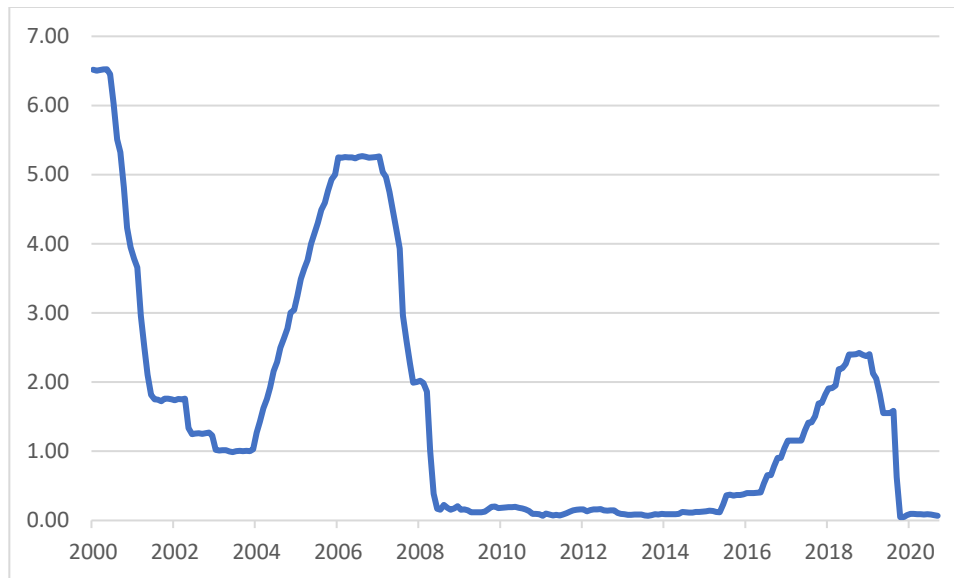
Figure 4: U3 Unemployment Rate 1994 – 2020



Source: U.S Bureau of Labor Statistics

Also, being that the Fed has a dual mandate of maximum employment and price stability with the inflation target of 2%, it is important to be aware of how thorough monetary policy, specifically the federal funds rate, the Fed aims to achieve these goals. Figure 5 shows the effective federal funds rate from 2000 – 2020. During a recession, the Fed cuts the federal funds rate to stimulate the economy to achieve its goals as a low federal funds rate provides accommodative policy. In this graph it is interesting to note how overtime the federal funds rate has been reaching lower highs after each recession and following the Great Recession the federal funds rate remained at the zero lower bound for quite some time before rising in 2016, and eventually reached a high of about 2.5% before being lowered again. Currently the federal funds rate is once again at the zero lower bound and the most recent FOMC dot plot showed the majority of the members not forecasting raising rates until 2023, especially with their new policy framework which is aiming to achieve average inflation of 2%. It will be interesting to see how this all plays out.

