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REVISITED: RULES VERSUS DISCRETION IN MONETARY POLICY

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ABSTRACT

The debate over whether to use rules or discretion in setting monetary policy has been longstanding in economics literature and in practice. This paper reviews the arguments on each side and compares these viewpoints in relation to the Federal Reserve. Using the federal funds rate, policy rules and their modifications are evaluated in order to determine if central bankers have seemingly followed a policy rule through time. Although each period of central banker from the 1970's onwards has shown to align more closely with a different form of rule, no one rule has been able to effectively capture the behavior of all Fed Chairmen.

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Chapter 1

Introduction

Considerable debate continues to exist among policymakers today on the decision of whether or not interest rates should be set as an ironclad rule or modified using discretion based on the current state of the economy. As recently as last July, the House Financial Services Committee was considering H.R. 5018, the Federal Reserve Accountability and Transparency Act (FRAT). This Act would ensure that the Federal Reserve would be bound to conducting monetary policy through a rule rather than using their own discretion, and report on this rule to Congress. The House Republicans who are in support of the Act seek to gain some oversight over the Fed's actions. The Act would also require the Fed to conduct a cost-benefit analysis to each new regulatory action they undertake, among other measures. These Republicans primarily cite that this would allow for a more transparent Fed. Several Fed officials and economists have come out in support of FRAT, the most highly publicized being John Taylor. Taylor created a formula for how monetary policy should be conducted through the Taylor Rule that he first created in 1993. Taylor and some Fed officials argue that with such a rule, a more predictable Fed would yield better economic outcomes (Da Costa, 2014, July 9). Yet not all economists agree. A survey from the Chicago Booth School of Economics polled economists at top universities in the United States and asked if the Act would in fact lead to better economic outcomes. Of the 44 economists who responded, 52% disagreed and 23% strongly disagreed with the statement (IGM Forum, 2014, July 14). In fact, not a single respondent agreed that better outcomes would be achieved under FRAT. Even Janet Yellen, the current Fed Chair, has publicly voiced concerns over the

Act and the danger of following a prescribed policy rule. Yellen contends that the Fed requires the flexibility to deviate from such rules as economic conditions allow. Yellen went so far as to remark that passing the FRAT would be a "grave mistake" (Appelbaum, 2014, July 16). Adopting a rule-based policy regime would have significant impacts on the Fed's ability to change policy based on unexpected economic events, and investors would form different expectations about those changes that would in turn have significant impacts on financial markets.

Although there is discrepancy between House Republicans and economists on the issue of setting monetary policy in accordance to a strict rule, the Fed does look to rules as a guideline for setting interest rates. In 2012 as the Vice Chairwoman of the Fed, Yellen said that the Fed looks to rules such as the Taylor Rule, including various forms of the rule. At the time, Yellen publicly announced that the Taylor rule was modified to give greater weight to employment (Da Costa, 2014, July 9).

As this paper points out, although the Fed currently uses its full discretion in setting monetary policy, there may be some evidence that Fed Chairmen have individually followed certain policy rules through time. It is important to first understand what is meant by a rule or discretion in monetary policy.

The Meaning of Policy Rules

The definition of a rule in monetary policy is not limited to simply one version, as each contributor seems to have a slight variation in viewpoints. Yet many share similar characteristics. In its most general form, a rule is best described as "a prescribed guide for conduct or action"

(Svensson, (1999), p. 614). Unlike discretion, rules restrict the ability of the policymaker to undertake actions at will. At the most extreme, central bankers often criticize that a rule achieves the same result as “a regime in which the central bank ‘has turned policy decisions over to a clerk armed with a simple formula and a hand calculator’” (McCallum, (2000), p.274). Yet those in academia often insist that rules have the ability to be revised based on current conditions, if only amended in a systematic way. Regardless of its ease and ability to be adjusted, rules certainly do not allow for the same kind of flexibility to be found in using discretion.

The Meaning of Discretion in Policy

As in the case of rules in policy, there is no one agreed upon definition of what is meant by policy discretion. Broadly, a discretionary monetary policy is one that can be chosen anew each period without reference to economic conditions in a previous period. Under this assumption, the central banker will essentially find “past conditions… as unalterable and therefore irrelevant” (McCallum, (2004), p. 267). Under discretionary policy, central bankers are not bound by conditions in which they have predetermined the action that will be undertaken. Kocherlakota (2015) deems this the ability of a central bank to “choose accommodation as it deems necessary to achieve its goals.”

With these interpretations in mind, this paper seeks to add to the debate on rules versus discretion by determining if the Fed has chosen to utilize various policy rules in setting the federal funds rate over time. By modeling the changes the Fed makes in policy based on economic events, the Fed’s so called reaction function, it could have important implications for the public about if the Fed appears to follow a rule. If so, this could signal a message to investors about Fed behavior. Chapter 2 of this paper summarizes the previous literature regarding the decision of whether to undertake rules or discretion. Chapter 3 analyzes the objectives of the Federal Reserve. Chapter 4 introduces the policy rules that mathematically set the federal funds rate that will be studied in this paper. Chapter 5 describes the results, followed by suggestions for future research.

Chapter 2

Review of the Literature

The debate on rules versus discretion in economics literature and in practice is longstanding. While the differences of opinion for advocating a policy rule or discretion may vary based on the model or reasoning behind each, classic arguments have arisen over time. The conventional wisdom of the controversy surrounding the use of purely discretionary policy has several main counterpoints. The first is that discretionary policy is difficult to use in practice due to "long and variable lags" and "inaccurate forecasts" that characterize policy actions in the economy (Mayer, (1990), p. 241). Additionally, some argue that the Fed may not always act in society's best interests. Friedman (1982) concludes that there are a variety of reasons why this may be the case, as certain conditions may arise that call for the Fed to first take into account their own interests ahead of the public's. Kocherlakota (2015) relates by adding the example that central banks may be tempted to over inflate the economy relative to the long-run societal goal. In this way, a policy rule would disallow the Fed to deviate from the public interest in both the short and long run.

Alternatively, the typical conventional wisdom from policymakers in the past has been that the Fed needs to retain the ability to conduct monetary policy as an art, rather than a science. For instance, many believe that "optimal outcomes can be achieved only is some discretion is left in the hands of the monetary authority" (Athey, Atkeson, & Kehoe, (2005), p. 1431). Much of the reasoning behind this is due to the Fed's ability to change policy as unforeseen economic events arise. This point is most strongly associated with ideas of current members of the Fed and many of those who make policy decisions in practice. I now turn to the literature for further discussion on the conventional wisdom and possible answers.

