FED UP WITH THE RULES
EMPIRICAL TESTING OF THE TAYLOR RULE IN THE UNITED STATES

A THESIS

Presented to

The Faculty of the Department of Economics and Business

The Colorado College

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Arts

By

Keeley Kandziora

May 2023

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Economics

Abstract

This study empirically tests the Taylor rule and its applicability to modern day monetary policy creation in the United States. Historic impreciseness in the Taylor rule as it pertains to monetary policy is detected and a search for a more thoughtful version of this rule is necessary given the impending and potentially dramatic shifts that we are to see in the country's future economic landscape. Using data pulled from Federal Reserve Economic Data (FRED), various multivariate regressions are presented to test both the standard Taylor rule as well as an alternative version of the rule including a measure of consumer sentiment. At the conclusion of this study, a more intentional and complex version of the Taylor rule is found that more accurately models the roughly forty-year period at hand.

KEYWORDS: (Taylor Rule, Output Gap, Inflation, Unemployment Rate, Personal Consumption Expenditure Chain-type Price Index, Consumer Sentiment)
JEL CODES: (C22, E21, E24, E31, E32, E37, E42, E43, E58, E62, E63, G01, G02, G18, G21)

ON MY HONOR, I HAVE NEITHER GIVEN NOR RECEIVED UNAUTHORIZED AID ON THIS THESIS

Keeley Kandziora

Signature

ACKNOWLEDGEMENTS

This thesis would not have been possible without the consistent support and guidance of my thesis advisor, Professor Daniel Johnson.

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I. Introduction

As the U.S. central banking system, the main responsibility of the Federal Reserve is to serve the public by implementing monetary policy. The objectives of monetary policy are illustrated explicitly in the Federal Reserve Act: The Federal Reserve System must "promote effectively the goals of maximum employment, stable prices, and moderate long-term interest rates" (Federal Reserve, 2021). The monetary policy objectives of the Federal Reserve are more frequently cited as a dual mandate: stable prices and maximum employment. The primary goal of price stability is centered around maintaining a target inflation rate of two percent. Price stability is often measured through the lens of the annual change in Personal Consumption Expenditures (PCE). PCE is an index measuring the spending of consumers in the United States on goods and services (Federal Reserve Economic Data, 2023). Alternatively, the Federal Open Market Committee (FOMC) measures the output gap through labor force market indicators to assess the level of employment within the United States. These labor market indicators can include the unemployment rate, the labor force participation rate and the employment-to-population ratio (Federal Reserve, 2021).

In 1993, economist John B. Taylor developed the Taylor rule to assist central banks, specifically the Federal Reserve, in setting its monetary policy target through alterations in the real federal funds rate (Gabriel, 2022). Historically, the Taylor rule has had a large influence in conversations surrounding monetary policy. In essence, the Taylor rule is a model that forecasts future interest rates and is often used to advise the Federal Reserve on how monetary policy should be conducted. The Taylor rule "prescribes a value for the federal funds rate—the short-term interest rate targeted by the

Federal Open Market Committee (FOMC)—based on the values of inflation and economic slack such as the output gap or unemployment gap" (Federal Reserve Bank of Atlanta, n.d.).

Pre-existing literature has provided evidence that the Federal Reserve benefits from examining simplistic benchmarks such as the Taylor rule as they have the ability to produce beneficial results to assist in the policy creation process (Kohn, 2007). In 2007, Vice Chairman of the Federal Reserve Donald L. Kohn accredited John Taylor's Contributions to monetary theory and policy. Kohn emphasized the importance that the Taylor rule has played in recent years in helping form expectations for future monetary policy actions. "Federal Reserve policymakers are shown several versions of Taylor rules in the material we receive before each meeting of the Federal Open Market Committee (FOMC)," Kohn says (2007). Utilizing simplistic rules maintains transparency with the public, allowing consumers to manage expectations on what potential monetary policy actions could be taken based on the current economic environment. The Taylor rule has frequently been cited as a guidepost for monetary policy. However, critics of the rule cite the lack of the model's ability in having an "explicit role for forecasts and related judgments about prospective economic developments," meaning that the simplistic model does not include impending economic factors that may impact decisions on future monetary policy (Fernandez, Koenig and Nikolsko-Rzhevskyy, 2010).

Conducting monetary policy is more complex than a rule and it is the Federal Reserve's duty to the public to anticipate future anomalies and behave proactively "because modest preemptive actions can obviate more drastic actions at a later date that would destabilize the economy" (Orphanides, 2003). Currently, the future of monetary policy could look very different given the troubling economic landscape ahead within the U.S. According to the 2020 census, the number of individuals within the United States aged 65 years and older reached 55.8 million accounting for 16.8% of the total population (Caplan, 2023). The retirement of this age group, made up predominantly of skilled laborers, will not only influence the productive capacity of many industries within the U.S. but will affect variables such as inflation, GDP, employment and the output gap which have large implications for monetary policy. Additionally, labor force participation rates have fallen to 62 percent from a high of 67 percent in the late 1990's (Atkins, White et al, 2023). Productivity growth has historically been one of the main drivers of GDP growth within the U.S. Yet, within the past fifteen years the rate of productivity growth has averaged around 1.4 percent compared to its long-term annual growth rate of 2.2 percent (Atkins, White et al, 2023). However, new technologies such as artificial intelligence have the potential to reverse the slowing productivity growth that the U.S. has been experiencing over the past decade. Previously, technological advancements have largely affected low wage and low skilled workers. The automation of worker's tasks will predominantly impact high wage high skilled workers, boosting worker efficiency and lowering company costs in the future. As artificial intelligence continues to be integrated into every aspect of our daily lives, it will be necessary for "workflows and workspaces [to] continue to evolve to enable humans and machines to work together" (Manyika and Sneader, 2018). Given that the future economic environment is uncertain, it is essential to test and find a version of the Taylor rule that can assist in future monetary policy creation.

Over the last few decades, monetary policy has deviated from its dual mandate during times of crises to promote financial stability. For instance, in the aftermath of September 11 of 2001, the 2007 Financial Crisis and the most recent Covid-19 pandemic, the Federal Reserve lowered interest rates by more than what would be expected given the state of the output gap and inflation (Boissay, Collard and Manea, 2021). These deviations are understandable given that the Federal Reserve takes the full economic landscape into consideration and values the financial and macroeconomic stability of the economy when making decisions about monetary policy. The noticeable variance in the Taylor rule is partially due to the latency of the data with respect to incorporating perceived economic shocks. For example, the effects of the pandemic took several weeks to months to appear completely in variables such as inflation, unemployment and real output. The most useful and earliest insights into how aggressively the financial landscape and its key players might be affected by economic stress is through data on consumer sentiment. Not only are these indices released quickly but they also "provide good forecasts of future economic activity… [given its] causal influence" on the economy (Piger, 2003). Incorporating consumer sentiment into the Taylor rule will not only increase transparency to the public but it will increase the rules' responsiveness to consumers in dialogue given that the main responsibility of the Federal Reserve is to serve the public by implementing monetary policy.

Historically, the real federal funds rate has strayed from the standard Taylor rule during periods of financial and cultural uncertainty and if the standard Taylor rule had followed a guidepost more closely tied to consumer sentiment, then its outcomes would be more similar to actual monetary policy. Given the impending changes that we can expect to see in the labor force and output gap, it is beneficial to investigate the predictive capacity of historic formulations of the Taylor rule to examine truly how representative they are with respect to previous policy decisions of the FOMC. The goal of this thesis is to uncover inaccuracies in the standard version of the Taylor rule during economic crises as it has proven to be outdated and less thoughtful than previously thought. Results consistent with the hypothesis would demonstrate historic impreciseness in the Taylor rule compared to the real federal funds rate. Additional results will find an updated version of the Taylor rule incorporating data on consumer sentiment that will prove advantageous to more adequately model decisions on previous monetary policy and address the systemic change in the economic landscape that we are likely to see in the near future. Finally, this thesis will propose how future studies can further improve on the Taylor rule to maintain thoughtfulness and precision.

The remainder of the paper is structured as follows: Section II discusses relevant literature within the discipline that supports the stated hypothesis. Section III contains the Theory where the quantitative regression model(s) used is presented. Section IV discusses the data utilized within this study. Summary statistics and tests for variable correlations are presented. Section IV provides context to assist readers in understanding and visualizing the data. Section V outlines the data collection process and the transformations made to resolve issues that are associated with time-series data sets. Section VI presents the Results and Analysis of initial and final regressions of Model 1 and Model 2. Finally, Section VII will contain conclusions about the results obtained and implications for the future with respect to continued advancements in the Taylor rule.

II. Literature Review

The Taylor rule suggests a real federal funds rate based on economic conditions such as the inflation rate and potential output. The Federal Reserve conducts monetary policy mainly through their adjustments of the federal funds rate. This is why the Taylor rule and monetary policy often share similar settings in their discourse. The general formula of the standard Taylor rule is as follows:

$$\mathrm{r} = p + 0.5y + 0.5(p - 2) + 2 \qquad \text{Equation 1}$$

where,

r = the federal funds rate

p = the rate of inflation over the previous four quarters

y = the percentage deviation of real GDP from a target (Okoye, 2018).

The Taylor rule suggests a real federal funds rate, r, to be implemented by the Federal Reserve. In practice,

> The real federal funds rate is expected to rise "in the event of inflation (p), rising above the target rate of 2 percent, or if real GDP (y) surpasses the estimated GDP for a given economic year… In the case where both the inflation rate and GDP are within the expected target, r would be equal to 4 percent, which is 2 percent in real terms" (Okoye, 2018).

2.1 A Strict Interpretation of the Taylor rule

Previous literature shared by author Athanasios Orphanides, Economist and Professor of the Practice of Global Economics and Management at MIT, discusses a strict interpretation of the Taylor rule. John Taylor's original rule estimates inflation utilizing the year-over-year change of the GDP deflator which represents the prices of all goods and services produced within the United States including exports. The deviation of real GDP from the FOMC's target level of GDP, usually referred to as the output gap, is measured as the excess of actual GDP over potential output. Taylor's initial coefficient of 0.5 represents the divergence of inflation and the output gap: for every 1% increase in either inflation or the output gap should result in a 0.5% increase in the federal funds rate (Real Vision, 2022). The weighted coefficient is in essence a measure of sensitivity to change in output or inflation. An increase in output causes inflationary pressure to increase price levels, thus generating a response from the Federal Reserve to increase the real federal funds rate by the sensitivity weight.

Orphanides concludes that the standard Taylor rule can be difficult to measure, specifically the production potential of the economy, and that these variables have previously been "obtained by observation of past macroeconomic behavior—either through informal inspection of the data, or more formally as embedded in models [insinuating that] the future will be like the past" (Orphanides, 2003). Subsequently, the standard Taylor rule is often cited as a backward-looking model. In its creation, John Taylor prefaced that the use of the rule is not necessarily intended for strict interpretation but rather as a guideline to suggest a potential policy. The plethora of ways to represent economic indicators such as inflation and the output gap inject a certain amount of subjectivity into the rule. Thus, since its inception, modified versions of the original Taylor rule have been created to generate alternative prescriptions of a suggested nominal federal funds rate based on substituted economic indicators for variables such as inflation and the output gap.

2.2 The Taylor Rule Through Times of Economic Crises

Previous literature and data show that the results of the Taylor rule prior to 1993 are in line with the nominal federal funds rate established by the Federal Reserve due to the creation of the rule being based on historical performance prior to its own inception (Carlstrom and Fuerst, 2014). However, the results of the Taylor rule in the years post 1993 show more frequent divergences from the nominal federal funds rate. Subsequently, there is much debate over its accuracy despite the rule ever having claimed to be as such.