Figure 5: Federal Funds Rate 2000 – 2020

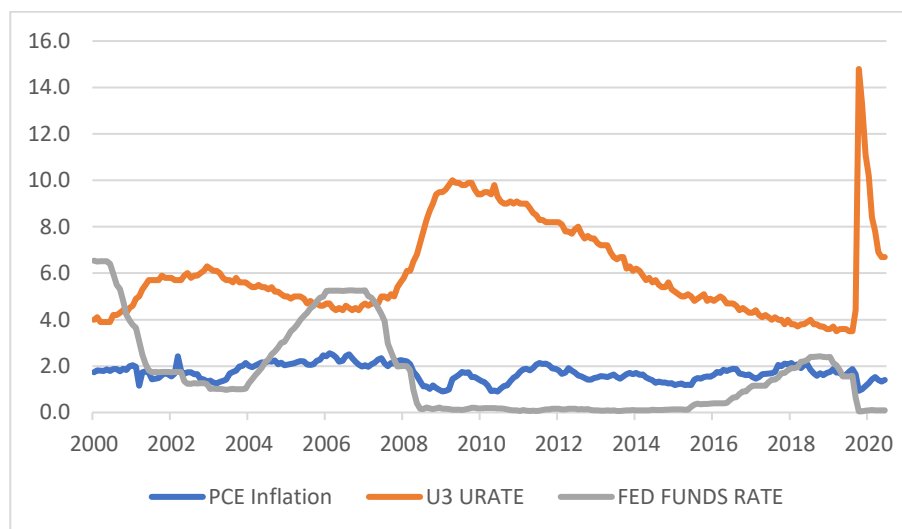


Source: Federal Reserve Bank of New York

Lastly, Figure 6 shows a graph with all three figures discussed in this section, PCE Inflation, the U3 unemployment rate, and the effective federal funds rate during the time period of 2000 to 2021. It is interesting to see all three at play because it shows how they may tend to move similarly, especially before and after a recession where a cyclical trend can be observed which is expected but PCE inflation hasn't been as high as it was before the 2007-08 Recession. As mentioned earlier where PCE inflation heads next will be interesting to see, and with the Federal Reserve's new policy framework going forward it may look different. Recently, in a speech given by the Federal Reserve's Vice Chair Richard Clarida, the downward trends have been observed and discussed. He mentions, that there has been a decline in the neutral real interest rate, r^* , with FOMC participants projecting a longer r^* of just 0.5% and a neutral setting for the Federal Funds rate of 2.5%. This can support the observation of the lower highs seen with the effective federal funds rate. He also mentions that "that price inflation seems empirically to be less responsive to resource slack, and that estimates of resource slack based on historically estimated price Phillips curve relationships are less reliable and subject to more material revision than was once commonly believed." Going further he talks about how the low unemployment seen did not result in higher inflation and that FOMC participants project u^* —the rate of unemployment consistent in the longer run with the 2 percent inflation objective—to now be 4 percent. This can help explain how today's economy is able to see and achieve low

unemployment and low inflation without the tradeoff between the two being as relevant. Finally, he reinforces the Federal Reserve's commitment to achieving its dual mandate with the new framework of achieving average 2% inflation which means that the Federal Reserve is not planning on raising rates until 2% inflation is observed and projected to remain above 2% for some time. This can work in conjunction with low unemployment as the Federal Reserve will not engage in preemptive lifting of the federal funds rate just because unemployment is at a low and so the future path of these three variables influencing each other will be interesting to observe.

Figure 6: PCE Inflation, U3 unemployment, & Effective Federal Funds Rate



Source: U.S Bureau of Economic Analysis

3.0 LITERATURE REVIEW

There has been lots of research done around inflation as it is a very important and widely taught concept in economics that is learned in foundational economic courses and talked a lot about in discussions on any given current economic state. Research on the causes of inflation is also vastly taken as it is valuable to know what contributes to the inflation rate and how one factor or another influences the inflation rate. Various economic variables influence the level of prices seen in a country or even globally and plenty of research has been done and continues to be done to explore how inflation may be able to be forecasted by these variables and what can be done to explain a given level of observed inflation.

Berganza et al. (2016) examine global inflation trends and the determinants such as globalization, population aging, commodity prices, and inflation expectations. They find that “falling inflation rates in advanced economies may be due to transient factors – such as the slump in commodity prices or the effects of exchange-rate fluctuations – or to structural shifts in the price and wage setting process – such as shifts in the cyclical sensitivity of inflation to economic slack or in the relevance of forward-looking inflation expectations.” They also observe that backward-looking inflation expectations can harm inflation expectation anchoring and central bank credibility if the stated inflation target is not being met and thus a country that experiences low inflation could continue to see lower inflation as a result.

If we move from global research to research done in the Euro area, we find similar results. Ciccarelli and Osbat (2017) study the cause of low inflation in the Euro area and find that low inflation was “primarily due to cyclical factors – domestic in the earlier part of the period and global in the latter part.” In the period after 2012 which they observe, they discuss the continued relevance of the Phillips Curve, how negative shocks constrain inflation, fall in commodity prices, inflation expectations, and economic slack. In terms of global shocks they found that commodity prices were the main drivers of disinflation observed and for domestic sources of the inflation rate find that the Phillips curve remains a useful tool in explaining inflation dynamics observed in their analysis.

