Economics Senior Thesis

The Role of Asset Prices in Monetary Policy

Positive and Normative Arguments

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Abstract

Various tools have been developed over time in order to better analyze the Federal Reserve's policy rule in hopes of developing more effective policies. However, essential to the majority of monetary economics literature is the assumption that the Fed targets only output and inflation. The question of whether or not asset prices have been taken into consideration in the past and its consequent implications on setting monetary policy in the future call for further examination. This paper finds initial empirical evidence that supports the existence of asset prices in the Fed's policy rule.

1. Introduction

A key discussion in monetary economics is the evaluation of central bank policy, specifically the actions and policy setting of the United States Federal Reserve (the Fed). Continued evaluation of the Fed's policies allows for further insights into the intricate role that monetary policy plays in the economy and thus contributes to developing more effective policies. Various tools have been developed over time in order to better analyze the policy rule that the Fed follows. However, essential to the majority of monetary economics literature is the assumption that the Fed only targets output and inflation. The question of whether or not asset prices have been taken into consideration in the past and its consequent implications on setting monetary policy in the future call for further examination.

Asset prices appear to be an intuitive third target in addition to output and inflation. Greenspan (1996) notably ponders over whether the stability of asset prices may be essential to the stability of the economy. However, despite the wealth of theoretical and empirical evidence both for and against an alternative reaction function targeting asset prices, there is no derivation of an asset price augmented reaction function along the lines of Taylor (1993) to test for and determine the relevancy of asset prices to the setting of the monetary policy in the past.

Taylor (1993) proposed the first of several formulations of policy rules, or reaction functions. Using graphical evidence, Taylor observed that inflation and the output gap tend to drive the short-term federal funds rate set by the Fed during the observed period from 1987 until 1992. This straightforward rule proposed by Taylor is popular among macroeconomists and still serves as a baseline suggestion for monetary policy, as empirical evidence has shown that the rule provides a fairly accurate summary of monetary policy under Paul Volcker and Alan Greenspan (Horne 2009).

Over time, various refinements for Taylor (1993) have been suggested to create a more effective reaction function. Most notably, Clarida, Gali and Gertler (2000) as well as Orphanides (2001) modernized the Taylor rule by constructing a rule that better described the actions of the Fed when compared with empirical data and provided a deterministic system for the macro-economy. As a result of the findings of these authors, both inflation and the output gap became widely accepted as components of the Fed's reaction function. However, these still exists no consensus as to whether additional variables such as asset prices should be included, and if so, which ones.

This paper seeks to build upon the existing research and improve upon the reaction function by Taylor (1993) via the addition of variables representative of asset prices. Important assets to consider include financial instruments such as equities, derivatives and bonds, as well as other assets such as real estate, commodities as well as other capital goods. These assets can be evaluated with an ordinary least squares regression model using stock prices, financial indices and the Consumer Price Index in conjunction with GDP. Manipulations of the data with respect to GDP are necessary to take out the effect of changes in asset prices that are due to output and inflation. Seeing as asset prices is likely co-vary with output and inflation as well, the model must also remedy potential issues such as multicollinearity by using as many data points as possible, which in this case would be all available quarterly data from 1967 to 2011.

With the important role of asset prices in the economy, it is essential to observe whether they have been taken into consideration by the Fed in the past in setting the monetary policy. If so, it would shed more light on how monetary policy has been conducted and allow economists to better understand the role of asset prices in the Fed's decisions. If not, further research could perhaps suggest ways to improve monetary policy by further taking asset prices into account. Thus, via the addition of asset prices to Taylor's rule (1993), this paper seeks to observe whether or not the Fed has taken asset prices into consideration in setting the effective federal funds rate in the past from the first quarter of 1967 to the last quarter of 2011, and as a result, better understand the role of asset prices in monetary policy.

2. The Policy Rule

A policy rule is a course of action chosen by a central bank for an indefinite time horizon, as summarized in Clarida, Gali and Gertler (1999). This policy rule is typically chosen through some form of optimization. Alternatively, the central bank could employ discretion, which is the formulation of a new policy action in each and every time period. In other words, a policy rule requires a commitment to actions whereas discretion does not, and this distinction results in drastically different outcomes. As Horne (2009) finds, since a policy rule tends to generate more effective monetary policy, as a result of credibility gained from holding to the policy rule, it would be effective to not consider discretion.