In the aftermath of the attacks on the World Trade Center and the Pentagon September 11, 2001, the Federal Reserve reduced interest rates four times in the subsequent three months. Immediately following the attacks, consumer spending and confidence as well as investment spending fell dramatically forcing the Blue-Chip Consensus GDP growth forecast to be revised down 0.5%, and 1.2% for 2001 and 2002 respectively (Neely, 2002). It was evident that an economic slowdown was imminent, but some economists believe that the FOMC moved rates far too low from 2002-2006 as large deviations from the Taylor rule are present within this time period. Others justify these deviations as they aligned with the dual mandate's pursuit of price stability and full levels of employment. If the Federal Reserve had aligned their policy with the prescriptions of the Taylor rule at this time, interest rates would have been unnecessarily high. Thus, if the Federal Reserve had in fact follow the interest rate recommendation of the Taylor rule during this period, abnormally high inflation would be somewhat tamed given that a slightly higher interest rate will not induce as much consumer spending, but consumer confidence would be hurt even further and high rates of unemployment would continue to persist. With the Phillips curve in mind, the FOMC enacted a decision regarding monetary policy that digressed from the Taylor rule but that bore in mind their dual mandate by reducing the risk of deflation and high unemployment (Groshenny, 2011).

Other outstanding deviations from the Taylor rule include the year shortly after the 2007-2008 financial crisis of and the Covid-19 pandemic. Emergency rate cuts were made in both cases when the effective federal funds rate was lowered to essentially zero percent. These rate cuts were not in line with the Taylor rule but were necessary to ease the effects of the unprecedented times and to provide short-term economic relief to the large number of people experiencing joblessness in the United States.

2.3 Variants of the Taylor rule

One previous journal from 2010 examines if variants of the Taylor rule could accurately model the monetary policy decisions of the Federal Reserve over time. Three models were examined with the first being the standard backward looking Taylor rule representing inflation with the year-over-year percent change in the GDP deflator and the output gap with the deviation of real GDP from a quadratic time trend. The study concluded that the third model best depicted the behavior of the federal funds rate in which inflation was represented by the Blue Chip inflation forecast (uses CPI until 1998 and GDP deflator from 1999 on), the current output gap by the difference between the current and natural rates of unemployment and the anticipated change in the output gap by the difference between the Blue Chip GDP growth forecast and a five-year average of the GDP growth rate (Fernandez, Koenig and Nikolsko-Rzhevskyy, 2010).

Another journal found that the unemployment rate proved to be the most beneficial measure for the output gap. Contextually, modeling the output gap via the unemployment rate is logical. In the early 1960s, Yale professor and economist Arthur Okun developed a widely used model relating the inverse relationship between output and unemployment commonly referred to as Okun' law. This linear regression model predicts how much unemployment will fall if output rises and vice versa. In an annual report from 1948 through 2011, to see a decrease in the unemployment rate, output growth needed to be above 3.4 percent (Meyer and Tasci, 2012). The report continues on to state the following:

> "As with any rule of thumb, its usefulness hinges on its applicability in a variety of settings and across different time periods…For Okun's rule to be useful as a rule of thumb, the relationship between real GDP growth and the unemployment rate needs to be stable across time. That is, we would need to have a reasonable expectation that today's relationship between output and the unemployment rate would behave in the same way tomorrow. Unfortunately, that does not appear to be the case, making it harder to draw simple inferences about unemployment rate movements from observed changes in output growth" (Meyer and Tasci, 2012).

As mentioned above, standard rules are helpful in guiding policy decisions of the future, but they often lack usefulness during times of economic, political or cultural uncertainty. However, the unemployment rate has proven to be a helpful guidepost in monitoring the output gap within the United States.

Lagged explanatory variables have proven as useful in promoting accurate performance within in the Taylor rule in line with actual monetary policy. Specifically,

> "Researchers have found that, unlike stated in the original Taylor-rule specification, the Federal Reserve tends to move incrementally, in a series of

> small or moderate steps in the same direction – a process called interest-rate smoothing or gradualism, usually modeled by including one or more lagged values of the federal funds rate as right-hand- side variables in the Taylor-rule equation" (Fernandez, Koenig and Nikolsko-Rzhevskyy, 2010).

Contextually, lagging variables within the Taylor rule is necessary since the Federal Reserve makes decisions on monetary policy based on how the overall economic landscape has improved or worsened in the previous period. The study concludes that "monetary-policy rules' performance varies as different inflation and output gap statistics are used" and suggests a rule that includes "both gradualism and preemption in order to describe Federal Reserve funds-rate decisions consistently well" (Fernandez, Koenig and Nikolsko-Rzhevskyy, 2010).

In 2007, Vice Chairman of the Board of Governors, Donald L. Kohn, discussed the progression of inflation modeling over time initially starting with the GDP deflator and later reworked by other economists to be represented by the Consumer Price Index (CPI) (Kohn, 2007). More recently, the Federal Reserve has emphasized monitoring inflation through the surveil of changes in the Personal Consumption Expenditure (PCE) which is defined by the Bureau of Labor Statistics as a measure of consumer spending on goods and services among households in the U.S (U.S. Bureau of Labor Statistics, 2023). For instance, to more realistically capture the monetary policy decisions of the Federal Reserve, former chairman Ben Shalom Bernake, who served from 2006-2014, modified the Taylor rule by using the PCE deflator to proxy inflation (Marsh, 2022). Other researchers have explored using Core PCE to model future inflation which excludes food and energy frequently cited as volatile sectors. Utilizing core indexes isolates the side of the market that is believed to be stickier with respect to price stability which coincides with the mandate of the FOMC in targeting long term economic stability. Bernake also altered the weight of the output gap coefficient of 0.5 to 1.0. The standard coefficient of 0.5 states that for every one percent increase in either GDP or the output gap, there should be a 0.5% increase in the federal funds rate. By increasing this coefficient to 1.0, Ben Bernake made the overall sensitivity of the model by generating a more severe response in the real federal funds rate to changes in right hand-sided variables (Marsh, 2022).

Faintly, a study in 2020 tested two different specifications of the Taylor rule based on Turkey's economy given its increasingly transparent central bank. The first model slightly alters the original Taylor rule by adding in Turkey's real exchange rate. This addition to the Taylor rule was made based on previous data emphasizing the sensitivity that changes in the country's exchange rate has on Turkey's economy. The second model takes the original Taylor rule into account in addition to the country's real interest rate. In this study, both models proxy inflation with the annual percent change of CPI while the output gap is represented by the HP filter of logarithmic output (Deniz, Stengos and Yazgan, 2020).

The subjective nature of the variables within the model is what further makes the Taylor rule a mere guidepost to monetary policy rather than a strict directive allowing the Federal Reserve to defend themselves when they are chastised for deviating from the rule (Carlstrom and Fuerst, 2014). But studies have shown that ‘‘If the policy rule comes so close to describe actual Federal Reserve behavior in recent years and if FOMC members believe that such performance was good and should be replicated in the future even under a different set of circumstances, then a policy rule could provide some guidance to future decisions (Orphanides, 2003).

2.4 Consumer Sentiment

Vice Chairman Donald L. Kohn of the Board of Governors highlighted the importance of simplistic rules such as the Taylor rule in keeping the public informed about potential FOMC decisions (Kohn, 2007). Previous critics of the Taylor rule have cited its lack of ability in taking forecasted economic developments into account (Fernandez, Koenig and Nikolsko-Rzhevskyy, 2010). A likely solution to this problem could be incorporating an exogenous variable that potentially will be able to insert some forecasting ability into the model. Consumer sentiment is a measurement of the economy's health based on consumer opinion. This measurement monitors "people's feelings toward their current financial health, the health of the economy in the short-term, and the prospects for longer-term economic growth, and is widely considered to be a useful economic indicator (Liberto, 2021). This measure provides a sense of how consumers are feeling and how willing and able they are to spend given the current or impending state of the economy.

The actions of consumers have a large impact on every economic indicator including inflation, unemployment and price levels. Other economic indicators take several months before they are fully realized in statistical data, resulting in late monetary policy reactions. Consumer sentiment is physically a timely variable as it is released at the end of the month whereas other variables modeling inflation, or the output gap take an additional month to be released. Consumers are good at forecasting the potential economic activity especially during periods when inflation is not volatile but proves to be less reliable during periods of economic instability (Federal Reserve Bank of St. Louis, 2021). Indices such as this provide data on how consumers are currently feeling given what the future could possibly be, whether that is positive or negative. Thus, consumer sentiment could serve as a variable that reflects the earliest signs of crisis. Consequently, the addition of consumer sentiment into a Taylor rule could provide a forecast of future economic well-being and foreshadow potential economic shocks or crises.

2.5 Summary

The literature review above reveals the complexity of the standard Taylor rule. John B. Taylor never intended the rule to be strictly interpreted, rather to serve as a guidepost to aid central banks such as the Federal Reserve in monetary policy. It is clear that deviations from the standard rule are common during periods of economic and cultural uncertainty. The plethora of ways to represent the rules' components inserts much subjectivity into the model based on the level of inclusivity and thoughtfulness of how its variables are modeled. But a model that is able to more accurately describe previous behaviors, including deviations from the rule, would be useful to not only FOMC members but to the general public. Incorporating an exogenous variable into the Taylor rule such as consumer sentiment could provide the model with the accuracy it has long desired while predicting periods of economic uncertainty ahead.

III. Theory

This study explores qualitative data to discover historic deviations in previous monetary policy implementation from the standard Taylor rule in the U.S. Further inquiry will test if an alternate version of the Taylor rule, including values representative of consumer sentiment, causes its outcomes to be more similar to actual monetary policy.

3.1 The Standard Taylor Rule

As previously stated, the original Taylor rule is as follows:

$$r = p + 0.5y + 0.5(p - 2) + 2 \qquad \text{Equation 2}$$

where

r = the federal funds rate

p = the rate of inflation over the previous four quarters

y = the percentage deviation of real GDP from a target (Okoye, 2018).

The standard Taylor rule will initially be tested against historic values of monetary policy to gauge where significant deviations occur and to assess a starting point for model improvement. A basic multivariate regression model is used to test the relationship between independent variables and a single dependent variable. The independent variables include those stemming from the original Taylor rule with an additional exogenous variable added into the right-hand side of Model 2. The regression will be used to assess if the addition of this external factor improves the predictive power of the model.

3.2 The Model for Quantitative Data

$$\hat{y} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon \qquad \text{Equation 3}$$

Where:

- $\hat{y}$ is the dependent variable of the regression.
- β_0 is the intercept if all X values equal zero. In the standard Taylor rule, the economy's steady state equilibrium occurs when the federal funds rate is 2% above the inflation rate.
- β_n represents the coefficients which reveals how much the dependent variable is expected to increase/decrease when the independent variable increases/decreases by one unit.
- X_n represents the independent variables.

3.3 Time Series Analysis

This case study includes data that requires time series analysis. A data set qualifies as a time series if the sequences of data points occur in successive order over some period of time. Accordingly, each observation in this data set is numeric as parameters from every month from January of 1978 through January of 2023 are recorded. Time series research provides a means to discover a temporal component to the data, uncovering patterns that can possibly be used to create future projections.

A prerequisite for modeling time series data will be testing for stationarity meaning that the statistical properties of the data remain constant over time. If stationarity is not found, then the data will need to be transformed. Further discussion resolving the issue of stationarity and a unit root will be presented in the Methodology section that follows. The evolution of the model with respect to variable transformation will also be presented and explained. Additional corrections for autocorrelation among variables will be conducted to improve the predicting power of the model.

3.4 Representation of Variables

As mentioned in the Literature Review, John Taylor's original rule estimates inflation utilizing the year-over-year change of the GDP deflator. The GDP deflator represents the prices of all goods and services produced within the United States (The Investopedia Team, 2023). Taylor modeled the output gap using the deviation of real GDP from the FOMC's target level of GDP as measured as the excess of actual GDP over potential output (Real Vision, 2022). In order to correctly isolate the potential increase in the model's predicting power, variables will be chosen on a strict basis in an attempt to closely resemble the original Taylor rule formula.