A popular theory to the recent low inflation is that it is partly due to demographics and an aging population. Bullard et al. (2012) find that “When older cohorts have more influence on the redistributive policy, the economy has a relatively low steady-state level of capital and a relatively low steady-state rate of inflation. The opposite happens when young cohorts have more control of policy.” This is important because one case study that people often look to in regard to low inflation is Japan which has observed an aging population, and this can help to explain the low inflation in the United States as there has been a decrease in the labor force participation rate as the population ages.

Inflation being a rising level of prices is largely explained by economic growth as observed by GDP. Lim and Sek (2015) support this observation by finding in their research that “GDP growth and imports of goods and services have the significant long run impact on inflation in low

inflation countries.” They also find that “Results also indicate that money supply, national expenditure and GDP growth are the determinants of inflation which impose long run impact on inflation in high inflation countries.” Their research backs up the research that has been done that has determined common determinants of inflation and they were able to look more into the factors that contribute to countries that experience low inflation and countries that experience higher inflation.

Fuhrer et al. (2012) continue the research on inflation expectations and wage rigidity and in their findings conclude that “In Japan inflation depends on the 1-year survey expectations” and when this variable is excluded from their regression for the United States it decreases the r-squared from 0.69 to 0.57, showing that this variable helps explain some inflation variation. To conclude they also find evidence that wage rigidities halting the decline of inflation is “also not entirely compelling”. This is important because it shows that even though wages won’t necessarily decline, this doesn’t mean that it will keep inflation up and the risk of inflation declining is still present.

Inflation happens in all sectors of the economy and although the PCE index encompasses overall price levels, it is still important to be aware of the determinants that may be affecting price levels of goods and services of the economy separately. Abdih et al. (2016) explore how PCE inflation for goods and services have evolved differently over the past two decades. They find that “domestic forces play a larger role relative to foreign factors in influencing core services inflation, while foreign factors predominantly drive core goods price changes.” For PCE inflation of goods their research finds that specifically import prices drive prices while for PCE inflation of services, long-term inflation expectations tend to be the key driving force behind prices. They also went as far as to predicting that inflation could reach as high as 2.4% by 2018 and they were not too far off given that inflation managed to hit 2% for Q2, Q3, and Q4 of 2018 which hasn’t been seen since. Like import prices, commodity prices are another factor that might be considered as influencing the inflation rate. However, Hobijn (2008) finds that “commodity prices—and particularly energy prices—are not the controlling force in core inflation dynamics that they are sometimes assumed to be” and that “If higher prices are observed in core consumer goods and services, other inflationary pressures are undoubtedly at work.”

With there being some difference in inflation for goods and inflation for services, Bhatnagar et al. (2017) find that “the decline in core inflation began in 2017 and has been driven mostly by service prices rather than goods prices and much of the weakness in core inflation has been driven by domestic economic slack.” To add onto this, research by the International Monetary Fund (2013) found that “the combination of anchored expectations and credible central banks has made inflation move much more slowly than caricatures from the 1970s might suggest.”

Two other recent trends that have been researched and associated to low inflation is technological progress and globalization. Lv et al. (2019) find that “technology and globalization well explain the low inflation dynamics in the U.S” and “At present, technology exerts a greater role than globalization on low-inflation in the U.S.” The reason that technological progress has had such an effect on inflation is that although it increases productivity it can lead to lowering the rate of wage-growth which is another determinant of inflation. It is interesting to be aware of how determinants of other economic variables such as with the example of technology and wages, are themselves determinants of inflation, and so trends happening to one variable can affect the trend of another variable. This will be useful to know when performing a data analysis, especially with a time series analysis, as variables will likely be interacting and affecting each other.

4.0 DATA AND EMPIRICAL METHODOLOGY

4.1 Data

The study uses quarterly data beginning from Q2 of 2007 to Q4 of 2020. Data were obtained from the Federal Reserve Economic Data, (FRED) website which gathers data from various sources into a cumulated database. Data gathered from FRED that was used in this analysis comes from sources such as Board of Governors of the Federal Reserve System, U.S. Bureau of Labor Statistics, U.S. Bureau of Economic Analysis, University of Michigan, and Federal Reserve Bank of New York. Summary statistics for the data are provided in Table 1.