Arguments for Rules

In the literature, Kydland and Prescott (1977) are highly cited as some of the first economists to substantially contribute to the discussion on rules versus discretion in economic policy. Using a two period model of decisions, their model seeks to maximize a social objective function given constraints on decisions. They find that when policy relies on rules, economic performance is better than when based solely on discretion. Discretion is only successful when decisions are based on current and past policy decisions and the current state of the economy. When future expectations of policy decisions are taken into account, rules lead to better outcomes, which Kydland and Prescott (1977) find is most relatable to real world conditions. Every new policy relies on the initial conditions, because initial conditions change future expectations. Kydland and Prescott (1977) found that the best policy rule “depended upon the initial conditions” (p. 475).

Regarding the tradeoffs between inflation and unemployment, similar results emerge. Kydland and Prescott (1977) agree with prior economic research that unemployment is a linear and “decreasing function of the discrepancy between actual and expected inflation rates” (p. 478). Kydland and Prescott (1977) use this relationship to again find that using discretion for policy relating to unemployment and inflation is only best when expectations of future prices depend only on past prices. In practice, future prices are subject to many more factors, including the past policy. This gives Kydland and Prescott (1977) reason to reject using discretion.

In summary, Kydland and Prescott (1977) conclude that rules should be followed rather than discretion. In terms of how to implement a rule, they agree that a simple rule would be preferable so that “it is obvious when a policymaker deviates from the policy” (p. 487). This would best forecast investor expectations. Additionally, in line with the current debate on FRAT, Kydland

and Prescott (1977) agree that the rule should be difficult to deviate from or change. This would disallow the Fed to deviate from the policy at will.

Barro and Gordon (1983) focused their case for rules using principally the inflation expectations that Kydland and Prescott (1977) mentioned. Barro and Gordon's (1983) case showed the benefits of both rules and discretion. Policymakers could use discretion to their advantage by creating more inflation than agents in the economy expect. Yet when people have an understanding of the policymaker's incentives, their expectations relate to this. Then, policymakers are not able to create this extra inflation. As people change their expectations, Barro and Gordon (1983) find that rules can improve economic performance because if not, inflation would be higher than expected. Barro and Gordon (1983) also considered the case where policymakers may have incentives to vary from rules and benefit from shocks caused by unexpected inflation. They find that when policymakers "cheat" in this way, it may work to benefit the economy for a short term but would violate the trust that the public places in policymakers over time. Barro and Gordon (1983) find this to be a good enough disincentive for policymakers to continually deviate from the policy rule.

McCallum (2004) used a different approach to illustrate why the Fed should follow monetary policy rules. He argues that central bankers and academics, who are often largely proponents for discretion and rules, respectively, may simply have differing ideas about what defines a policy rule. Central bankers, according to McCallum (2004), find that policy rules are not flexible enough. In academia, these are sometimes referred to as nonactivist rules. McCallum (2004) proposes that most academics define rules as more flexible than central bankers think. These activist rules can be altered as needed. McCallum (2004) also contends that academics view discretion as "period-by-period" decisions that do not rely on past data but only today's conditions (McCallum (2004) p. 367). He views academics that consider a forward looking approach that relies on past and present conditions as using policy rules. Additionally, McCallum (2004) is clear to point out that rules can be changed, “such as the Taylor Rule, that relates instrument settings to current economic conditions” (McCallum (2004) p. 368).

Arguments for Discretion

On the other hand, a wide portion of the literature has taken the stand of discretion being the best approach to monetary policy. Kocherlakota (2015) presented his findings that defend the use of discretion in U.S. monetary policy. Using a static choice model of inflationary accommodations, five scenarios are drawn relating to possible inflationary biases of a central bank. The scenarios range from an unbiased central bank to a highly biased central bank who both has and does not have information that can be put into a mathematical policy rule. Overwhelmingly, Kocherlakota (2015) finds discretion to be best. This result is based on the smallest variances from inflation incentives between the central bank and society. There is only one case where rules were preferred, which was when the central bank has a slight inflation bias and no information that could not be put into a rule. In the real world, Kocherlakota (2015) argues that the Fed does not display a large if any inflationary bias and has a significant amount of information that cannot be modified into a simple mathematical rule. He points to the empirical evidence that suggests no inflationary bias from the Fed, as well as that society’s optimal inflation matches the Fed’s reported inflationary target of 2%. For these reasons, Kocherlakota (2015) finds discretion to be better than policy rules.

Athey, Atkeson, and Kehoe (2005) also take into account the Fed's private information that may not be able to be formed into a mathematical rule. Their model assumes that discretion occurs when policy is allowed to vary with private information held by the central bank. Athey et al. (2005) construct a social welfare function that is dependent on the state of the economy. They find that the time inconsistency problem has a significant impact on the source of the decision on rules versus discretion. The time inconsistency problem is that the central bank may try to boost the economy with unexpected inflation, which society wants to prevent. Athey et al. (2005) find that the time inconsistency problem worsens as private information held by only the central bank loses importance. In these instances in the economy that are characterized by large time inconsistency problems and no important private information, Athey et al. (2005) find there should be less discretion and more rule-based policy. Additionally, Athey et al. (2005) find that the policy rule does not need to be complex. In their results, the policy rule can be as simple as setting a cap on the inflation rate to curb the full discretion of central banks. When private information becomes more important, discretion should be used. Romer and Romer (2000) provide empirical evidence to support the claim that the Fed does have important nonpublic information, which they use to make policy decisions. With this in mind, Athey et al.'s (2005) case for discretion gains strength.

Literature Review Conclusion

It is clear from the literature that there is no set agreement as to the policy actions that the Fed should take. Model assumptions and other factors have led to differences in results. Yet one question remains: In practice, is it clear that the behavior of the Fed has seemed followed a policy rule throughout recent history? Specifically, this paper will examine the federal funds rate and the most widely known policy rules as a way to track changes in both the federal funds rate and Fed behavior. This way, the Fed's behavior can be analyzed to see if the Fed seems to have matched a policy rule even through changes in Fed Chairmen with differing opinions and biases toward how policy should be conducted.

Chapter 3

Analysis

When the Fed faces the decision on whether to commit to a policy rule, they must first examine the purpose of the central bank. The objectives set forth by Congress and given to the Fed to follow are widely known. The Federal Reserve Act of 1977 stated that the Fed should conduct monetary policy in a way that would "promote effectively the goals of maximum employment, stable prices and moderate long-term interest rates." These goals have come to be known as the Fed's dual mandate. Stable prices and moderate long-term interest rates are intertwined by the Fisher effect, which states that real interest rates are a combination of nominal interest rates minus inflation. The goal of stable prices is the Fed's nominal objective, while the goal of full employment is the real objective. Though the language of the Act is simple, a great deal of flexibility comes forth in how the Fed will achieve those objectives. The Full Employment and Balanced Growth Act of 1978, better known as the Humphrey-Hawkins Act, clarified the goals of the Federal Reserve Act of 1977. The Humphrey-Hawkins Act set an unemployment rate of 4% and an inflation rate of 3% as targets for the next few years from its enactment until 1983, to be reconsidered and updated each year thereafter (Judd and Rudebusch, 1999). Both the unemployment rate and inflation rate targets in the dual mandate continue to be refined to this day. Over time as a result of the most current economic events, the emphasis that the Fed places on each area of the mandates has evolved. After significant economic events such as the Great Depression and the Great Recession, a so-called unspoken third mandate of financial market stability has emerged. Even through these volatile times, the Fed has sought to keep inflation and unemployment around target levels in line with these mandates.