There is much complexity in deciding how variables such as inflation and the output gap should be modeled. There are hundreds of economic factors that influence these variables. In theory, it would be ideal to create a data set that aggregates every variable that the literature presents as a good measure of inflation and the output gap. Similarly, consumer sentiment could be modeled through the collection of a spectrum of variables that reflect different aspects of consumer sentiment unveiling a possibly more accurate picture of the variation in consumer confidence in the United States. The feasibility of creating a data set such as this is not attainable given the countless ways in which these variables could be represented and the time frame of this case study. Consequently, the Data sections will explain how each of these variables will be modeled in this thesis.

IV. Data

This section outlines each variable utilized in the multivariate regression for analysis. Independent and dependent variables will be identified, and their modeling selection will be justified. Additional summary statistics and correlation coefficients will be presented. These summary statistics will be contextualized to outline and explain the data set to readers. Furthermore, potential limitations and flaws will be identified to provide transparency for review of the modeling and analytical process.

This data set originates from the Federal Reserve Economic Database (FRED). Each variable within the regressions were collected on a monthly basis beginning January 1978 to January 2023. Increasing the scale of measurement expands the predicting power of the model allowing this case study to produce impactful results. The substantial amount of data points available will increase the robustness and reliability of the regression. Hence, parameter estimates will be close to their true population values given that the standard error of the coefficients will be low. Large data sets enhance the statistical power of the model allowing for relationship subtleties between variables to be detected.

4.1 Dependent Variable

The original Taylor Rule predicts the real federal funds rate given that the rate of inflation is at its target level and the output gap is zero. The dependent variable for this original rule involves the real federal funds rate. However, in this study, it will be modeled strictly as Effective Federal Funds Rate (EFFR) measured on a monthly basis, not seasonally adjusted, from January of 1978 until January of 2023.

It was important to utilize a dependent variable that closely resembled the real federal funds rate. Given this, it is necessary to distinguish between the real federal funds rate and the Effective Federal Funds Rate (EFFR). As previously mentioned, the former can be defined as the interest rate at which depository institutions lend reserves balances to one another on an overnight basis, set by the FOMC. The Federal Reserve influences monetary policy directly through changes in the real federal funds rate. Furthermore, it is the nominal federal funds rate adjusted for the effects of inflation over time. The Effective Federal Funds Rate is a volume-weighted median of overnight federal funds transactions across all transactions from central banks in the United States (Federal Reserve Bank of New York n.d.). This rate is “essentially determined by the market but is influenced by the Federal Reserve through open market operations to reach the federal funds rate target” (Board of Governors of the Federal Reserve System (US), 2023).

4.2 Independent Variables

Independent variables were chosen and identified based on previous literature and from the available data at hand. Various interpretations of the original Taylor rule measure the rate of inflation and the output gap differently. Therefore, there is much debate over what measures are most accurate to model these economic measures.

4.2.1 Inflation. Previous studies have discussed the progression of inflation modeling within the original Taylor rule over time. Early models have represented the overall changes in price levels beginning with the GDP deflator while later renditions used the Consumer Price Index (CPI) (Kohn, 2007). However, the Federal Reserve states its inflation target in terms of PCE and it is generally their preferred method of tracking increases or decreases in price levels (Haubrich and Millington, 2014).

The PCE index sources its data from surveys of businesses, while CPI is measured based on surveys of consumers. “This choice ensures PCE captures expenditures that are made on behalf of consumers, like health insurance paid for by employers or government assistance programs” (Curry, 2023). Additionally, this index accounts for substitutions that consumers make when items they frequently buy become more expensive. Given this, slight modifications in weekly and monthly purchases are taken into account when price level changes are modeled through PCE rather than CPI (Curry, 2023). In his own modeling process, former chairman of the Federal Reserve Ben Shalom Bernake modified the Taylor rule by using the PCE deflator to proxy inflation instead of CPI. However, if price levels were to be modeled by PCE, it would be necessary to obtain data on the PCE deflator specifically. As a result, this study utilizes the Personal Consumption Expenditures Chain-type Price Index, acting as a PCE Deflator, to model inflation. The Personal Consumption Expenditures Chain-type Price Index was developed by the Bureau of Economic Analysis (BEA) and displays a measure of price changes that individuals within the United States are experiencing, or those buying on their behalf, based on the linking of indexes for consecutive periods to form a time series (Federal Reserve Economic Data, 2023). The PCE Chain-type Price Index captures inflation over a prolonged period of time based on changes in consumer behavior.

4.2.2 The Output Gap. There are several labor market indicators that can sufficiently model the output or productivity gap. These can include the unemployment rate, the labor force participation rate and the employment-to-population ratio. For the purpose of this study, the output gap will be modeled by the unemployment rate. Previous research has found the unemployment rate to be the best measure of the output gap. The output gap and the unemployment rate are directly related throughout business cycle fluctuations over time. An increase in the unemployment rate above its natural level is oftentimes associated with output falling below its potential, and vice versa. Consequently, the unemployment rate will represent the output gap in both multivariate equations.

4.2.3 Consumer Sentiment. The most frequently used index to model consumer sentiment within the United States has been the University of Michigan Consumer Sentiment index. The index is created as follows:

> "Each month, the university conducts a minimum of 500 phone interviews across the continental U.S. The survey asks 50 core questions and covers three areas: personal finances, business conditions, and buying conditions" (Hayes, 2023).

Consumers across the country are surveyed based on the following five questions:

1. "We are interested in how people are getting along financially these days. Would you say that you (and your family living there) are better off or worse off financially than you were a year ago?
2. Now looking ahead – do you think that a year from now you (and your family living there) will be better off financially, or worse off, or just about the same as now?
3. Now turning to business conditions in the country as a whole – do you think that during the next twelve months we'll have good times financially, or bad times, or what?

4. Looking ahead, which would you say is more likely – that in the country as a whole we'll have continuous good times during the next five years or so, or that we will have periods of widespread unemployment or depression, or what?
5. About the big things people buy for their homes – such as furniture, a refrigerator, stove, television, and things like that. Generally speaking, do you think now is a good or bad time for people to buy major household items?" (University of Michigan, n.d.).

Consumer sentiment should reflect a spectrum of variables that affect the lives of those living in the United States. Similarly, the Taylor rule should be responsive to consumers in dialogue as the main responsibility of the Federal Reserve is to serve the public by implementing monetary policy.

4.3 Summary Statistics

The chosen variables were ready to be tested for potential covariance through a correlation coefficient test measuring their statistical significance. Included below is descriptive statistics for the dependent and independent variables that are contained within both multivariate models. This table provides measures of dispersion and concentration for each variable between 1978 and 2023 by outlining the mean, standard deviation, and minimum/maximum.

Table 1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Effective Federal Funds Rate (EFFR)	550	4.632	4.081	.05	19.1
Unemployment Rate	550	6.114	1.76	3.4	14.7
PCE Chain-type Price Index	549	74.756	22.178	31.011	120.953
UM Consumer Sentiment	548	85.111	13.198	50	112

Source: Author's Calculations

Variables in which the presence of correlation with respect to covariance was also tested in association with one another. The matrix of correlations for each variable is listed below in Table 2.

Table 2: Matrix of Correlations

Variables	(1)	(2)	(3)	(4)
(1) Effective Federal Funds Rate (EFFR)	1.000			
(2) Unemployment Rate	0.109	1.000		
(3) PCE Chain-type Price Index	-0.822	-0.301	1.000	
(4) UM Consumer Sentiment	-0.048	-0.404	-0.052	1.000

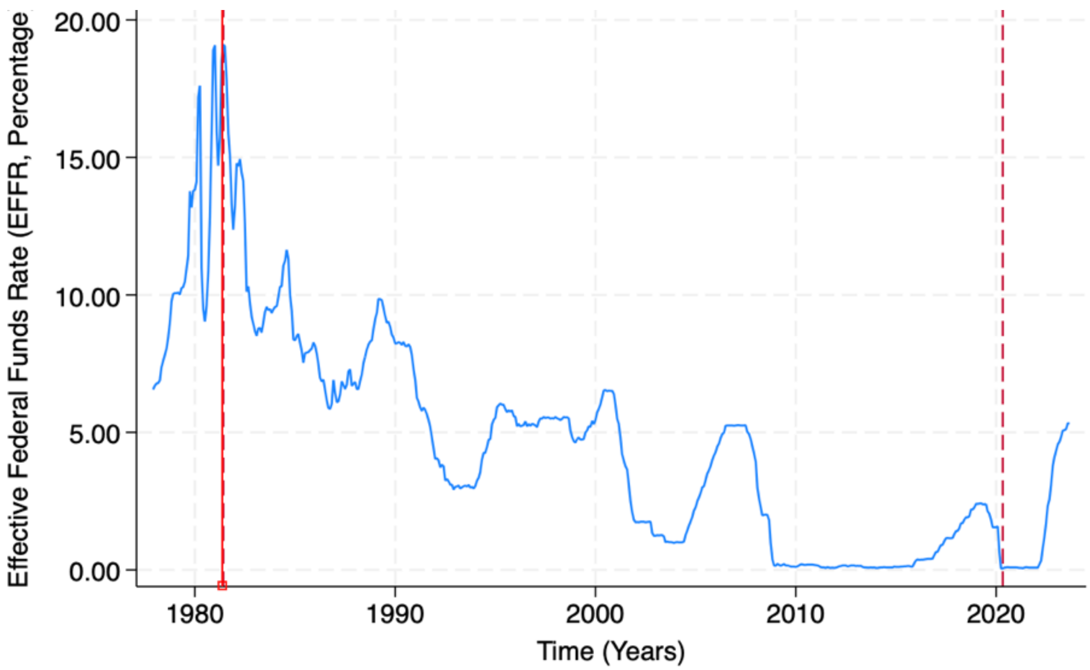
Source: Author's Calculations

4.4 Contextualizing the Data

Interpreting summary statistics for each variable is a necessary step in painting a picture of the data set. With respect to the dependent variable, the Effective Federal Funds Rate (EFFR), its standard deviation was 4.08 percent from the mean of 4.632

percent. Both the maximum and minimum Effective Federal Funds rate values, in 1981 and 2020 respectively, are highlighted and can be seen in Figure 1 below.

Figure 1: The Effective Federal Funds Rate from 1978 through 2023



Source: Author's Calculations

The maximum value from 1978 through 2023 of the EFFR occurred during June of 1981. During this period, the Federal Reserve hiked interest rates significantly to compensate for spiraling inflation nearing close to 15 percent. Double-digit inflation was mainly a result of the following:

> "In the late 1970s, in America, prices were rising fast. In other words, inflation was running rampant, usually thought to be the result of the oil crisis of that era, government overspending, and the self-fulfilling prophecy of higher prices leading to higher wages leading to higher prices" (Volcker, 2009).

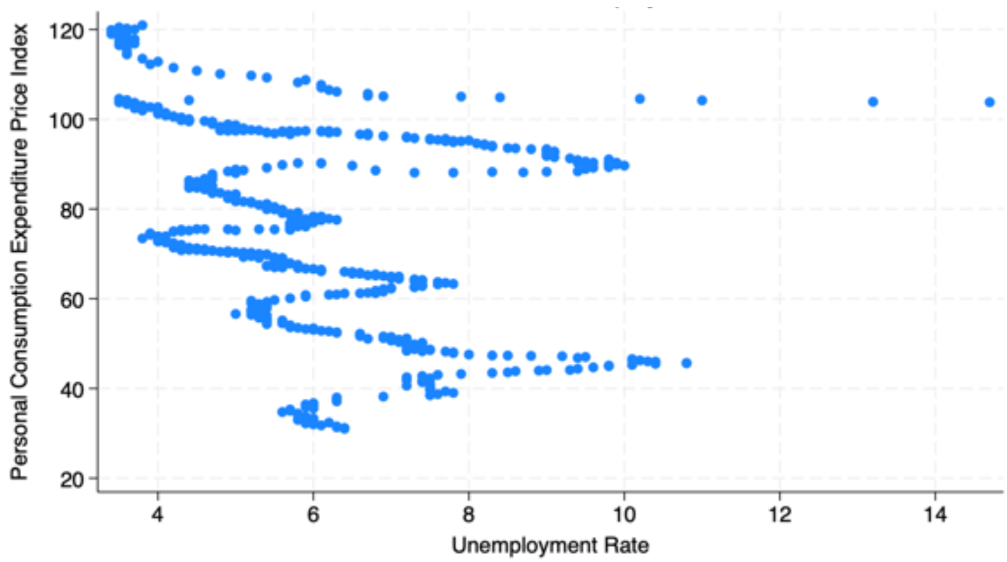
The EFFR hit a minimum value of 0.05 percent in May of 2020 during the peak of the global COVID-19 pandemic. Low interest rates were a product of quantitative easing (QE) instituted by the Federal Reserve to stimulate spending within the economy. According to the Congressional Research Service,

> "To provide more stimulus, the Fed also made large-scale purchases of Treasury securities and mortgage-backed securities in an effort to reduce interest rates generally. Those purchases also added more liquidity to the financial system…In April alone, the Fed's securities holdings increased by about $1.2 trillion. The Fed [had] financed all of these activities by expanding its balance sheet, which surpassed its previous all-time high ($4.5 trillion) by March 2020 and exceeded $7 trillion by May 2020" (Labonte, 2021).