Table 1 Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
pce	55	1.621818	0.3386744	0.9	2.3
effr	55	.8963636	1.274841	0.06	5.25
unrate	55	6.461818	2.250555	3.6	13.1
mich	55	2.972727	.5403889	2.0	5
t10yie	55	1.937636	.3842018	0.65	2.54
m2ms	55	778.2273	666.902	160.3	3706.3
output	55	1.527273	2.832317	-4.8	10.6
impi	55	.6854546	7.567387	-17.1	19.1
lfpr	55	63.67636	1.294284	60.8	66.1
wages	55	2.674545	.8619999	1.8	6.6
gdp	55	1.64	6.712912	-31.4	33.4

4.2 Empirical Model

This study aimed to incorporate variables discussed across the multiple papers mentioned in the literature review section. In running a time series analysis, a series of steps was necessary to determine the type of model to be run.

The following steps were necessary to conduct this time series analysis:

1. Test for the presence of a unit root using the Augmented Dickey-Fuller Test (ADF).
2. In the presence of a unit root, difference the data and run the ADF test again on the differenced data.
3. Estimate co-integration using the same order of integrated variables using the Johansen test.
4. Based on the results of the Johansen test, run either a Vector-autoregression (VAR) or Vector Error Correction (VEC) model to test causality.

In this time series analysis, *PCE* is the PCE inflation rate, excluding food and energy (percent change from quarter one year ago). *PCE* is used as an endogenous variable. It represents the personal consumption expenditures price index.

Independent variables consist of ten variables obtained from various sources. Appendix A and B provide data source, acronyms, descriptions, expected signs, and justifications for using the variables. First, *EFFR* is the effective federal funds rate. *UNRATE* is the U3 unemployment rate. *MICH* is the University of Michigan Inflation Expectations. *T10YIE* is the 10-Year Breakeven Inflation Rate. *M2MS* is the M2 Money Stock, change from a year ago, in billions of dollars. *OUTPUT* is Nonfarm Business Sector: Real Output per Hour of All Persons, a proxy for productivity. *IMPI* is Import Price Index (End Use): All Commodities, Percent change from a year ago, and is a proxy for both import prices and commodity prices. *LFPR* is the Labor Force Participation Rate. *WAGES* is the Average Hourly Earnings of All Employers, Total Private, percent change from a year ago, and *GDP* is Real Gross Domestic Product, percent change from the preceding period.

5.0 EMPIRICAL RESULTS

The initial Augmented Dickey Fuller test results are presented in Table 2. It shows that *PCE* has unit root and is not stationary, as the test statistic is less than the 5% critical value, and therefore the first difference must be taken.

Table 2: ADF results of *PCE*

	Test Statistic	1% Critical Vaue	5% Critical Value	10% Critical Value	
<i>z(t)</i>	-0.956	-2.618	-1.950	-1.610	
D.pce	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
pce L1.	-.019812	.0207307	-0.96	0.344	[-.0613925, .0217686]

Table 3 shows that after taking the first difference of *PCE* and running the ADF test, the results show that the variable no longer has unit root and is stationary.

Table 3: ADF Results of *PCE* First Difference

	Test Statistic	1% Critical Vaue	5% Critical Value	10% Critical Value	
z(t)	-4.451	-2.622	-1.950	-1.610	
D.d1_pce	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
d1_pce L1.	-1.691552	.3800326	-4.45	0.000	[-2.457457, 0.9256467]
L2D.	.6239555	.3035645	2.06	0.046	[.0121614, 1.23575]
L3D.	.6453598	.2590902	2.49	0.017	[0.1231978, 1.167522]
L4D.	.4677575	.2210452	2.12	0.040	[0.0222702, 0.9132448]
L5D.	.0291861	.1738478	0.17	0.867	[-.3211811, .3795534]

The results of the Johansen Test of Cointegration in Table 4 show that there is a cointegration of seven. This means that a Vector Error Correction model (VECM) must be run because the variables are cointegrated.