3. Literature Review

This paper first look to monetary economic literature that discuss the formulation of policy rules to gather theoretical and empirical evidence regarding the relevancy of asset prices in the Fed's setting of monetary policy. Taylor (1993) proposed the first of several formulations of policy rules, or reaction functions. Using graphical evidence, Taylor observed that inflation and the output gap tend to drive, or predict, the short-term interest rate set by the Fed. His empirical data suggest that there is a linear relationship among his variables during the observed period from 1987 to 1992.

Taylor (1993) modeled the federal funds rate as a linear function of inflation and the output gap using graphical evidence. As a result, he recommended that monetary policy be conducted through an interest rate rule that responds to output and inflation of the form $r = r(Y, \pi)$, so that it sets a higher real interest rate when either output or inflation is higher. Taylor argued that this is a good way to conduct monetary policy as it is intended to foster price stability and healthy employment levels by systematically reducing uncertainty and increasing the credibility of future actions by the central bank. Taylor also suggested that the inefficiencies of time inconsistency from discretionary policy may be avoided by following the aforementioned interest rate rule.

This rule proposed by Taylor still serves as a baseline suggestion for monetary policy, especially since empirical evidence has shown that the rule fairly accurately describes the setting of monetary policy under Paul Volcker and Alan Greenspan. However, over time, various refinements have been suggested to create a more effective reaction function. Despite Taylor 's empirical approach to the reaction function, subsequent monetary economic literature that provided a theoretical derivation of the reaction function, such as Clarida et al. (1999), yielded a similar policy rule to that of Taylor.

Clarida, Gali and Gertler (2000) as well as Orphanides (2001) modernized the Taylor rule by constructing a rule that better described the actions of the Fed when compared with empirical data. They provided a deterministic system under which the macroeconomy functioned. As a result of the findings of these authors, both inflation and the output gap became widely accepted as components of the Fed's reaction function. However, there still exists no consensus as to whether additional variables should be included, and if so, which ones.

Papers such as Hayford and Malliaris (2004) and Rigobon and Sack (2003) argued for the inclusion of asset prices in the reaction function. Similar to Taylor's analysis, these arguments are predominantly empirically motivated. On the other hand, theoretically driven reaction functions, such as those found in Clarida, Gali and Gertler (1999), did not seem to suggest a relationship between the federal funds rate and asset prices. In fact, some notable authors, including Benjamin Bernanke, have constructed various theoretical arguments against a central bank's consideration of asset prices.

Nonetheless, essential to most literature is the assumption that a central bank only targets output and inflation. Thus, the question of whether asset prices have been taken into consideration in the past, and if so, its consequent normative implications on setting the monetary policy in the future is unclear. Despite the fact that there currently does not exist a derivation of an asset price augmented reaction function along the lines of Clarida et al. (1999), this paper will explore more in depth the existing wealth of theoretical and empirical evidence both for and against an alternative reaction function, including normative and positive discussions on the relevancy of asset prices to monetary policy.

3.1 Normative Arguments

Of the normative literature, there are strong arguments both for and against asset price targeting. Bernanke and Gertler (1999 and 2001) led arguments against asset price targeting. They claimed that asset price targeting is unnecessary and that inflation targeting would be optimal regardless of the state of the financial sector. On the other hand, Cecchetti (1998) led arguments for asset price targeting. These monetary economists claimed that asset price targeting can improve the efficacy of monetary policy.

3.1.1 Opponents

Bernanke and Gertler (1999 and 2001) argued that asset price targeting is unnecessary, as inflation targeting would be optimal regardless of the state of the financial sector. They contended that inflation targeting sufficiently stabilizes asset prices, and thus, any targeting of asset prices by a central bank is ineffective and unnecessary. Bernanke and Gertler (1999) claimed that maintaining constant levels of current and expected inflation is the equivalent of sustaining output at its natural level. When a bubble exists, either there is no effect on aggregate demand or the bubble causes an increase in aggregate demand through the wealth effect. In both of the aforementioned scenarios, the optimal response is the monetary policy prescribed through inflation targeting, in which asset prices targeting would be irrelevant. They further critiqued that any asset price targeting is misguided, as asset price bubbles are extremely difficult to identify a priori, if even possible.