Thereafter, the Fed did not raise interest rates until the economy reached full unemployment and was able to consistently maintain the natural steady-state rate of inflation.

Analysis of the unemployment rate and the Personal Consumption Expenditure Chain-type Price Index concludes that there is a correlation between the two independent variables over time, as seen in Figure 2 below.

Figure 2: PCE Price Index vs. Unemployment Rate from 1978 through 2023

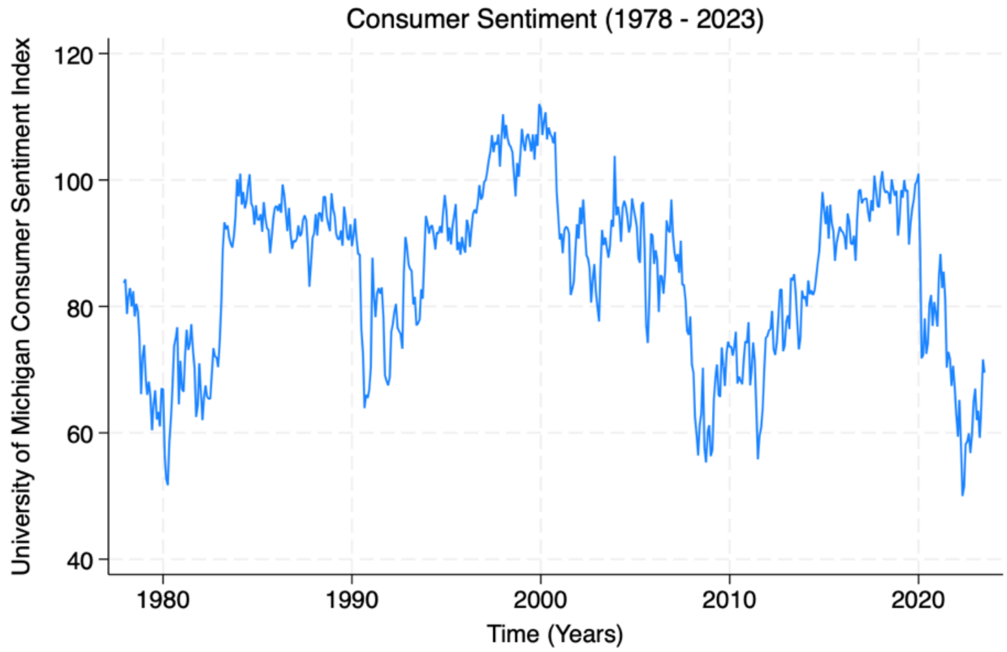


Source: Author's Calculations

At low unemployment rates, wages and price levels are historically higher whereas higher rates of unemployment often saw lower price levels. This inverse relationship is often referred to as the Phillips Curve. The dramatic pattern visible in this figure can be explained by the transitory periods between the natural shifts in the economy.

Summary statistics displayed that the mean index of Consumer Sentiment from 1978 through 2023 was 85.111 units with a standard deviation of 13.198 units. Notable bottoms in consumer confidence occurred during the onset of the Financial Crisis and the COVID-19 Pandemic in June of 2008 and April of 2020, respectively. Fluctuations in the University of Michigan Consumer Sentiment Index can be seen in Figure 3.

Figure 3: The University of Michigan Consumer Sentiment Index from 1978 through 2023



Source: Author's Calculations

Finally, over the past four decades consumer sentiment has been negatively correlated with the Effective Federal Funds Rate (EFFR), the unemployment rate and the Personal Consumption Expenditure Chain-type Price Index.

4.5 Limitations of the Data

Throughout the data collection process, several limitations presented themself. As the previous literature suggests, there are many variables available that could adequately model changes in price levels, the output gap, the real federal funds rate and consumer sentiment. This case study selected data in which prior cases studies found to accurately model the chosen variables. In addition to this, modeling for the independent variables were chosen based on how the Federal Reserve states its target levels of inflation and output. An additional requirement for each variable within the multivariate regression was the frequency of the variables' data collection. To produce impactful results, both independent and dependent variables within the models required monthly data.

A notable limitation pertains to the addition of consumer sentiment into the second model. Ideally, this study would have preferred to measure this independent variable with a spectrum of variables that reflect different aspects of consumer sentiment rather than solely through the University of Michigan Consumer Sentiment index. The Taylor rule should be responsive to consumers in dialogue. Monetary policy decisions should be based on data from the individuals themselves who are directly affected by the Federal Reserves' implementation of policy because it is a tool that is intended to serve the people. Therefore, representing consumer sentiment through the University of Michigan Consumer Sentiment index was the most accurate portrayal of consumer confidence levels in the United States given the time limitations of this case study.

V. Methodology

5.1 Data Collection

This case study uses data collected from the Research Division of the Federal Reserve Bank of St. Louis. This division contains over 816,000 economic time series from national, international, public, and private sources (Federal Reserve Economic Data, 2023). The dissertation at hand utilizes a uniquely compiled dataset composed of variables measured on a monthly basis from 1978 and 2023. These dates were selected not only based on the data available but also due to recommendations from the previous literature.

This uniquely compiled data set contains points of reference pertaining to the COVID-19 pandemic. The decision to incorporate these dates is purposeful given that the purpose of this case study is to uncover possible inaccuracies in previous Taylor rule prescriptions compared to actual monetary policy and develop a more meaningful version of the rule to better represent policy decisions during points of economic uncertainty. In the first model presented, the variables representative of the original Taylor rule's components, inflation and the output gap, were modeled through the monthly Personal Consumption Expenditure Chain-type Price Index and the monthly rate of unemployment in the United States, respectively. The second model introduces surveyed data from the University of Michigan Consumer Sentiment index as an exogenous variable into the original Taylor rule.

5.2 Analyzing & Transforming the Data

After compiling and cleaning the data, necessary transformations were made to the variables. Previous studies investigating if alternative versions of the Taylor rule can describe Federal Reserve policy decisions have found that the Federal Reserve utilizes a technique referred to as interest rate smoothing wherein policymakers alter the federal funds rate in small increments in the same direction. This is frequently modeled by lagging the components of the Taylor rule. Additionally, the Federal Reserve tends to base decisions on monetary policy based on how the economic environment has improved or worsened in the previous month. As a result, it became evident that lagging independent variables modeling inflation and the output gap by one period would be necessary. Consumer sentiment was also a necessary independent variable to lag given that its data is based on a survey of consumer confidence within the United States. Consumer confidence in the present period is significantly dependent on how consumers felt in the previous period and if they expect economic conditions to worsen or improve. Consequently, this variable will also be lagged by one period.

5.3 Testing for Stationarity

Given that the uniquely compiled data set is a time series, tests for stationarity had to be conducted to prove that the statistical properties of the time series do not change over the specified period of time. This is a necessary step before running regressions. Thus, a statistical diagnostic such as the Augmented Dickey-Fuller Unit Root test had to be performed on the data. This type of statistical test proposes the following null and alternative hypothesis:

Null Hypothesis (HO): The time series is non-stationary and contains a unit root.

Alternative Hypothesis (HA): The time series is stationary and does not contain a unit root.

The Augmented Dickey-Fuller Unit Root Test indicated that there was non-stationarity and a unit root present. With each Dickey-Fuller test conducted, experimenting with various lags of zero through twelve, the null hypothesis could not be rejected, and subsequent steps were taken to resolve the issue of non-stationarity and a unit root. Both the lagged versions of the dependent and independent variables were first differenced to resolve the unit root and issue of non-stationarity. First differencing is an essential step in removing trends from time series data, making the statistical properties of the data stationary. After the statistical properties of the data set were transformed, the Augmented Dickey-Fuller Unit Root Test was run again. Its results proved the model to be stationary and without a unit root given that the test statistics contained a p-value that was less than the chosen significance level of 0.01. Thus, the null hypothesis was able to be rejected with more than 99 percent confidence and the time series was stationarity and without a unit root.

After all regressions were run and the final model was found, the Breusch-Pagan test for heteroskedasticity and constant variance of errors was run. The null hypothesis in this test is that there is no heteroskedasticity in the regression model meaning that the variance of the error term is constant across independent variables. The Chi Squared value of a Breusch-Pagan Test was larger than the critical value meaning that we can reject the null hypothesis. Thus, there heteroskedasticity was present within the model and alterations were required to be made. To fix the issue of heteroskedasticity, the Newey West correction was utilized. This correction adjusts the standard errors of the coefficients in the regression model generating robust standard errors while also correcting serial correlation detected among the variables within the model. The final regression for Model 1 and Model 2 was rerun with the Newey West correction thereby correcting for heteroskedasticity and the autocorrelation of errors.

5.4 The Initial Models

Two models were run to determine statistical significance between independent and dependent variables. The first model provided context for when the Taylor Rule diverges from actual monetary policy and its independent variables will represent the original components of the Taylor Rule as precisely as possible. Conclusions for when the original Taylor rule diverges from monetary policy will be drawn. This first model will contain the lagged independent variables representative of inflation and the output gap mentioned to create the following multivariable equation:

$$Effective\ Federal\ Funds\ Rate, EFFR_t = \qquad \text{Equation 4}$$

$$\beta_0 + \beta_1(\text{Personal Consumption Expenditures Chain} - \text{type Price Index})_{t-1} + \beta_2(\text{Unemployment Rate})_{t-1} + \varepsilon$$

The second model will include independent variables contained in the initial model with the addition of the University of Michigan Consumer Sentiment Index. The second multivariate model is as follows:

$$Effective\ Federal\ Funds\ Rate, EFFR_t = \qquad \text{Equation 5}$$

$$\beta_0 + \beta_1(\text{Personal Consumption Expenditures Chain} - \text{type Price Index})_{t-1} + \beta_2(\text{Unemployment Rate})_{t-1} + \beta_3(\text{University of Michigan Consumer Sentiment Index})_{t-1} + \varepsilon$$

5.5 Model Alterations

As a result of first differencing both the dependent and independent variables as discussed in Methodology, the structure of the model itself remained the same, however, its components were altered.