Table 4: Results of Johansen Test of Cointegration

Maximum Rank	parms	LL	eigenvalue	trace statistic	5% Critical Value
0	132	-598.99035	.	500.4332	277.71
1	153	-543.08182	0.87873	388.6162	233.13
2	172	-498.18515	0.81626	298.8228	192.89
3	189	-460.43977	0.75934	223.3321	156.00
4	204	-428.06428	0.70528	158.5811	124.24
5	217	-402.71947	0.61573	107.8915	94.15

6	228	-384.911	0.48932	72.2745	68.52
7	237	-371.63332	0.39410	45.7192*	47.21
8	244	-361.42492	0.31970	25.3024	29.68
9	249	-354.6519	0.22554	11.7563	15.41
10	252	-349.49848	0.17673	1.4495	3.76
11	253	-348.77373	0.02698		

The results of the VECM in Table 5 show that there is long-run causality among the variables. Specifically, the results indicate that *output* and *impi* have a negative effect/impact on *pce*, while *lfpr*, wages, and *gdp* have a positive effect on *pce* inflation (all are statistically significant at the 1% level). These results produce two results, the cointegrating equation/ long run model (1) and an equation with *PCE* has the target variable (2). Interpreting the error correction term (ECT) coefficient tells that the adjustment term (-0.2438493) is statistically significant at the 10% level, suggesting that previous year's errors (or deviation from long-run equilibrium) are corrected for within the current year at a convergence speed of 24.38%.

Table 5: Multivariate Vector Error Correction Model

Johansen normalization restrictions imposed					
_ce1:					
beta	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]
pce	1	.	.	.	.
effr	-9.99e-16	.	.	.	.
unrate	-5.55e-16	.	.	.	.
mich	-7.77e-16	.	.	.	.

t10yie	2.22e-16	.	.	.	.
m2ms	1.30e-18	.	.	.	.
output	5.567969	0.519153	10.73	0.000	6.58549
impi	0.4625321	0.0908912	5.09	0.000	0.6406756
lfpr	-3.37468	0.7879963	-4.28	0.000	-1.830236
wages	-9.023391	1.17678	-7.67	0.000	-6.716945
gdp	-4.035708	0.5204763	-7.75	0.000	-3.015593
_cons	235.7529	.	.	.	.

(1)

$$\begin{aligned}
& ECT_{(t-1)} \\
& = 1.000(pce)_{(t-1)} + 5.568(output)_{(t-1)} \\
& + 0.463(impi)_{(t-1)} - 3.375(lfpr)_{(t-1)} - 9.023(wages)_{(t-1)} - 4.036(gdp)_{(t-1)} \\
& + 235.753
\end{aligned}$$

(2)

$$\begin{aligned}
PCE_t = & -0.0098676 - .1550945(PCE)_{t-1} + 0.0436757(output)_{t-1} \\
& + .0154668(impi)_{t-1} - 0.4271539(lfpr)_{t-1} \\
& - 0.0001342(wages)_{t-1} - 0.0525415(gdp)_{t-1} - 0.2438493(ECT)_{t-1}
\end{aligned}$$

Lastly, it is important to run some diagnostics of the VECM. The first diagnostic to be run is the Lagrange-Multiplier Test, which checks for autocorrelation. The second diagnostic to be run is the Jarque-Bera Test which checks if the residuals are normally distributed. The results of the Lagrange-Multiplier Test in Table 6, shows that in this model there is no autocorrelation at lag 1 or lag 2. The results of the Jarque-Bera test in Table 7, shows that most of the variables have residuals that are normally distributed though as a whole the residuals of the model are not normally distributed which means the results can still be accepted but this should be remembered.