Bullard and Schaling (2002) took a different approach to dismissing targeting asset prices. They constructed a macroeconomic model under which a central bank targets equity prices in addition to the traditional output and inflation. With this model, they suggested that asset price targeting can interfere with the minimization of inflation and output variation. They also showed that under certain conditions, asset price targeting can lead to indeterminacy. Thus, they concluded that targeting equity prices leads to suboptimal levels of inflation and the output gap.

3.1.2. Proponents

On the other hand, Cecchetti (1998) argued that asset price targeting can improve the efficacy of monetary policy. Contrary to the arguments of Bernanke and Gertler (1999), Cecchetti (1998) argued for the targeting of asset prices. Cecchetti and et al (2000) claimed that by considering asset prices, a central bank can improve economic performance. Similarly, Cecchetti, Genberg and Wadhwami (2003) examined how the end of a bubble can lead to unnatural levels of either inflation or deflation, and thus suggested the potential benefits of targeting asset prices.

In addition, Blanchard (2000) directly addressed Bernanke and Gertler (1999) to make a case for asset price targeting. He asserted that stock market bubbles can lead to increased capital accumulation, an economic condition that inflation targeting cannot combat. Under such circumstances, he argued that asset prices should to be included as a third target of monetary policy to mitigate such economic issues. He emphasized that by considering asset prices in its policy rule, the Fed would be able to address a wider range of economic situations and thus enhance the effectiveness and robustness of its monetary policy.

Similarly, Bordo and Jeanne (2001) also differed with Bernanke and Gertler (1999). They reasoned that in cases of extreme financial instability, as in the United States in 1929 and Japan during the 1990's, ignorance of asset prices can worsen already grim levels of output. In agreement with Bordo and Jeanne (2001) is Mishkin (2000), who stated that financial collapses should be prevented by monetary policy. As a natural consequent, Mishkin argued that asset price targeting should be considered by the Fed to mitigate the effects of potential financial issues that arise.

3.2 Positive Arguments

Of the positive arguments for and against asset price targeting, Rigobon and Sack (2003) explored whether or not the Fed did target asset prices in the past. They claimed that monetary policy reacts significantly to changes in the stock market. In fact, they found that a 5 percent rise (fall) in the S&P 500 increases the likelihood of a 25 basis-point tightening (easing) of the federal funds rate by approximately 50 percent. Rigobon and Sack attributed this result to how monetary policy anticipated stock market movements, though they did note that this conclusion is tentative and that the results should be taken cautiously.

In extension, Hayford and Malliaris (2004) tested the relationship between stock market bubbles and the federal funds rate. Similar to Clarida et al. (2000), they constructed an asset price augmented reaction, where they included the price earnings

(P/E) ratio as their financial variable. Through their empirically based research, Hayford and Malliaris found a significant and negative relationship between the P/E ratio and the federal funds rate. Thus, they concluded that through the 1990's, the Fed accommodated the formulation of stock market bubbles and consequently considered asset prices in the setting of monetary policy.

3.3 Literature Review Conclusion

Given this review of relevant monetary economic literature, this paper finds mixed normative arguments and limited positive arguments both for and against the practice of asset price targeting by the Fed. Although there appears to be more theoretical and empirical literature favoring the inclusion of asset prices, the role of asset prices in monetary policy is ambiguous at best. Despite the wealth of normative literature, the lack of a clear theoretical conclusion regarding the relevancy of asset prices in monetary policy is evident. In fact, there is no conclusive consensus in the economic community about whether or not asset prices have been taken into consideration by the Fed, rendering it difficult to judge the inclusion or exclusion of asset prices in a normative manner.