The standard form of the model is displayed below:

$$\hat{y} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon \qquad \text{Equation 6}$$

The independent and dependent variables from Equation 4 were first differenced to resolve the issue of stationarity and a unit root. Thus, the entire model lagged by one period results in the following:

$$Effective\ Federal\ Funds\ Rate, EFFR_{t-1} = \qquad \text{Equation 7}$$

$$\beta_0 + \beta_1(\text{Personal Consumption Expenditures Chain} - \text{type Price Index})_{t-2} + \beta_2(\text{Unemployment Rate})_{t-2} + \varepsilon$$

As a result of first differencing, the dependent variable must equal the first difference of the Effective Federal Funds Rate. For the model to contain a first difference dependent variable, Equation 4 subtracted from Equation 7 yields the following result:

$$Effective\ Federal\ Funds\ Rate, EFFR_{\_d} = \qquad \text{Equation 8 \& Model 1}$$

$$\beta_1(\text{Personal Consumption Expenditures Chain} - \text{type Price Index})_{(t-1)\,(d)} + \beta_2(\text{Unemployment Rate})_{(t-1)(d)} + \varepsilon$$

Effectively, Model 2 yields a similar result:

$$Effective\ Federal\ Funds\ Rate, EFFR_{\_d} =$$ Equation 9 & Model 2

$$\beta_1(\text{Personal Consumption Expenditures Chain} - \text{type Price Index})_{(t-1)\,(d)} +$$

$$\beta_2(\text{Unemployment Rate})_{(t-1)(d)} +$$

$$\beta_3(\text{University of Michigan Consumer Sentiment})_{(t-1)(d)} + \varepsilon$$

Thus, the first differenced Effective Federal Funds Rate equals the change in the lagged, first differenced Personal Consumption Expenditures Chain-type Price Index plus the change in the lagged, first differenced Unemployment Rate for Model one. Model two would equate to the same model with the addition of the change in the lagged, first differenced University of Michigan Consumer Sentiment index.

VI. Analysis and Results

In this section, the quantitative multivariate regression results are displayed and analyzed. Subsequent models with the additional independent variables including interaction and quadratic terms are presented and the methodology behind their generation is justified. A more accurate and thoughtful version of both Model 1 and Model 2 are found and their regression results are explained thoroughly.

6.1 Initial Regression Results

Regression results for Model 1 are listed in Table 1 below. As previously stated, this regression and its components reflect the original Taylor rule.

Table 1: Taylor rule Multivariate Regression Results

Linear regression

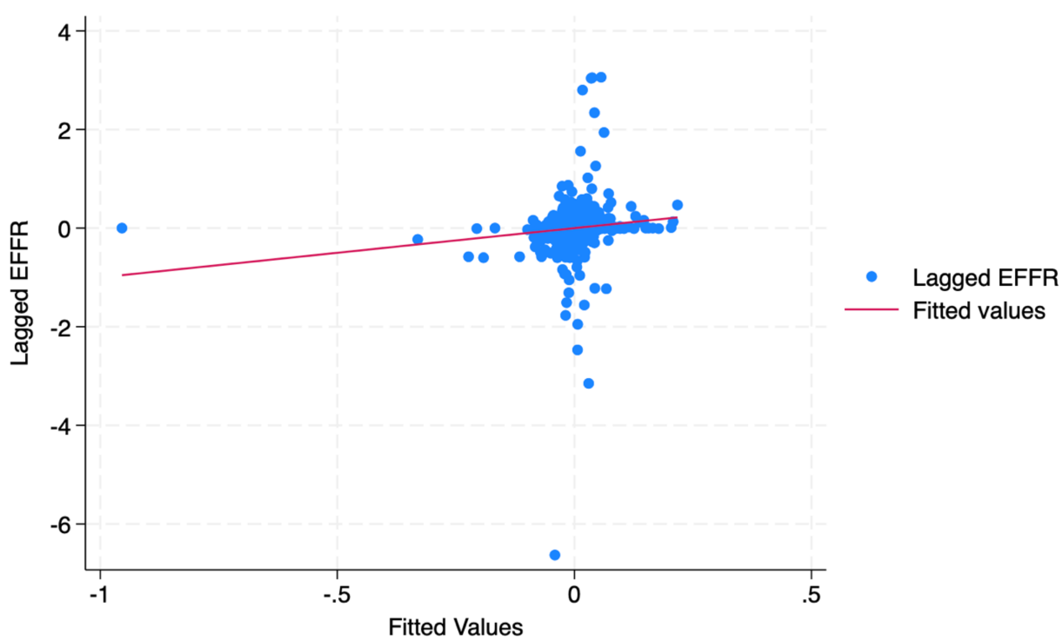
EFFR	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Unemployment Rate	-.078	.047	-1.67	.096	-.169	.014	*
PCEPI	.249	.135	1.84	.066	-.016	.514	*
Constant	-.044	.032	-1.38	.168	-.106	.019	

Mean dependent var	-0.003	SD dependent var	0.534
R-squared	0.014	Number of obs	548
F-test	3.811	Prob > F	0.023
Akaike crit. (AIC)	864.559	Bayesian crit. (BIC)	877.478

Source: Author's Calculations
*Note. *Statistically significant at the 90 percent confidence level,* EFFR = First differenced Effective Federal Funds Rate. Unemployment Rate = Lagged, first differenced unemployment rate. PCEPI = Lagged, first differenced Personal Consumption Expenditure Chain-type Price index. UM Consumer Sent. = Lagged, first differenced University of Michigan Consumer Sentiment index.

The first step in interpreting Model 1's results is to begin looking at the coefficients of its independent variables. The coefficients of (-0.078) and (0.249) within this model prove that increases in the unemployment rate causes the effective federal funds to decrease while increases in price levels cause the effective federal funds rate to increase, respectively. While Model 1 proves that the standard Taylor rule tradeoff between the unemployment rate and inflation is true, there is much more to the story. In this case, the most important regression result to note is the low R-squared value. Despite that the model is significant, as indicated by the model's p-value, the R-squared value is 0.014. This low R-squared value indicates that a very low proportion of the dependent variable is explained by the independent variables within the model. A scatterplot depicting the actual Effective Federal Funds Rate values versus Model 1 of the Taylor rule's prescription of the federal funds rate is shown in Figure 4. The line of best fit, displaying the line with the least sum of square errors, proves that the model's correlation between its dependent and independent variables is weak.

Figure 4: Actual vs. Taylor Rule Predicted Values of the Federal Funds Rate



Source: Author's Calculations

Model 1 contains many outliers along with a cluster of points around the same values. It is worthwhile to point out a few notable outliers to provide context into the data set. The outlier closest in proximity to the Fitted Values axis at a value close to 0 represents May of 2020 and the outlier closest to the Lagged EFFR at a value of 0 represents May of 1980. These outliers represent years in which the real federal funds rate strayed from the Taylor rule dramatically. These points in themselves prove that the Taylor rule struggles to maintain consistency with respect to the real federal funds rate during times of economic uncertainty. Despite the cluster of data points, the model does not accurately describe the relationship between the dependent and independent variable. Thus, we can conclude that the results are consistent with the hypothesis in that historic impreciseness in the Taylor rule compared to the real federal funds rate is demonstrated.

Next, the second model is run in which Consumer Sentiment is added as an independent variable into the model in hopes that it increases the predicting power of the model. When Model 2 is run, the R-squared test statistic is extremely low at a value of 0.015. This can be seen in Table 2 displaying Model 2's results.

Table 2: Taylor rule with Consumer Sentiment Index Multivariate Regression Results

Linear regression

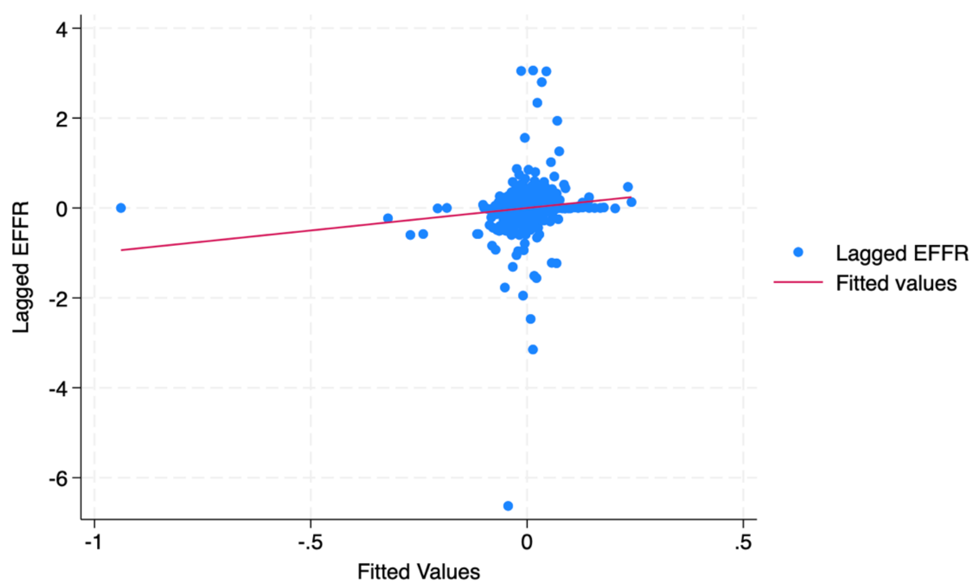
EFFR	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Unemployment Rate	-.076	.047	-1.62	.105	-.168	.016	
PCEPI	.259	.136	1.90	.058	-.009	.527	*
UM Consumer Sent.	.004	.006	0.76	.445	-.007	.015	
Constant	-.045	.032	-1.42	.156	-.108	.017	

Mean dependent var	-0.003	SD dependent var	0.534
R-squared	0.015	Number of obs	547
F-test	2.732	Prob > F	0.043
Akaike crit. (AIC)	865.393	Bayesian crit. (BIC)	882.611

Source: Author's Calculations
*Note. *statistically significant at the 90 percent confidence level,* EFFR = First differenced Effective Federal Funds Rate. Unemployment Rate = Lagged, first differenced unemployment rate. PCEPI = Lagged, first differenced Personal Consumption Expenditure Chain-type Price index. UM Consumer Sent. = Lagged, first differenced University of Michigan Consumer Sentiment index.

The original hypothesis in this case study stated that historically the real federal funds rate has strayed from the standard Taylor rule during periods of financial and cultural uncertainty and if the standard Taylor rule had followed a guidepost more closely tied to consumer sentiment, then its outcomes would be more similar to actual monetary policy. The regression results in Table 2 prove that this hypothesis, with the current linear and simplistic model, is incorrect. It is reasonable to believe that the R-squared value of the Model 2 increased from Model 1 because of adding an additional independent variable into the multivariate regression rather than from the variable itself improving its efficiency. Furthermore, the scatterplot and line of best fit of Model 2 also displays equivalent correlation results and the same outliers as in Model 1 given that residuals lye increasingly far from the actual plotted data points. These results can be seen in Figure 5 below.

Figure 5: Actual vs. Taylor Rule Predicted Values of the Federal Funds Rate Adding Consumer Sentiment



Source: Author's Calculations

Additionally, even with the addition of consumer sentiment, Model 1 and Model 2's independent variable coefficients are almost identical, further emphasizing the lack of significance that consumer sentiment had after being added into the standard Taylor rule.

Therefore, it became apparent at this stage in the modeling process that alternative, and potentially non-linear, models to represent the Taylor rule, as well as a model reflecting thoughtful improvements to the Taylor rule, must be investigated.

6.2 Alternatives to Model 1

Subsequent versions of Model 1 and Model 2 are experimented with and presented in the following section. Independent variables in which statistical significance was evident were kept within the model. Final versions of both Model 1 and Model 2 are presented. The accuracy of the model's dependent variable, the Effective Federal Funds Rate (EFFR), will be compared to historical values of the real federal funds rate from January 1978 through January 2023.

6.2.1 The Addition of the Lagged, First Differenced EFFR. Based on previous research, alterations in the federal funds rate each period are largely based on the value of the real federal funds rate in the previous period. Thus, the first additional independent variable that was considered for Model 1 was the lagged, first differenced Effective Federal Funds itself. The regression results after the addition of this variable are displayed in Table 3 below.