Essentially, the dual mandate can be translated mathematically through monetary policy set by the Fed where it seeks to minimize a loss function.

The Fed's loss function can be arranged in two ways. The first is:

$$L = -[\alpha (\pi-\pi^*)^2 + \beta (UR - NAIRU)^2]$$

where:

π	is the actual inflation rate
π^*	is the target inflation rate
UR	is the actual unemployment rate
NAIRU	is the non-accelerating inflation rate of unemployment
α	measures the relative weight placed on inflation
β	measures the relative weight placed on unemployment growth

The Fed wants to minimize the function in order to optimally choose an interest rate policy where levels of each variable fluctuate around targets. The squared terms dictate that policymakers are wary of hitting levels that are both lower and higher than targets. Another way of writing the loss function that the Fed seeks to minimize is similar to the first, but simply changes the unemployment focus to GDP growth, another economic indicator of importance to the Fed. This loss function is presented below.

$$L = - [\alpha (\pi-\pi^*)^2 + \beta (y-y^*)^2]$$

where:

y	is actual real GDP growth
y*	is potential GDP growth

Written either way, the loss function draws attention to the stark contrast between the focus on inflation versus unemployment and GDP growth through the parameters α and β. The relative weight on each shows the degree of attention the central bank places on each. A policymaker with a high α is considered an inflation hawk. This parameter is also known as the policymaker's "inflation variability aversion" (Checchetti (2000), p. 51). This is a policymaker who is very concerned about inflation, and subsequently strives to conduct monetary policy in a way that places the most emphasis on directing inflation. Alternatively, a central banker who conducts monetary policy resulting in a large β parameter is considered an inflation dove, a policymaker who is less concerned about inflation and more about other economic aspects such as output or full employment. In the loss function, when α is zero the policymaker only cares about those other economic aspects (Checcetti (2000), p. 51). Similarly, with a β of zero the central banker cares only about inflation. With this in mind, it leads us to question possible biases among central bankers of the Fed themselves. For example, within the United States, biases have arisen historically in the way monetary policy is executed. These biases can be at least partly attributed to the Fed Chairmen themselves. Although these differences may also be partly attributed to economic events and the FOMC, the change in chairmanship leads to more concretely measurable results.

Chapter 4

Methodology

Through simple reaction functions like the Taylor Rule and modifications of them, this paper seeks to measure the hawkish or dovish biases toward inflation present in each Fed chair as a way to measure if the Fed has seemed to follow a policy rule to set the federal funds rate over the last 40 years. Keeping in line with this paper's use of simple policy rules, tests will be run through a framework of multiple models to determine a best fit for the entire time period from the 1970's to the present as well as each central banker period based on the reputations of hawkishness or dovishness of each Fed Chairman. In this paper, three simple rules will be primarily used and modified in order to attempt to best match each Fed Chairman's policies.

The first rule that will be used and modified is the Taylor Rule, which is a forecast of the federal funds rate. Below is the original Taylor Rule, presented by Taylor (1993), where:

$$i_{ff} = p + r + .5y + .5(p-p^*) \quad (1)$$

where:

i_{ff} is the short term federal funds rate

p is the average rate of inflation from the previous four quarters

r is the equilibrium real rate of interest

y is the output gap

p^* is the target rate of inflation

The variable r, the equilibrium real rate of interest, was assumed by Taylor to have a value of 2%. The variable y for the output gap was measured as:

$$100^* ((\text{actual real GDP} - \text{potential GDP}) / \text{potential GDP})$$

Taylor "assumed that the weights the Fed gave to deviations of inflation and output were both equal to 0.5" in the equation (Judd & Rudebusch (1998), p. 5). A higher parameter in front of y portrays a more dovish central banker. These parameters will be adjusted in the sample in hopes of tuning in each Fed chair for inflation or unemployment biases. The merits of the Taylor Rule were seen through Taylor's (1993) findings that his rule proved to be a very good predictor of the actual federal funds rate under Greenspan. Additionally, the use of the Taylor Rule is further solidified by Barro and Gordon (1983), who had first commented on the importance of expectations to the goals of the monetary authority. Their model assumed that "the monetary authority's objective as reflecting the preferences of the 'representative' private agent" and that it could be written "as a function of actual and expected rates of inflation" (Barro & Gordon, (1983), p. 102). This objective is clearly exemplified in Taylor's Rule, and the Taylor Rule continues to be widely referenced in economics literature. Lastly, as noted in the introduction, Yellen commented that a version of the Taylor Rule was being used as a reference when setting monetary policy in the Fed today. For these reasons, the Taylor Rule was selected for this paper.

The second rule under consideration to describe the actions of the Fed chairs is the Mankiw Rule. This rule takes the form:

$$i_{ff} = c + \gamma(p - UR) \tag{2}$$

where:

i_{ff} is the federal funds rate

p is the core rate of inflation

UR is the unemployment rate

The constant term c was assumed by Mankiw (2001) to be 8.5, while the parameter γ was assumed to have a value of 1.4. These values will be used in this paper. Mankiw (2001) created this rule, and found it to produce a very good representation of the actual federal funds rate during the Greenspan regime between 1987 and 2008. This rule was selected in order to determine if the inputs to determine the Federal Funds rate differed from the Taylor Rule, which does not include the unemployment rate in its calculation.

The third component that this paper will use to tune in the monetary policy Fed chair is not a policy rule, but rather Okun's Law. Okun's Law was presented in 1962 by Arthur Okun. The law states that a 1% fall in the unemployment rate will result in a 2.5% rise in GDP growth (Okun, 1962). Although originally created many years ago, researchers have still found that Okun's Law holds true today. Over the time period from 1948 to 2007, Knotek III (2007) found that Okun's Law held true to its original estimates. Using this, Chuderewicz (2014) proved how Okun's Law can be related back to the Taylor Rule in the place of the output gap. If unemployment does fall by 1%, the 2.5% rise in GDP growth can be placed into the output gap in Taylor's Rule, so that:

$$i_{ff} = p + r + .5(-2.5\%*u) + .5(p-p*)$$

$$\text{Then, } i_{ff} = p + r - (1.25\%*u) + .5(p-2) \quad (3)$$

where:

i_{ff} is the short term federal funds rate

p is the rate of inflation from the previous four quarters

r is the equilibrium real rate of interest

u is the unemployment gap

$p*$ is the target rate of inflation

Equation (3) shows that effectively, a 1% fall in the unemployment rate is also associated with a 1.25% change in the short term federal funds rate. This relationship will also be used in this paper as another modification to try to determine the federal funds rate and biases of each Fed Chairman through time.