Table 6: Results of Lagrange-Multiplier Test

lag	chi2	df	Prob > chi2
1	141.8022	121	0.09514
2	131.3609	121	0.24494

Table 7: Results of Jarque-Bera Test

Equation	chi2	df	Prob > chi2
D_pce	0.923	2	0.63041
D_effr	0.068	2	0.96668
D_unrate	73.717	2	0.00000
D_mich	2.608	2	0.27141
D_t10yie	1.701	2	0.42718
D_m2ms	7.175	2	0.02767
D_output	0.446	2	0.80024
D_impj	6.245	2	0.04404
D_lfpr	1.314	2	0.51849
D_wages	0.637	2	0.72174
D_gdp	1.784	2	0.40975
ALL	96.619	2	0.00000

5.0 CONCLUSION

In summary, long run causality exists among the variables of PCE inflation, output per person, import price of commodities, the labor force participation rate, wages, and GDP. More specifically, *output* and *impj* have a negative effect/impact on *pce*, while *lfpr*, *wages*, and *gdp* have a positive effect on *pce* inflation. Policy implications from this research suggests that there should be a continued focus on employment as the employment related variables were significant in the model. This could be through increasing the labor force participation rate which has recently declined due to the COVID-19 Pandemic and promoting an increase of wages, which could be through increasing the minimum wage. Of course, the usual methods and goals of reducing the unemployment rate and promoting overall economic growth would also be beneficial to increasing PCE inflation. This would go to show that in this model, the Phillips Curve is still somewhat relevant. Limitations of this study include that there were many variables used so some may have been overtaken by others, the overall residuals were not normally distributed, only a lag of 2 was used, and the model did not incorporate a technology variable. Even so, the results of this analysis, support the Federal Reserve's current policies of focusing on achieving maximum employment

and promoting higher inflation with accommodative monetary policy and with that inflation at or above 2% may eventually be seen again.

Appendix A: Variable Description and Data Source

Acronym	Description	Data Source
PCE	PCE Inflation Rate, Excluding Food and Energy, Percent Change from Quarter One Year Ago	U.S. Bureau of Economic Analysis
Obs_date	Observation date (Quarterly)	

EFFR	Effective Federal Funds Rate	Federal Reserve Bank of New York
UNRATE	U3 Unemployment Rate	U.S. Bureau of Labor Statistics
MICH	University of Michigan: Inflation Expectations	University of Michigan
T10YIE	10-Year Breakeven Inflation Rate	Federal Reserve Bank of St. Louis
M2MS	M2 Money Stock, Change from Year Ago, Billions of Dollars	Board of Governors of the Federal Reserve System
OUTPUT	Nonfarm Business Sector: Real Output Per Hour of All Persons	U.S. Bureau of Labor Statistics
IMPI	Import Price Index (End Use): All commodities, Percent Change from Year Ago	U.S. Bureau of Labor Statistics
LFPR	Labor Force Participation Rate	U.S. Bureau of Labor Statistics
WAGES	Average Hourly Earnings of All Employees, Total Private, Percent Change from Year Ago	U.S. Bureau of Labor Statistics
GDP	Real Gross Domestic Product, Percent Change from Preceding Period	U.S. Bureau of Economic Analysis

Appendix B- Variables and Expected Signs

Acronym	Variable Description	What it Captures	Expected Sign
EFFR	Effective Federal Funds Rate	The interest rate set by the Federal Reserve	-
UNRATE	U3 Unemployment Rate	The rate at which percent of the labor force is unemployed	+
MICH	University of Michigan: Inflation Expectations	Consumer inflation expectations	+

T10YIE	10-Year Breakeven Inflation Rate	Financial Forecaster inflation expectations	+
M2MS	M2 Money Stock, Change from Year Ago, Billions of Dollars	The money supply	+
OUTPUT	Nonfarm Business Sector: Real Output Per Hour of All Persons	Productivity	+
IMPI	Import Price Index (End Use): All commodities, Percent Change from Year Ago	Commodities and import prices	+
LFPR	Labor Force Participation Rate	The percent of the population that is employed or actively looking for work. Also, can represent the aging population of the work force	+
WAGES	Average Hourly Earnings of All Employees, Total Private, Percent Change from Year Ago	The wage earned per hour of employees	+
GDP	Real Gross Domestic Product, Percent Change from Preceding Period	Level of output produced by the United States	+

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