Table 3: Model 1 Multivariate Regression Results with the First Differenced, Lagged EFFR

Linear regression

EFFR	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Unemployment Rate	-.04	.043	-0.92	.356	-.125	.045	
PCEPI	.143	.126	1.14	.255	-.104	.39	
L.EFFR	.379	.04	9.53	0.00	.301	.457	***
Constant	-.025	.029	-0.86	.39	-.083	.032	

Mean dependent var	-0.003	SD dependent var	0.534
R-squared	0.155	Number of obs	548
F-test	33.206	Prob > F	0.000
Akaike crit. (AIC)	782.020	Bayesian crit. (BIC)	799.245

Source: Author's Calculations

*Note. *** statistically significant at the 99 percent confidence level,* EFFR = First differenced Effective Federal Funds Rate. Unemployment Rate = Lagged, first differenced unemployment rate. PCEPI = Lagged, first differenced Personal Consumption Expenditure Chain-type Price index. L.EFFR = Lagged, first differenced Effective Federal Funds Rate.

Clearly, the addition of the lagged, first differenced effective federal funds rate as an independent variable increases the R-squared value of Model 1 from 0.014 to 0.155. The effective federal funds rate is the most significant variable within the model at a 99.99 percent confidence level. However, a R-squared result of 0.155 is not great enough in value to be considered as the final model of this case study because there is still very little of the model's variance that is explained by its independent variables even with the addition of the lagged, first differenced effective federal funds rate. However, the impactful significance of this variable justifies that it remains within the model moving forward.

6.2.2 The Addition of Interaction Terms. Interaction terms were then generated with the intention of aiming to improve the overall significance of the whole model and its R-squared value. In this case, these terms will be able to provide further insight into the model given that interaction terms enable you to examine the relationship between the dependent and independent variable depending on the value of another independent variable. The first two terms created were the interaction that the lagged, first differenced PCE Price Index and the lagged, first differenced Unemployment Rate had with the lagged, first differenced EFFR. These interaction variables were generated based on prior knowledge hypothesizing that the federal funds rate in the previous period could be impacted by what inflation and unemployment looked like in the previous period. Thus, each interaction term was separately introduced into the model in order to effectively isolate their results and determine which one was more impactful.

Firstly, the interaction term between the lagged, first differenced EFFR and the lagged, first differenced PCE Price Index was inserted into Model 1. Its results are displayed in the Table 4 below.

Table 4: Model 1 Multivariate Regression Results Plus the Interaction Between the First Differenced, Lagged EFFR and the First Differenced, Lagged PCE Price Index

Linear regression

EFFR	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Unemployment Rate	-.031	.02	-1.57	.117	-.07	.008	
PCEPI	.095	.057	1.66	.098	-.018	.207	*
L.EFFR	.044	.02	2.25	.025	.006	.082	**
EFFR*PCEPI	3.228	.071	45.61	0.00	3.089	3.367	***
Constant	-.044	.013	-3.31	.001	-.071	-.018	***

Mean dependent var	-0.003	SD dependent var	0.534
R-squared	0.825	Number of obs	548
F-test	640.238	Prob > F	0.000
Akaike crit. (AIC)	-79.171	Bayesian crit. (BIC)	-57.640

Source: Author's Calculations
*Note. *** statistically significant at the 99 percent confidence level, ** statistically significant at the 95 percent confidence level for a two-tail test & *statistically significant at the 90 percent confidence level for a two-tail test.* EFFR = First differenced Effective Federal Funds Rate. Unemployment Rate = Lagged, first differenced unemployment rate. PCEPI = Lagged, first differenced Personal Consumption Expenditure Chain-type Price index. L.EFFR = Lagged, first differenced Effective Federal Funds Rate. EFFR*PCEPI = Interaction term between the first differenced Effective Federal Funds Rate and the lagged, first differenced Personal Consumption Expenditure Chain-type Price index.

The regression results indicate that the addition of lagged, first differenced PCE Price Index as an independent variable increases the R-squared value from 0.155 to 0.825. Next, the interaction variable referencing the lagged, first differenced EFFR and the lagged, first differenced Unemployment rate was inserted into Model 1 to analyze how the two interacting variables affect the model differently. Its results are displayed in Table 5 below.

Table 5: Model 1 Multivariate Regression Results Plus the Interaction Between the First Differenced, Lagged EFFR and the First Differenced, Unemployment Rate

Linear regression

EFFR	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Unemployment Rate	.003	.036	0.09	.931	-.067	.073	
PCEPI	.195	.103	1.89	.059	-.008	.398	*
L.EFFR	.322	.033	9.79	0.00	.257	.386	***
EFFR*Unemployment Rate	1.479	.091	16.28	0.00	1.3	1.657	***
Constant	0	.024	0.02	.986	-.047	.048	

Mean dependent var	-0.003	SD dependent var	0.534
R-squared	0.432	Number of obs	548
F-test	103.216	Prob > F	0.000
Akaike crit. (AIC)	566.272	Bayesian crit. (BIC)	587.804

Source: Author's Calculations

*Note. *** statistically significant at the 99 percent confidence level & *statistically significant at the 90 percent confidence level for a two-tail test.* EFFR = First differenced Effective Federal Funds Rate. Unemployment Rate = Lagged, first differenced unemployment rate. PCEPI = Lagged, first differenced Personal Consumption Expenditure Chain-type Price index. L.EFFR = Lagged, first differenced Effective Federal Funds Rate. EFFR*Unemployment Rate = Interaction term between the first differenced Effective Federal Funds Rate and the lagged, first differenced Unemployment Rate.

The addition of this second interaction term separately caused the R-squared value to increase to 0.432. The most significant independent variables after the addition of both interaction terms were the interaction terms themselves and the lagged, first differenced Effective Federal Funds Rate.

Next, both interaction terms were added into the regression to test how impactful both newly generated independent variables could have on the model simultaneously.

Inserting both interaction terms into the model caused the R-squared value to increase to 0.860. However, the addition of independent variables itself causes the R-squared value to increase because adding many variables increases the sum of squares, accounting for at least some of the additional variance. Thus, the more impactful interaction term will be kept within the model. This will allow the study to avoid increasing how much of the variance in the dependent variable that is explained by the independent variable solely by adding in a large number of independent variables into the model. Given that the R-squared value increases significantly more with the addition of the first interaction term rather than the second, the first term was kept within the model as the analysis progressed forward. An updated variation of Model 1 looks as follows:

$$Effective\ Federal\ Funds\ Rate, EFFR_{\_d} =$$ Equation 10 & Model 1

$$\beta_1(\text{Personal Consumption Expenditures Chain} - \text{type Price Index})_{(t-1)\,(d)} +$$

$$\beta_2(\text{Unemployment Rate})_{(t-1)(d)} + \beta_3(\text{Effective Federal Funds Rate, EFFR})_{(t-1)(d)} +$$

$$\beta_4[\ (\text{Effective Federal Funds Rate, EFFR}\ )_{(d)} *$$

$$(\text{Personal Consumption Expenditure Chain} - \text{type Price Index})_{(t-1)(d)}\ ] + \varepsilon$$

6.2.3 The Addition of Quadratic Terms. After the previous updated model was found, quadratics were introduced to experiment with their potential significance. When testing the initial versions of Model 1 and Model 2, the nonlinear and potentially quadratic relationship between inflation, the output gap and consumer sentiment was worth investigating. Transforming the lagged, first difference versions of these variables into quadratic terms allows this case study to capture the unique relationship between the dependent and independent variables in the regression. Thus, the lagged, first differenced versions of the Effective Federal Funds Rate, Personal Consumption Expenditures Chain-type Price Index and the Unemployment Rate were squared and added into the model.

Variables of statistical significance were left within the model. As a result, the quadratic lagged, first differenced Effective Federal Funds Rate was removed from the model. The model was rerun with and without this variable and their regression results were compared. The R-squared value with and without this independent quadratic variable remained at 0.851 and the coefficients for each independent variable remained constant. The other two quadratic terms were statistically significant at a 99 percent confidence level. Henceforth, the statistically significant quadratic terms were added as independent variables in the model. An updated and final version of Model 1 is presented below in Equation 11.

$Effective\ Federal\ Funds\ Rate, EFFR_{\_d} =$ Equation 11 & Model 1

$\beta_1(\text{Personal Consumption Expenditures Chain} - \text{type Price Index})_{(t-1)\,(d)} +$

$\beta_2(\text{Unemployment Rate})_{(t-1)(d)} + \beta_3(\text{Effective Federal Funds Rate, EFFR})_{(t-1)(d)} +$

$\beta_4[\,(\text{Effective Federal Funds Rate, EFFR}\,)_{(d)} *$

$(\text{Personal Consumption Expenditure Chain} - \text{type Price Index})_{(t-1)(d)}\,] +$

$\beta_5(\text{Personal Consumption Expenditures Chain} - \text{type Price Index})^2{}_{(t-1)(d)} +$

$\beta_6(\text{Unemployment Rate})^2{}_{(t-1)(d)} + \varepsilon$

6.3 An Updated Version of Model 1

The regression results for the final version of Model 1 run with the Newey-West Correction are listed in Table 8 below.

Table 8: Final Model 1

Regression with Newey-West standard errors

EFFR	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Unemployment Rate	-.133	.062	-2.17	.031	-.254	-.012	**
PCEPI	.362	.123	2.95	.003	.121	.603	***
L. EFFR	.024	.053	0.45	.656	-.081	.129	
EFFR*PCEPI	3.336	.374	8.93	0.00	2.602	4.07	***
PCEPI^2	-.863	.21	-4.10	0.00	-1.276	-.45	***
Unemployment Rate^2	.016	.006	2.64	.009	.004	.028	***
Constant	-.045	.02	-2.22	.027	-.085	-.005	**

Mean dependent var	-0.003	SD dependent var	0.534
Number of obs.	548	F-test	62.181
R-squared	0.851		

Source: Author's Calculations

R-squared value was added into Newey-West regression results.

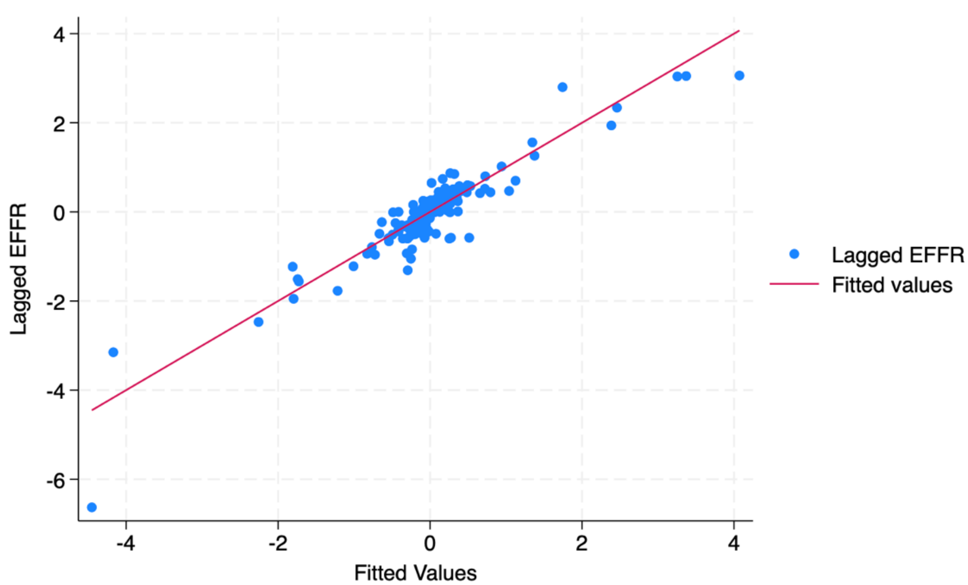
*Note. *** statistically significant at the 99 percent confidence level, **statistically significant at the 95 percent confidence level.* EFFR = First differenced Effective Federal Funds Rate. Unemployment Rate = Lagged, first differenced unemployment rate. PCEPI = Lagged, first differenced Personal Consumption Expenditure Chain-type Price index. L.EFFR = Lagged, first differenced Effective Federal Funds Rate. EFFR*PCEPI = Interaction term between the first differenced Effective Federal Funds Rate and the lagged, first differenced Personal Consumption Expenditure Chain-type Price index. PCEPI^2 = Lagged, first differenced Personal Consumption Expenditure Chain-type Price index squared. Unemployment Rate^2 = Lagged, first differenced unemployment rate squared.