By changing certain parameters on these rules, modifications can be made that may allow for an understanding of the amount of hawkish or dovish policy actions of Fed chairs over the last 45 years. Of course, this will not completely describe Fed behavior. Yet, it is a useful starting point.

The Issues

Each rule has specification issues that require further discussion before moving forward. Measurement techniques and assumptions in each rule have been made. Each of these issues will be discussed in turn.

Coupled with the debate on rules versus discretion in monetary policy yields a second debate as to the complexity of the optimal rule, regardless of inflation biases. Kocherlakota (2015) points that “some observers argue that simple reaction functions will give rise to better outcomes.” Additionally, he comments that “simple reaction functions may be near optimal in many models.” Williams (1999) researched the use of simple versus complex rules using the FRB/US model. He finds that the more simple policy rules are best at “minimizing the fluctuations in inflation, output, and interest rates” (Williams (1999), p. 27). This simple three parameter policy rule that Williams researched therefore satisfies the Fed’s loss function. Williams found that adding more variables to increase the complexity of the policy found no benefits to the economy. In a forward-looking model, Giannoni (2012) finds that simple rules that target the price level over inflation show minimal disturbance to welfare and shocks in the economy. These rules are referred to by Giannoni as Wicksellian rules, which in the short term let policy respond to price levels over the output gap. Giannoni's findings oppose the Taylor rule, which responds solely to inflation and output gap. Yet, Giannoni has a key assumption that a central bank "is able to credibly commit to a policy rule" rather than use discretion (Giannoni (2012), p. 4).

Policy that responds to price levels over inflation may not always be the most optimal rule, however. Unlike Giannoni, Taylor and Williams (2010) found there to be no difference between policy rules that respond to the price level over inflation in terms of performance. Taylor and Williams (2010) also find that simple policy rules yield better economic results than adding complex variables. Additionally, simple rules created throughout recent history still prove to "perform well with a variety of newer and more rigorous models and policy evaluation methods" (Taylor and Williams (2010), p. 1). Although economic research has had a difficult time agreeing on a single best policy rule, Taylor and Williams (2010) found that similar characteristics prevail between each. The most optimal policy rules had interest rate focus prevail over money supply and exchange rate instruments, and that when rules reacted to both inflation and output they had the best results.

It appears that there is a consensus among most economic research that at a minimum highlights the certain cases where simple policy rules are the most effective, albeit much less agreement on the form that those rules take. For these reasons, this paper focuses its aim on using simple policy rules in its analysis.

In terms of measuring the variables in the rules, in both the Taylor Rule and the Taylor Rule modified using Okun's Law, there have been discussions in the literature for the appropriate level of the inflation target, p*. This target has been heavily researched (e.g., Reifschneider and

Williams, 2000) in the last century and is agreed to be around 2%. Taylor (1993) himself assumed a "steady state growth rate of 2.2," yet used 2% as his measure (p. 202). Moreover, in 2012 the Fed added to the discussion directly. In an effort to be more transparent, the Fed explicitly announced a 2% target. For these reasons, this paper will substitute p* as 2%.

It is also worth mentioning the considerable debate over the measure of inflation used in these simple policy rules. Taylor and Williams (2010) point to the distinction required by whether rules should "respond to expectations of future inflation and output" (Taylor and Williams (2010), p. 13). Levin, Wieland, and Williams (2003) found that inflation forecasted further than one year into the future gave no additional benefit. Further, the use of inflation by the Federal Open Market Committee has changed over time. Before 1988, inflation was forecasted with the "implicit deflator of the gross national product" (Mehra and Sawhney (2010), p. 124). After mid-1988, the Consumer Price Index (CPI) was used. In 2000, the personal consumption expenditures (PCE) took over. It was refined in 2004 to the core PCE, which excludes shocks from food and energy. Taylor (2007) takes these issues into account in his original rule, by using "headline CPI as a measure of inflation" (Mehra and Sawhney (2010), p. 124). These factors will be considered moving through the simple rules during the time period of each central banker.

The unemployment rate is generally targeted to be close to the non-accelerating inflation rate of unemployment, or NAIRU. Most economists agree that the rate is set between 5-6%, a percentage at which the economy does not risk overheating.

The Parameters

In order to better tune in the inflationary or unemployment rate policy biases present in each central banker, this paper will manipulate the parameters on each simple rule. By adjusting these parameters, it will allow for a better idea of how each Fed Chairman behaved in terms of hawkishness or dovishness. Even with these parameters changing, all the simple Taylor Rules still uphold the so called Taylor Principle. This principle states that the change in the federal funds rate should be greater than the change in inflation.

The first adjustment will be to Taylor's original rule. Rather than using the overall rate of inflation, I will use the core rate for the reasons listed above.

$$i_{ff} = p_{CORE} + r + .5y + .5(p_{CORE} - p^*) \quad (4)$$

As noted previously, Taylor's original rule gave equal weights to inflation and output. Since both the equilibrium real rate of interest r and the target rate of inflation p* are both assumed to be 2%, this equation formulated that a change in either the inflation rate or the output gap would lead to a 1.5% change in the short term federal funds rate.

Chairman Ben Bernanke, however, has been said to disagree with Taylor's choice of parameters. He suggests that the value of 0.5 on the output gap of the original Taylor Rule is too low to follow the responsiveness of policy to that variable (Bernanke, January 3, 2010). For this reason, the parameter will be arbitrarily adjusted to account for Bernanke's statement, and a parameter of 0.8 will first be tested in this paper. Additionally, Chairman Bernanke was a proponent of using the core rate of inflation rather than the overall rate. The core rate will also be used in this modification, as well as another test using the overall rate. These modifications may lead to better results in Chairman Bernanke's time in office. Therefore, the modified Taylor Rule becomes:

$$i_{ff} = p + r + .8y + .5(p\text{-}p^*) \qquad (5)$$

$$i_{ff} = p_{CORE} + r + .8y + .5(p_{CORE}\text{-}p^*) \qquad (6)$$

As for the Taylor Rule that has been modified using Okun's law, both the original and a modification will be tested. The modification will increase the value of -1.25% on the unemployment gap, y, to -2.50%. This will allow for a stronger examination of the degree of dovishness present among each Fed Chairman.

$$i_{ff} = p + r - (2.50\%*y) + 5(p\text{-}2) \qquad (7)$$

The data used for each equation is retrieved from the Federal Reserve Bank of St. Louis Economic Data (FRED). The data is divided by time period with each Chairman, beginning with Chairman Arthur Burns in the first quarter of 1970. Quarterly data is used consistently in each rule due to the lag in policy, where policy has a lag on inflation and unemployment with estimates between one and a half to two years. Quarterly data is also used as a way to remove unnecessary noise, since it is most important for Central Bankers look at trends in the economy. Quarterly data will allow for enough data to see such trends, rather than monthly or daily which would lead to focus on short term results rather than long-term. This will also allow for a broader oversight of the policy results due to the lag in policy actions. Results from the data are omitted from Chairman G. William Miller from the second quarter of 1978 to the second quarter of 1979 due to the relatively small period of time that he held office. Data finishes near present day with the end of Chairman Ben Bernanke's term, due to Chair Janet Yellen's shorter place in office at the time this paper is being written.