Consequently, this paper does not attempt to construct a robust normative argument for asset price targeting, but rather takes a step back and ventures to better understand the role of asset prices in monetary policy through building upon the existing research with an empirical approach. Thus, this paper seeks to construct a reaction function similar to that of Taylor (1993), with the addition of variables for asset prices. In fact, elucidating the role of asset prices in monetary policy and understanding whether or not asset prices have been taken into consideration by the Fed—even if implicitly—will yield insights that allow for better normative judgments regarding asset price targeting.

4. Discussion of Variables

In order to construct a model that fully considers all of the relevant independent variables, this paper bases its model on Taylor's rule (1993). Taylor (1993) constructed a regression model in which he estimated the effective federal funds rate. By regressing variables including the percentage change in inflation and the annualized percent change in the difference between GDP and potential GDP, Taylor observed that from 1987 to 1992 inflation and the output gap tends to drive, or predict, the short-term interest rate set by the Fed. This elegant rule still serves as a baseline suggestion for monetary policy, despite the refinements made at later dates, due to its practical use in describe monetary policy under Paul Volcker and Alan Greenspan. Thus, Taylor's rule (1993) will serve as the basis upon which the model for this paper is built.

4.1 Time Horizon

In considering the role of the time horizon in the model, this paper observes Taylor's backward-looking rule (1993), such that the effective federal funds rate in a given quarter t is a function of inflation and the output gap in the previous quarter $t-1$. In contrast, a forward-looking rule is one in which the effective federal funds rate for a given quarter t is a function of variables dated in a future quarter $t+k$, for some integer k. Some literature favors a forward-looking rule due to the fact that it is well accepted that the actions of a central bank have a lagged affect. However, the purpose of this paper is to observe whether or not asset prices are relevant in the setting of monetary policy, not whether or not monetary policy influences asset prices. Thus, a rule similar to that of Taylor (1993), which observes the relationship between the effective federal funds rate and the relevant variables in the same quarter, would suffice.

A non-lagged rule is sufficient due to the fact that in a given quarter t, the Fed would not have had access to absolutely certain data regarding a given future quarter $t+k$, but only the data in the current quarter. With the known lagged effect of monetary policy, the Fed would not base its decisions on economic variables from the previous quarter, but use the economic variables in the current quarter to make decisions in setting the interest rate, in hopes of using the most recent and thus reliable variables available.

4.2 Inflation Targeting

In terms of inflation targeting, although many controversies exist in the literature on monetary economics, almost all literature agree that inflation targeting is important if policy is to be effective. Indeed, Bernanke and Mishkin (1997) provided a very compelling argument for inflation targeting. Similarly, Clarida et al. (2000) and Orphanides (2001) attempted to integrate inflation targeting into their models as well. Consequently, inflation targeting has become a widely accepted variable in the Fed's reaction function as a result of its extensive usage.

However, in spite of its importance, an inflation target is difficult to identify and quantify in terms of economic research. The fact that the Fed never publicly states their inflation targets, or even whether or not they actively practice inflation targeting, makes an this variable difficult to identify. Thus, in this paper, the percentage change in the

Consumer Price Index is used to as the variable for inflation targeting, as is conventional in monetary economics literature.[1]

4.3 The Output Gap

There is general consensus in monetary economics literature for the output gap variable. Essential to constructing the output gap is the approximation of potential output. Taylor (1993), Hayford and Malliaris (2004), Clarida et al. (2000), and Orphanides (2001) first projected the log of real GDP on a polynomial function of time to obtain potential GDP. The output gap is then calculated as the difference between real GDP and potential GDP. Other authors have derived potential GDP from a structural equation like a Cobb-Douglas production function or the Philip's curve, for potential GDP and NAIRU respectively. Detailed descriptions of these different methods can be found in Judd and Rudebusch (1998).

Additionally, potential output can be derived from Okun's Law by using the rate of change of unemployment. Clark (1982) and Braun (1990) provided a detailed description of this process. However, as the U.S. Congressional Budget Office annually releases a real potential GDP as a part of the Budget and Economic Ooutlook, this paper follows Taylor (1993) and constructs the output gap by taking the difference between actual real GDP and the real potential GDP and dividing by the real potential GDP.