The final version of Model 1 results in an R-squared value of 0.851 allowing the study to strongly conclude that 85 percent of the variation within the dependent variable is explained by the variance in the independent variables. The R-squared value was added into the Newey-West regression results given that the correction does not alter the R-squared as it does not influence the regression's variance matrix or coefficients.

The regression results indicate that every independent variable within the model is statistically significant with at least 95 percent confidence with the exception of the lagged, first differenced Effective Federal Funds Rate. Previous researchers, cited in the Literature Review of this case study, state that the Federal Reserve alters the real federal funds rate incrementally through a process called interest-rate smoothing. This study pointed out that interest-rate smoothing is oftentimes modeled by including one or more lagged values of the federal funds rate as an independent variable in the Taylor-rule equation (Fernandez, Koenig and Nikolsko-Rzhevskyy, 2010). In light of the importance that this variable has had in previous studies, the lagged, first differenced Effective Federal Funds Rate will be kept as a right-hand sided variable in the multivariate regression despite its lack of statistical significance with respect to its t-statistic.

The scatterplot of the actual values of the Effective Federal Funds Rate versus the predicted results of the federal funds rate from Model 1 can be seen in Figure 6. The line of best fit accurately models what the actual values of the federal funds rate were from 1978 through 2023. The scattered residuals are far closer to the line of best fit compared to either of the previous versions of Model 1 or Model 2 meaning that the current version of Model 1 approximates the data points well.

Figure 6: Actual vs. Fitted Values Model 1 of the Taylor Rule



Source: Author’s Calculations

It is important to explain a few key outliers from the line of best fit to incite certainty and confidence in readers with respect to Model 1. Two main outliers that are necessary to point occur in the bottom left quadrant of Figure 6 at lagged EFFR rates of -6.63 and -3.15 Theses data points occurred during the month of May of 1980 and February of 1981, respectively, when the economy was suffering from a deep recession. During both times, the Federal Reserve dramatically increased interest rates, potentially beyond what the Taylor rule prescribed, to combat rising price wages and price levels. This is why these points lie further from the line of best fit. Outliers are bound to occur even with the most precise models due to the natural variation that happen within every data set across time.

6.4 Interpreting the Final Version of Model 1

The remaining portion of the analysis of Model 1 will be analyzing each independent variable and their corresponding coefficient and t-statistics. While it is important to note that the model itself is statistically significant, it is necessary to understand the unique relationship that each independent variable has with the dependent variable.

Assuming a 95 percent confidence interval, there is a negative and significant relationship between the Effective Federal Funds Rate (EFFR) and the unemployment rate. The negative correlation between the dependent variable and unemployment is logical given that historically when unemployment rates start to rise, the Federal Reserve begins to decrease the real federal funds rate. However, the relationship between the Effective Federal Funds Rate (EFFR) and the unemployment rate squared is positive at the 99 percent confidence level. Figure 7 displays what the Effective Federal Funds Rate would look like based on the Unemployment Rate and the Unemployment Rate squared along with their respective coefficients.

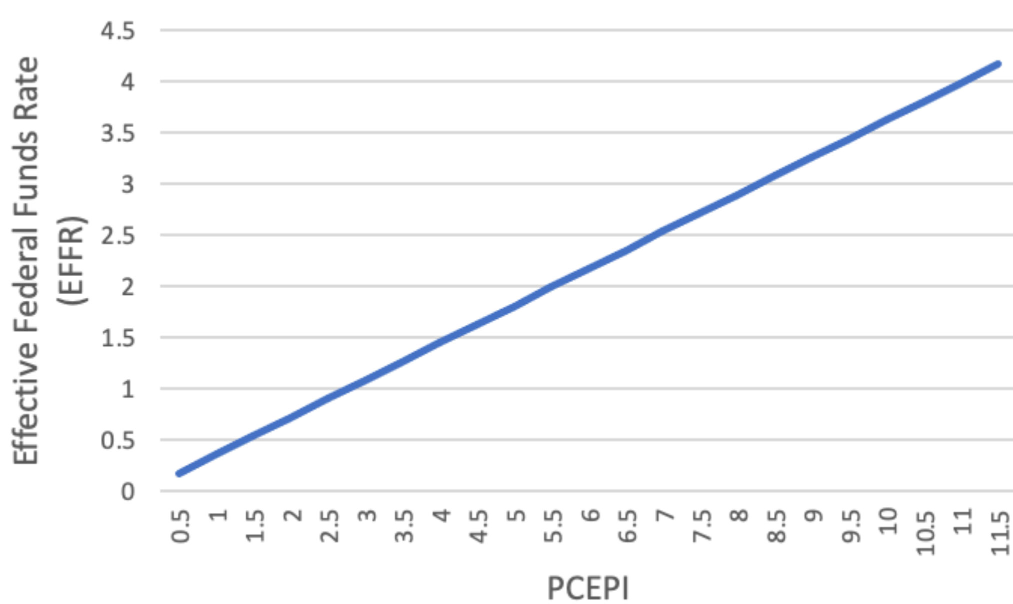
Figure 7: The Relationship Between the Unemployment Rate, the Unemployment Rate Squared and EFFR

Source: Author's Calculations

These two independent variables should be interpreted simultaneously. Thus, based on the unemployment rate and unemployment rate squared, when the unemployment rate is high, the Federal Reserve should lower the real federal funds rate to incentivize economic growth. This can be seen in Figure 7 given that at high levels of unemployment, the EFFR is negative. But at unemployment levels past 8 percent, the EFFR can be seen to increase rather than decrease. For monetary policy purpose, this rule does not make sense nor is it justifiable to raise interest rates when unemployment is high. Raising the real federal funds rate when economic activity is weak would only further induce a recessionary period. However, the model at hand does not apply to EFFR values beyond 8 percent because these data points did not occur within the sample from January 1978 through January 2023. The only time in which dramatic inflation rates occurred in this sample set was during 1980-1981 perhaps explaining why the model's outliers are located at such points. Consequently, it is reasonable to conclude that the results of this model in terms of unemployment should only be interpreted at values at which the unemployment rate hit most often within the data set at hand.

With 99 percent confidence again, there is a positive and significant relationship between the Effective Federal Funds Rate (EFFR) and the linear measure for Personal Consumption Expenditure Chain-type Price Index (PCEPI). The positive correlation between the dependent variable and PCEPI is logical given that historically when inflation starts to rise, the Federal Reserve begins to increase interest rates. This positive relationship can be seen in Figure 8: As PCEP (modeling the inflation rate) increases, the EFFR increases (modeling the real federal funds rate).

Figure 8: The Relationship Between PCEPI & EFFR

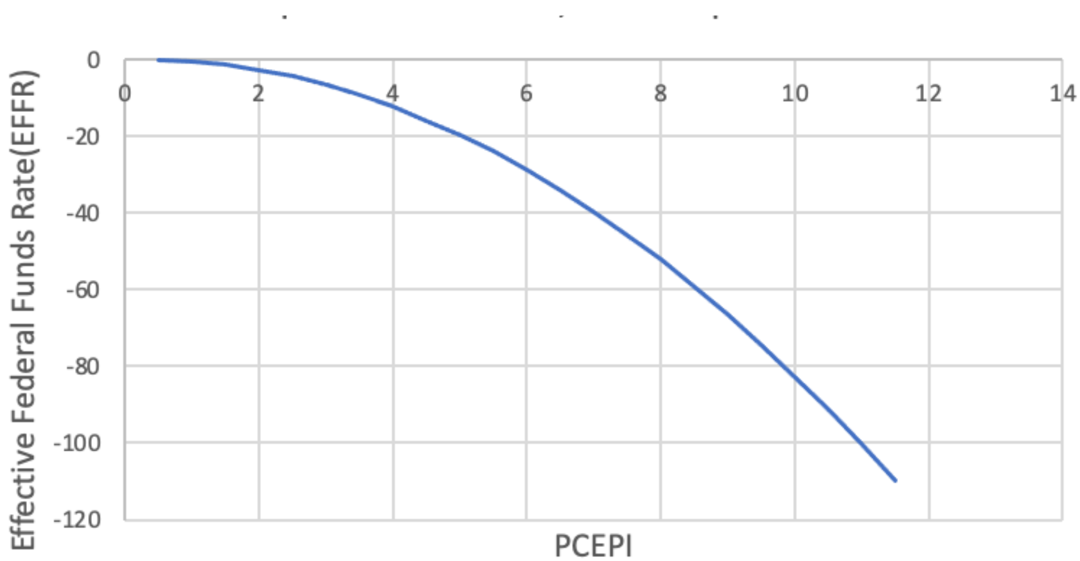


Source: Author's Calculations

The Federal Reserve increases interest rates when inflation increases to combat rising price levels and to disincentivize consumer from further spending. High interest rates can reduce economic activity when inflation is out of control. More specifically, the model predicts that a one unit increase in PCEPI (inflation) is associated with a 0.38 increase in the Effective Federal Funds Rate (real federal funds rate).

However, the regression results indicate a negative relationship between the PCEPI squared and the dependent variable. PCEPI and PCEPI squared, and their respective coefficients are graphed in relation with the dependent variable in Figure 9.

Figure 9: The Relationship Between PCEPI, PCEPI Squared and EFFR



Source: Author's Calculations

The regression results display that the squared PCEPI variable is statistically significant but prior knowledge indicates that the relationship between the dependent variable and the squared PCEPI is not accurate. For example, when inflation rises, the Federal Reserve responds by increasing the federal funds rate to curb rising price levels. Model 1 shows that when PCEPI and PCEPI squared rise in tandem, that the Effective Federal Funds

Rate decreases. In reality, this is not what has happened from January 1978 through January 2023. A potential explanation for this negative result from the regression of Model 1 could be that the Federal Reserve does not make monetary policy decisions based on the squared inflation rate. For them, the relationship between inflation and general interest rates is strictly linear. If the relationship between the dependent variable and PCEPI (inflation), the lagged, first differenced Effective Federal Funds Rate and the interaction term between the two variables themselves is regressed, the paradox previously found disappears. Each independent variable with PCEPI (inflation) contained within it has a positive relationship with the dependent variable.

Moving on to the next independent variable interpretation, as previously mentioned, there is much significance and importance pertaining to the lagged, first differenced Effective Federal Funds Rate as an independent variable within the model. Despite its lack of statistical significance in the final version of Model 1, this variable has proven to be impactful in past studies. Since it lacks statistical significance at any of the chosen confidence intervals, its coefficients are not important to interpret. However, it is necessary to reiterate that this variable had much statistical significance in previous versions of Model 1. Thus, it can be concluded that the dependent variable (the Effective Federal Funds Rate) is very much impacted by the value of the Effective Federal Funds Rate in the previous period.

Again, assuming a 99 percent confidence interval, there is a strong positive correlation between the EFFR and the interaction term between the EFFR and the PCEPI. A one unit increase in the interaction term between the EFFR and the PCEPI is associated with a 3.336 increase in the dependent variable (the Effective Federal Funds Rate). Part of the statistical significance within this variable pertains to the inclusion of the dependent variable itself within the interaction term. The results of this variable present that the value of the EFFR in this period is dependent on what the value of the EFFR was in the previous which is also based on what the value of inflation was in that period.

6.5 An Updated Version of Model 2

The regression results for the final version of Model 2 run with the Newey-West Correction are listed in Table 9 below.