Chapter 5

Results

Full Sample Results

The first step in the analysis was to construct a ‘correlation derby’ by examining the simple correlation coefficients for the aforementioned Taylor type specifications. The coefficient is between the actual federal funds rate and the federal funds rate implied by each specification. The full sample results are below in Table 1.

Table 1. Full Sample Correlations of Federal Funds Rate and Policy Rules

FEDERAL_FUNDS_RATE	1.000000
(1) TAYLOR	0.759461
(2) MANKIW	0.753650
(3) OKUN	0.746178
(4) TAYLOR_PCE_CORE	0.811728*
(5) TAYLOR_ADJ_OUTPUT	0.743963
(6) TAY_ADJ_OUTPUT_CORE	0.796340
(7) OKUN_ADJ	0.681222

The correlation results indicate that the Taylor Rule using the core rate of inflation, equation (4), most closely follows the actual Federal Funds rate over time from 1970 to 2013 due to the highest correlation result at 0.811728. This shows that, while not perfectly correlated, the Taylor Rule may have been a source of guidance to the Fed over that time period. The next highest result comes from the Taylor Rule using the core inflation rate with the adjusted 0.8 parameter on the output gap, equation (6), at 0.796340. Although slightly smaller, it may yield an important result about the importance of the Fed for using the core rate of inflation. As we know, monetary policy works with lags and the fact that both of front running rules over the entire sample includes the core rather than the overall rate of inflation perhaps points to the fact that the core eliminates, for the most part, the 'noise' caused by volatile food and energy prices and thus, gives the Fed a better forecast inflation for the intermediate to long term horizon. Figure 1 depicts a graph of the federal funds rate and the funds rate implied by the front running Taylor Rule. Notice that they move very closely together and in fact, almost match from the mid-1980’s to early 1990’s and from the mid-2000’s on. This would cover the periods of both Alan Greenspan and Ben Bernanke, with slightly larger gaps in the mid-1990’s Greenspan timeframe. Even so, the high correlation is apparent.

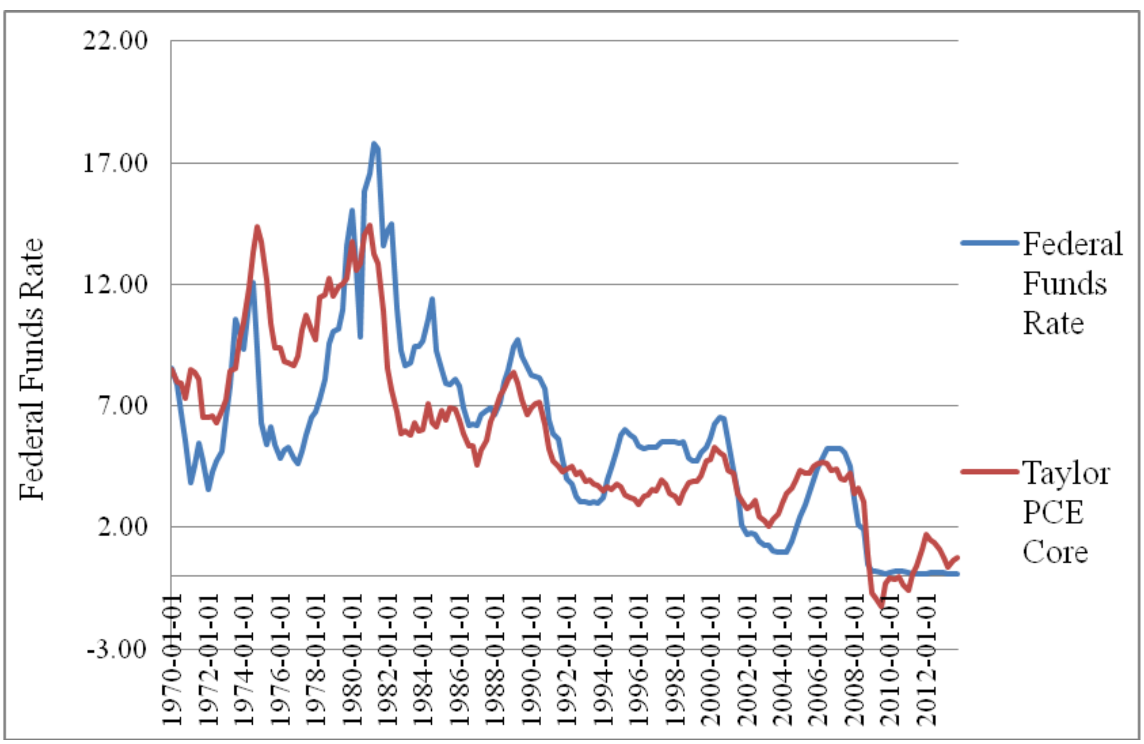

Figure 1. Graph of Federal Funds Rate against Taylor Rule PCE Core

As an alternative to the correlation analysis, simple OLS regressions will be estimated with the actual federal funds rate as the dependent variable with the right hand side representative of the relevant Taylor rule type specification. For purposes of brevity, this paper will only consider the regression results of the Taylor Rule using the PCE core rate of inflation and the Mankiw Rule. In order to estimate the Taylor rule with OLS, a slight modification is in order. In particular, the p_{CORE} term, which represents the actual core rate of inflation, was taken to the left hand side of the regression equation so that the dependent variable is the actual federal funds rate minus the core rate of inflation (denoted FFMINUSCORE). The result is a nice and 'clean' OLS specification with the right hand side including a constant which represents the natural or equilibrium real rate of interest (r) in which Taylor suggested a value of 2%, with the other independent variables being the GDP gap (y) and the inflation gap (p-p*) respectively.

$$i_{ff} - p_{CORE} = r + \alpha y + \beta(p_{CORE} - p^*) \qquad (8)$$

Note importantly that if the original Taylor rule holds exactly, then the implied values of r, the constant in the regression, should be two and the implied values of α and β should be 0.5. When we return the actual core inflation rate (p_{CORE}) to the right hand side, the Taylor principle holds with the implied response to a one percent positive shock to inflation equal to a one and one half percent rise in the federal funds rate, exactly consistent with Taylor's original specification equation. In fact, we can state clearly that if α is greater than zero, the Taylor principle is maintained but if not, then the Taylor principle is violated and we can argue that the central banks is soft (dovish) on inflation.

The full sample results follow.

Table 2. Full Sample Taylor Rule Regression Results

Dependent Variable: FFMINUSCORE
Method: Least Squares
Date: 04/11/15 Time: 11:20
Sample (adjusted): 1970Q2 2013Q4
Included observations: 175 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.251993	0.224154	10.04662	0.0000
PCEINFGAPCORE(-1)	0.288862	0.073679	3.920528	0.0001
GDP_GAP(-1)	0.442266	0.066129	6.687925	0.0000

R-squared	0.245859	Mean dependent var	2.085491
Adjusted R-squared	0.237090	S.D. dependent var	2.542160
S.E. of regression	2.220443	Akaike info criterion	4.450284
Sum squared resid	848.0228	Schwarz criterion	4.504538
Log likelihood	-386.3999	Hannan-Quinn criter.	4.472291
F-statistic	28.03700	Durbin-Watson stat	0.191185
Prob(F-statistic)	0.000000		

The full sample Taylor Rule OLS results are quite consistent with the original Taylor rule. The constant at 2.25% is very much in line with the 2% assumption originally made by Taylor. The Taylor principle holds with an implied response of the federal funds rate to a 1% positive shock to inflation equal to 1.29%. The reaction parameter for the GDP gap is at .44, only slightly smaller as compared to the .50 as assumed by Taylor.

We now consider the results of the Mankiw rule. Here, no modification is needed. The following regression is estimated:

$$i_{ff} = c + \gamma(p - UR) \quad (2)$$

where according to Mankiw, $c = 8.5$ and $\gamma = 1.4$.

Table 3. Full Sample Mankiw Rule Regression Results

Dependent Variable: FF
Method: Least Squares
Date: 03/14/15 Time: 11:36
Sample: 1970Q1 2013Q4
Included observations: 176

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	9.003344	0.286963	31.37460	0.0000
PCE_CORE-UR	1.182058	0.078152	15.12505	0.0000

R-squared	0.567989	Mean dependent var	5.732159
Adjusted R-squared	0.565506	S.D. dependent var	3.795953
S.E. of regression	2.502147	Akaike info criterion	4.683474
Sum squared resid	1089.369	Schwarz criterion	4.719502
Log likelihood	-410.1457	Hannan-Quinn criter.	4.698087
F-statistic	228.7672	Durbin-Watson stat	0.126664
Prob(F-statistic)	0.000000		

Turning to the Mankiw Rule, results are certainly in line with the higher coefficient of 9, compared to the 8.5 found by Mankiw (2001). The Taylor principle does hold with the parameter on the difference between p_{CORE} - UR estimated at 1.18 vs. Mankiw's 1.4 value. The r-squared is quite a bit higher than the Taylor rule results, perhaps suggesting the unemployment rate plays at least as big a role in monetary policy as the GDP gap plays.

I now break down my results by period of Fed Chairman. I begin with the Arthur Burns Period from the second quarter of 1970 to the fourth quarter of 1977.

The Burns Period

As in the full sample, the first step in the results for the Burns period was to sample correlations of each rule to the actual federal funds rate. From the second quarter of 1970 to the fourth quarter of 1977, the correlation results follow.

Table 4. Burns Period Correlation Results

FEDERAL_FUNDS_RATE	1.000000
(1) TAYLOR	0.789806
(2) MANKIW	0.739685
(3) OKUN	0.853275
(4) TAYLOR_PCE_CORE	0.517983
(5) TAYLOR_ADJ_OUTPUT	0.853263
(6) TAY_ADJ_OUTPUT_CORE	0.693735
(7) OKUN_ADJ	0.921251*

Unlike the full sample, here the highest correlation appears with equation (7), where Okun's Law was modified to fit the Taylor Rule combined with an adjustment on the unemployment gap to 2.50%. This is most certainly the best fit for the data at a correlation of 0.921251. The next two highest correlation coefficients occur for equations (3) and (5). Equation (3) has the unemployment gap as well where equation (5) has a 0.8 as a parameter rather than the 0.5 as originally proposed by Taylor. This period is well known as being a 'dovish' period in US monetary policy and our correlation results are certainly consistent with that notion. Historically, this would perfectly explain the high inflation levels of the 1970s along with Burns' reputation as being too easy on inflation. I now turn to the regression results for this period.

Table 5. Burns Period Taylor Rule Regression Results

Dependent Variable: FF_minus_PCE_inf
Method: Least Squares
Date: 03/19/15 Time: 14:58
Sample (adjusted): 1970Q2 1977Q4
Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.608580	0.345277	4.658814	0.0001
PCEINFGAP(-1)	-0.246737	0.079215	-3.114771	0.0042
GDP_GAP(-1)	0.570126	0.076849	7.418738	0.0000

R-squared	0.797264	Mean dependent var	0.321371
Adjusted R-squared	0.782783	S.D. dependent var	1.949553
S.E. of regression	0.908619	Akaike info criterion	2.737985
Sum squared resid	23.11650	Schwarz criterion	2.876758
Log likelihood	-39.43877	Hannan-Quinn criter.	2.783222
F-statistic	55.05535	Durbin-Watson stat	1.479682
Prob(F-statistic)	0.000000		

The results indicate that the Burns period was indeed dovish. The real rate of interest is estimated to be .96% as compared to the 2% proposed by Taylor. What this implies is that if the Fed was spot on with the inflation and GDP gaps equaling zero, the neutral federal funds rate would be at 2.96% as compared to Taylors 4% assumption. The Taylor principle is barely satisfied and the response to the GDP gap is twice that proposed by Taylor, again consistent with this period being characterized as dovish.

Table 6. Burns Period Mankiw Rule Regression Results

Dependent Variable: FF
Method: Least Squares
Date: 03/16/15 Time: 07:33
Sample: 1970Q1 1977Q4
Included observations: 32

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.186227	0.296305	24.25279	0.0000
PCE_CORE-UR	1.112865	0.184850	6.020353	0.0000

R-squared	0.547133	Mean dependent var	6.488437
Adjusted R-squared	0.532038	S.D. dependent var	2.255005
S.E. of regression	1.542598	Akaike info criterion	3.765275
Sum squared resid	71.38829	Schwarz criterion	3.856884
Log likelihood	-58.24440	Hannan-Quinn criter.	3.795641
F-statistic	36.24465	Durbin-Watson stat	0.510315
Prob(F-statistic)	0.000001		

The regression results using the Mankiw rule are similar in that they portray a relatively dovish central banker. The Taylor principle is satisfied although the coefficient is at 1.11 versus the 1.4 as proposed by Mankiw. The constant is quite a bit lower, at 7.2 versus the 8.5 as proposed by Mankiw. The Taylor Rule here is a much better fit of the data than the Mankiw Rule with an R-squared of 79.73% versus 54.71% in the Mankiw Rule.