Table 9: Final Model 2

Regression with Newey-West standard errors

EFFR	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Unemployment Rate	-.12	.057	-2.09	.037	-.232	-.007	**
PCEPI	.38	.12	3.16	.002	.144	.616	***
L. EFFR	.029	.052	0.57	.572	-.073	.132	
EFFR*PCEPI	3.342	.371	9.02	0.00	2.614	4.07	***
PCEPI^2	-.867	.208	-4.16	0.00	-1.276	-.458	***
Unemployment Rate^2	.015	.006	2.65	.008	.004	.026	***
UM Consumer Sentiment	.009	.003	3.16	.002	.004	.015	***
Constant	-.047	.02	-2.39	.017	-.086	-.008	**

Mean dependent var	-0.003	SD dependent var	0.534
Number of obs	547	F-test	55.825
R-squared	0.856		

Source: Author's Calculations
R-squared value was added into Newey-West regression results.
*Note. *** statistically significant at the 99 percent confidence level, **statistically significant at the 95 percent confidence level.* EFFR = First differenced Effective Federal Funds Rate. Unemployment Rate = Lagged, first differenced unemployment rate. PCEPI = Lagged, first differenced Personal Consumption Expenditure Chain-type Price index. L.EFFR = Lagged, first differenced Effective Federal Funds Rate. EFFR*PCEPI = Interaction term between the first differenced Effective Federal Funds Rate and the lagged, first differenced Personal Consumption Expenditure Chain-type Price index. PCEPI^2 = Lagged, first differenced Personal Consumption Expenditure Chain-type Price index squared. Unemployment Rate^2 = Lagged, first differenced unemployment rate squared

The final version of Model 1 results in an R-squared value of 0.856 allowing the study to strongly conclude that 85 percent of the variation within the dependent variable is explained by the variance in the independent variables. This R-squared value is 0.005 percent higher than the R-squared value from Model 1 allowing the study to conclude that the increase in the explained variance is due to the additional variable inserted into the model rather than the variable itself being extremely impactful.

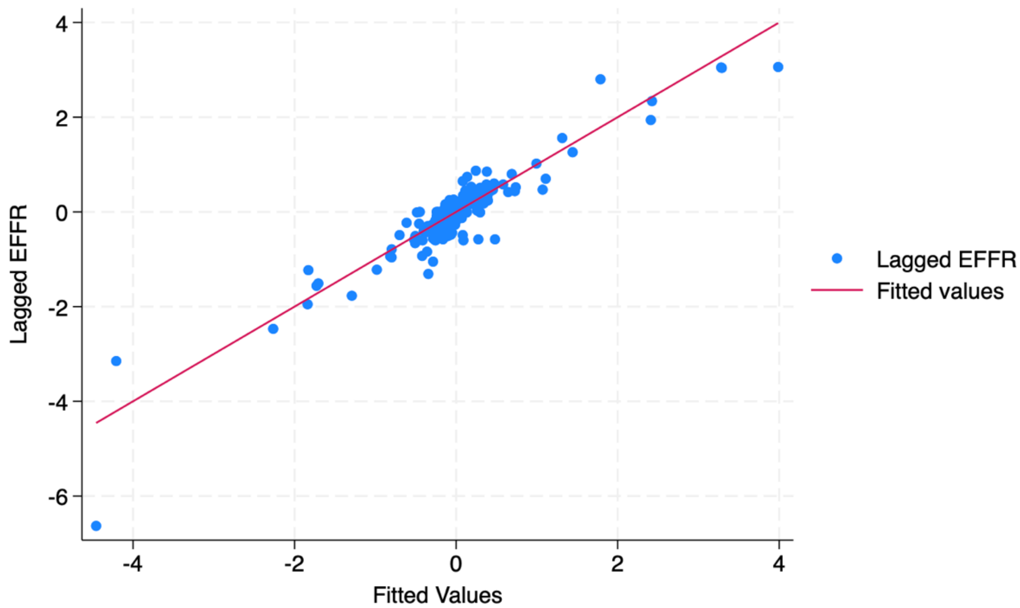
6.4 Interpreting the Final Version of Model 2

The independent variable coefficients from Model 1 are Model 2 are strikingly similar even with the addition of the University of Michigan Consumer Sentiment Index. Consequently, reinterpreting the relationship between these independent variables and the dependent variable is redundant given that the same conclusions will be drawn.

With a 99 percent confidence interval, there is a positive relationship between Consumer Sentiment and the Effective Federal Funds Rate (dependent variable). A one unit increase in the University of Michigan Consumer Sentiment Index is associated with a 0.009 increase in the EFFR. Given that this association is so minimal, and that the R-squared improvement of the model as a whole is extremely small in magnitude, it is reasonable to conclude that Consumer Sentiment does not improve the Taylor rule as seen in Model 1.

The scatterplot of the actual values of the Effective Federal Funds Rate versus the predicted values of the federal funds rate from Model 2 can be seen in Figure 10 below.

Figure 10: Actual vs. Fitted Values of Model 2



Source: Author's Calculations

The line of best fit accurately models what the actual values of the federal funds rate just as well as the line of best fit from Model 1. The scattered residuals are equally as close to the line of best fit compared to the final version of Model 1. Consequently, the current version of Model 2 approximates the data points well just as well as Model 1 meaning that the addition of the University of Michigan Consumer Sentiment index did not statistically improve the model. Additionally, the outliers in Model 2 strongly resemble the same outliers in that occurred in Model 1. These outliers represent times of economic uncertainty. As previously stated in the Literature review, consumers are good at forecasting the potential economic activity especially during periods when inflation is not volatile but proves to be less reliable during periods of economic instability (Federal Reserve Bank of St. Louis, 2021). Considering this information, these outliers make sense with respect to the model itself given that they reflect data points of economic and societal uncertainty. Thus, Model 2 did not cause the distance from the residuals and the line of best fit to be reduced further emphasizing the lack of statistical improvement from Model 1 to Model 2.

VII. Conclusion

7.1 Concluding Remarks

Through a thoughtful and statistical analysis, this study aimed to test if the standard Taylor rule accurately reflects the real federal funds rate values from 1978 through 2023. This case study also hypothesized that if the standard Taylor rule had followed a guidepost more closely tied to consumer sentiment, then its outcomes would be more similar to actual monetary policy given that the real federal funds rate deviates from the Taylor rule during times of economic uncertainty.

The original multivariate regression of Model 1 tested the relationship between the standard linear components of the Taylor rule with the dependent variable. This study can conclude that the results from this model are consistent with the hypothesis in that historic impreciseness in the Taylor rule compared to the real federal funds rate is demonstrated. Model 2's multivariate regression tested if the Taylor rule could be improved upon by adding in an additional variable being Consumer Sentiment. Both Model 1 and Model 2's regression results showed little statistical significance. Thus, further multivariate models with interaction terms and quadratic variables were tested to assess if the significance of the model itself along with its variables could be improved upon.

The final version of Model 1, representative of the Taylor rule, proved to be extremely statistically significant. Of the six independent variables, four proved to be statistically significant at the 99 percent confidence level and one variable at the 95 percent confidence level. Variables of interest that have proved to explain up to 85% of the variance in the Effective Federal Funds Rate (EFFR) include the following: the unemployment rate, the personal consumption expenditure chain-type price index (PCEPI), the lagged EFFR, the interaction between PCEPI and the EFFR, the unemployment rate squared, and the personal consumption expenditure chain-type price index squared.

The inverse relationship between the dependent variable and the unemployment rate in addition to the direct relationship between the dependent variable and PCEPI (inflation) was affirmed from the previous literature and reaffirmed by Model 1. However, it can be reasonably concluded that the relationship that both independent variables have with the dependent variables is not linear. The Federal Reserve could be making decisions on monetary policy based on more than what the Taylor rule prescribes the committee to do given that variables outside their dual mandate of maximum employment (the unemployment rate) and price stability (PCEPI) are statistically significant, such as the lagged effective federal funds rate.

Model 2 provided evidence to disprove the original hypothesis. As a result, it can be concluded that a Taylor rule including a reflection of Consumer Sentiment does not prove to generate outcomes more similar to actual monetary policy during times of economic uncertainty. Even though this hypothesis was proven to be incorrect, the results of this study are meaningful. In fact, a new and more thoughtful Taylor rule was in fact generated despite it lacking an index tracking Consumer Sentiment. This more thoughtful version of the Taylor rule includes the original components of the Taylor rule in addition to non-linear versions of the same components within the model.

The literature review presents previous research pertaining to the strict interpretation of economic policy rules such as the Taylor rule. As previously stated, the Federal

Reserve benefits from examining simplistic benchmarks such as the Taylor rule as it has the ability to produce beneficial results to assist in the policy creation process (Kohn, 2007). The results of this study can be impactful moving forward because the final version of Model 1 emphasize the importance of following a rule loosely rather than strictly.

It is not always beneficial to strictly interpret rules to determine economic policy during times of economic uncertainty. The economic wellbeing of the people should be prioritized rather than how well a potentially outdated rule is being followed. Two authors from the Federal Reserve Bank of Cleveland shared their own analysis of the benefits of rule such as Okun's law:

> "Rules of thumb can be very useful. At their best, they can help us avoid huge mistakes—testing the bathwater with your elbow to save the baby from a scalding, for example. These rules are not complicated or ambiguous, which allows us to make snap decisions without costly errors. So it's probably not a surprise that analysts attempt to use simple rules of thumb to describe economic phenomena. However, attempts to describe complex interactions in the economy with overly simple adages can lead to incorrect conclusions" (Meyer and Tasci, 2012).

If the complicated and the mostly non-linear nature of the Taylor rule is not taken lightly, then the model produced within this case study (Model 1) is an adequate answer to the original hypothesis. Model 1 not only reflects the original components of the Taylor rule but contains the complexities that the standard Taylor rule lacks in aiding Federal Reserve policy decisions during times of economic crises.

If the Federal Reserve wanted to follow a rule to create policy closely, it would be wise to follow Model 1 rather than the original Taylor rule as it captures the intricacies of each variable far better than the linear prediction of the Taylor rule. Furthermore, if the Federal Reserve seeks to continue to follow the standard Taylor rule, then they need to acknowledge and present to the public that they do not merely look at inflation and the output gap alone but that they take into account a wide range of variations of these variables such as the real federal funds rate itself, interaction terms, quadratic variables and much more. The final version of Model 1 reflects the main components of the original Taylor rule as well as its complexities and it can be concluded that this version of the Taylor can represent historical monetary policy decisions taken by the Federal Reserve and can serve as a useful tool for monetary policy decisions in the future.

7.2 Limitations

Prior works of literature express the complexities in the modeling process of the independent variables within this study. There are hundreds of ways to represent inflation, the output gap and consumer sentiment in the data. In a perfect world, this study would have preferred to measure each independent variable with a spectrum of variables that reflect different aspects of the variable itself, creating an all-encompassing and inclusive data set. However, due to the time constraints on this study, the modeling of each independent variable was chosen to be represented by a singular piece of data that would thought best reflect the variable for the purpose of this thesis.

Other possible limitations within this study include the methodology of lagging each variable. Based on the previous literature, a one period lag was chosen for the independent variables within this study. The Federal Reserve could be making decisions one monetary policy utilizing data from more than just the previous period. This idea was difficult to model and thus a one period lag was chosen knowing this limitation would potentially affect the results of the model. It would be wise for future scholars to attempt to model the independent variables within the Taylor rule as suggested in this section to generate as inclusive of results as possible.

7.3 Recommendations

Though the analysis in this study cannot provide an ultimate solution, it was able to uncover a more thoughtful version of the Taylor rule. The conclusion and literature review discuss the benefits and downsides in following rules for economic policy. In the context of this case study, the Federal Reserve seems to follow the Taylor rule but with discretion. Specifically, they follow a version of the Taylor rule that more closely resembles the final version of Model 1. As the original hypothesis states, this updated version of the Taylor rule will prove advantageous to more adequately model decisions on previous monetary policy and address the systemic change in the economic landscape that we are likely to see in the near future.

Having rules for policy are beneficial to fall back on and provide guidance at the onset of a financial crisis, whether they are followed or not. However, the Federal Reserve does not follow the Taylor rule strictly during times of economic certainty or uncertainty. Rather, the committee uses it as a guidepost considering that the original Taylor rule is not as inclusive or thoughtful as previously thought. It would be beneficial for the public to know that the Federal Reserve is guided by a version of the Taylor rule that is much more complex but that does emulate the standard rule so that they are able to forecast the landscape of the economy in the future.

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