The Volcker Period

I next move on to Chairman Volcker. The correlation results from the 3rd quarter of 1979 to the second quarter of 1987 follow.

Table 7. Volcker Period Correlation Results

FEDERAL_FUNDS_RATE	1.000000
(1) TAYLOR	0.760243
(2) MANKIW	0.753126
(3) OKUN	0.729295
(4) TAYLOR_PCE_CORE	0.831577*
(5) TAYLOR_ADJ_OUTPUT	0.706852
(6) TAY_ADJ_OUTPUT_CORE	0.759570
(7) OKUN_ADJ	0.616101

As in the full sample data, equation (4) is the best fit of the data with a correlation of 0.831577. The lowest result is found in equation (7), the opposite of the Burns period. The results indicate that Volcker and Burns were very different in their approach to monetary policy. Clearly, Volcker had no intentions of being dovish. After the high inflation of the Burns period, this is exactly what the economy had been asking for with a Chairman who would be tough on inflation.

Table 8. Volcker Period Taylor Rule Regression Results

Dependent Variable: FFMINUSCORE
Method: Least Squares
Date: 04/11/15 Time: 11:53
Sample: 1979Q3 1987Q2
Included observations: 32

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.507579	0.688134	5.097234	0.0000
PCEINFGAPCORE(-1)	0.406037	0.146670	2.768371	0.0097
GDP_GAP(-1)	0.082462	0.132835	0.620789	0.5396

R-squared	0.209107	Mean dependent var	4.885413
Adjusted R-squared	0.154563	S.D. dependent var	1.898480
S.E. of regression	1.745608	Akaike info criterion	4.041143
Sum squared resid	88.36731	Schwarz criterion	4.178556
Log likelihood	-61.65829	Hannan-Quinn criter.	4.086692
F-statistic	3.833706	Durbin-Watson stat	1.036383
Prob(F-statistic)	0.033320		

The results indicate that Volker was indeed hawkish. The equilibrium real rate of interest is estimated to be 3.5% as compared to 2% proposed by Taylor. The Taylor principle is satisfied and there appears to be no response to the GDP gap consistent with a central banker being much more concerned with inflation than full employment. The R-squared is a moderate 20.9%.

Table 9. Volcker Period Mankiw Rule Regression Results

Dependent Variable: FF
Method: Least Squares
Date: 03/16/15 Time: 07:36
Sample: 1979Q3 1987Q3
Included observations: 33

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	12.64667	0.516896	24.46655	0.0000
PCE_CORE-UR	1.056830	0.165806	6.373876	0.0000

R-squared	0.567198	Mean dependent var	10.57909
Adjusted R-squared	0.553237	S.D. dependent var	3.458746
S.E. of regression	2.311838	Akaike info criterion	4.572654
Sum squared resid	165.6824	Schwarz criterion	4.663352
Log likelihood	-73.44880	Hannan-Quinn criter.	4.603171
F-statistic	40.62629	Durbin-Watson stat	0.472484
Prob(F-statistic)	0.000000		

The results from the Mankiw Rule are similar. The estimated neutral federal funds rate is much higher during the Volcker period as compared to that proposed by Mankiw where the constant is estimated to be 12.6 compared to 8.5 proposed by Mankiw. The Taylor principle holds and the fit is better than the corresponding Taylor rule results.

The Greenspan Period

Next, I turn to the Greenspan period.

Table 10. Greenspan Period Correlation Results

FEDERAL_FUNDS_RATE	1.000000
(1) TAYLOR	0.725200
(2) MANKIW	0.836369*
(3) OKUN	0.797277
(4) TAYLOR_PCE_CORE	0.806393
(5) TAYLOR_ADJ_OUTPUT	0.726613
(6) TAY_ADJ_OUTPUT_CORE	0.810794
(7) OKUN_ADJ	0.808077

The Mankiw Rule best fits the Greenspan Period.

Table 11. Greenspan Period Taylor Rule Regression Results

Dependent Variable: FFMINUSCORE
Method: Least Squares
Date: 04/11/15 Time: 12:07
Sample: 1987Q3 2005Q4
Included observations: 74

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.482264	0.167592	14.81138	0.0000
PCEINFGAPCORE(-1)	0.698134	0.159678	4.372124	0.0000
GDP_GAP(-1)	0.763797	0.093707	8.150864	0.0000

R-squared	0.511347	Mean dependent var	2.406977
Adjusted R-squared	0.497582	S.D. dependent var	1.827837
S.E. of regression	1.295597	Akaike info criterion	3.395516
Sum squared resid	119.1786	Schwarz criterion	3.488925
Log likelihood	-122.6341	Hannan-Quinn criter.	3.432778
F-statistic	37.14866	Durbin-Watson stat	0.120890
Prob(F-statistic)	0.000000		

The results from the Greenspan period are quite revealing. First, the equilibrium real rate is estimated to by in line with the original Taylor rule, 2.48 vs. 2, implying that Greenspan was slightly hawkish. The Taylor principle is clearly satisfied with the implied response to a one percent positive shock to inflation equal to a 1.7% rise in the federal funds rate. The response parameter on the GDP gap is at .76, higher than that proposed by Taylor and consistent with Ben Bernanke's statement alluded to earlier.

Table 12. Greenspan Period Mankiw Rule Regression Results

Dependent Variable: FF
Method: Least Squares
Date: 03/16/15 Time: 07:37
Sample: 1987Q3 2005Q4
Included observations: 74

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	10.61691	0.470665	22.55724	0.0000
PCE_CORE-UR	1.857234	0.143455	12.94646	0.0000

R-squared	0.699513	Mean dependent var	4.818919
Adjusted R-squared	0.695339	S.D. dependent var	2.256439
S.E. of regression	1.245466	Akaike info criterion	3.303551
Sum squared resid	111.6853	Schwarz criterion	3.365823
Log likelihood	-120.2314	Hannan-Quinn criter.	3.328392
F-statistic	167.6109	Durbin-Watson stat	0.111413
Prob(F-statistic)	0.000000		

The results for the Mankiw rule tell the same story as above. The constant is higher than that proposed by Mankiw suggesting that Greenspan was a little hawkish. Also, the Taylor principle is clearly satisfied, with a coefficient of 1.86 compared to the original 1.4 proposed by Mankiw.

In line with the correlations, the Mankiw Rule is a much better fit for the data with an R-squared value at 69.95%. Both the Taylor Rule and the Mankiw Rule here are statistically significant.

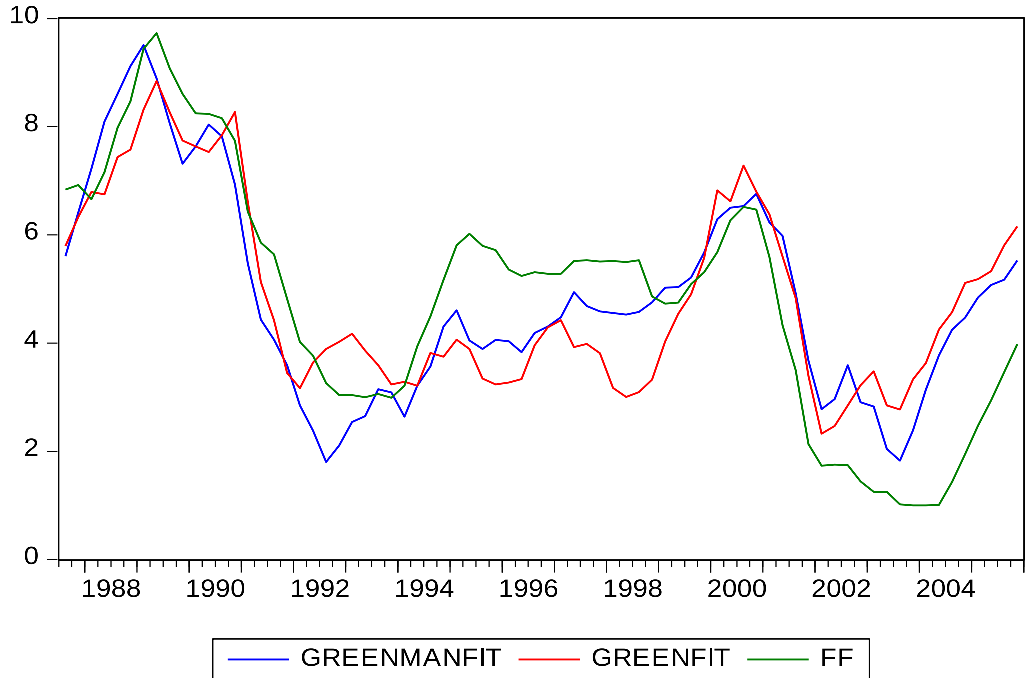

Figure 2. Mankiw and Taylor Rules under Greenspan

Figure 2 shows the Mankiw Rule and the Taylor Rule against the actual federal funds rate. "GREENMANFIT" refers to the Mankiw Rule in blue and "GREENFIT" refers to the Taylor Rule in red. In the jobless recovery in the early 1990's, the Mankiw Rule says to lower the federal funds rate where the Taylor Rule says to raise them. The actual funds rate under Greenspan is in between, erring closer to the Mankiw Rule. In the job loss recovery of the early 2000's, again we see the same results. The Mankiw Rule again says to lower the federal funds rate where the Taylor Rule says to raise them. During the early 2000's, the actual federal funds rate is well under both rules consistent with the Greenspan critics that argued that he kept interest rates too low for too long.

The Bernanke Period

Table 13. Bernanke Period Correlation Results

FEDERAL_FUNDS_RATE	1.000000
(1) TAYLOR	0.764882
(2) MANKIW	0.903517
(3) OKUN	0.814009
(4) TAYLOR_PCE_CORE	0.914134
(5) TAYLOR_ADJ_OUTPUT	0.820228
(6) TAY_ADJ_OUTPUT_CORE	0.922838*
(7) OKUN_ADJ	0.854758

The Taylor Rule using the core rate of inflation and an adjusted output gap of 0.8 yields the best correlation results under Bernanke. These two measurements both align with Bernanke's statements presented earlier in this paper about why he was a proponent of using the core rate and a stronger parameter on the output gap.

For the Bernanke period, I choose not to run regression results. This is because the Fed was at the zero bound for much of the period, so running a regression on the series would not adequately give information on the federal funds rate and its relationship to policy rules.

Chapter 6

Conclusion

Through simple reaction functions like the Taylor Rule and modifications of them, this paper seeks to add to the debate on rules versus discretion in monetary policy for the Federal Reserve since 1970. I considered each Fed Chairman since 1970 and discovered that the rule that fits the data the best does seem to depend on the Chairman or at the very least, the time period under consideration. The results also indicate that the Burn's regime was the most dovish period as the Taylor principle was non-existent with the Burn's regime applying much more weight to the GDP gap as compared to the inflation gap. The opposite is the case for the Volcker regime where at least empirically, little or no weight was placed on the GDP gap. In addition, the neutral federal funds rate was much larger under the Volcker regime as compared to the Burns regime, consistent with Volcker's hawkish reputation. The empirical results of the Greenspan regime are much more consistent with the Federal Reserve spreading the weights more evenly in terms of reacting to both the inflation gap and GDP gaps respectively, certainly in line with the Taylors original specification. In addition, the results indicate that the Greenspan Fed did crank up the weight on the GDP gap consistent with what Bernanke stated in his speech, *Monetary Policy and the Housing Bubble* (Bernanke, January 3, 2010). With regard to the Bernanke regime, it is clear that estimating Taylor type specifications would lead to little additional insight since the federal funds target hit and was at the zero bound for 75% of Bernanke's regime.

With regard to the debate on rules versus discretion, there clearly has been no single optimal rule that fits the data the best. Using the literature review and some empirical results, this paper finds discretion to be a much better indicator of Fed policy, with tendencies to move toward a rule dependent on the central banker.

An example that follows that may yield some insights into the way the Fed thinks about rules vs. discretion. Suppose that a town finds that there are too many expenses related to fires breaking out that are caused by careless drunk people from midnight to five a.m. early Sunday morning. To combat this, the town decides to adopt an explicit rule that they will not answer any fire calls between midnight and five a.m. on Sunday mornings. The idea is to deter people from being irresponsible and if they continue to be irresponsible, then they must pay the consequences. The first Sunday morning under this new regime, an electrical storm breaks out at 12:01 a.m. spawning many house fires. Since the fire department has the explicit rule in place, they know that they cannot break it now for fear of jeopardizing their credibility, and they watch as the town burns. The ironclad rule did not yield a result that made the town better off, in fact, the rule made the town worse off. This example illustrates the case for flexible rules being the most socially optimal.

Indeed, this case is precisely the type that Chairwoman Yellen was referring to in the aftermath of the 2008 financial crisis. Yellen herself stated that if a strict policy rule had been followed, given “the recommendations of any of the simple rules that are widely discussed, the outcomes would have been even more disappointing than what we experienced” (Vinik, 2014). The results presented here conclude that rules should serve as a guideline rather than be ironclad. The Fed has never followed a policy rule with any strong predictability through time, and still requires the discretion necessary to overcome unexpected economic conditions that rules simply cannot capture.

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