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[1] Many thanks to Professor Eichengreen for all his guidance regarding generally accepted methods taken in macroeconomics literature.
[2] Data from the Board of Governors of the Federal Reserve System, retrieved through Federal Reserve Economic Data
[3] Data from the U.S. Department of Labor: Bureau of Labor Statistics
[4] Data from the U.S. Department of Commerce: Bureau of Economic Analysis

4.4 Asset Prices

In terms of asset prices, there currently exists little monetary economics literature that takes into account asset prices variables in a reaction function similar to that of Taylor (1993). This paper argues that in order to represent a comprehensive picture of asset prices, important assets to consider include financial instruments such as equities, derivatives and bonds, as well as other assets such as real estate, commodities as well as other capital goods. All of the above should be included under variables for asset prices to provide a comprehensive view.

This paper takes financial instruments into account via the inclusion of a variable for the Standard and Poor 500 (S&P 500). The S&P 500 is generally accepted to be a gauge of the large cap U.S. equities market, which is the foundation for derivatives. Fixed-income instruments such as bonds do not need to be considered via a separate variable, as they are directly affected by changes in the effective federal funds rate, and may result in issues of serial correlation within the model if introduced. Other assets such as real estate, commodities and other capital goods are taken into consideration via the inclusion of the consumer price index for housing.

5. Model

This paper seeks to build upon the existing research and improve upon the reaction function by Taylor (1993) via the inclusion of variables representative of asset prices. The model for this paper takes time horizon, inflation, output gap, real GDP, and a comprehensive array of asset prices into consideration to build a comprehensive reaction function. As such, the equation for the model used in this paper is as follows:

$$\boldsymbol{DFF = \text{constant} + \beta_1 CPIAP + \beta_2 YGAP + \beta_3 RSP500 + \beta_4 LRCPIH + \beta_5 RGDP + \beta_6 Time}$$

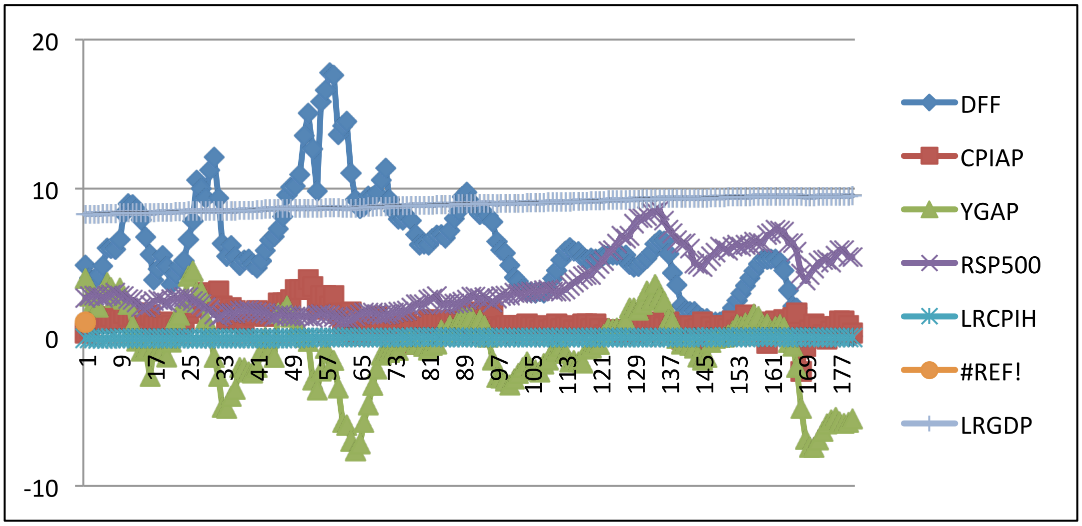
The independent variable in this model, denotated as *DFF* by monetary economic convention, represents the effective federal funds rate in percentage.[2] The rest of the variables are similarly abbreviated and denoted by commonly accepted monetary economic convention. All of these variables are represented with quarterly data from the first quarter of 1967 to the forth quarter of 2011, which is chosen to utilize the most of available data (Table 1 and Table 2). Consequently, a time series index is constructed with the variable *Time*, numbered as 1 in the first quarter of 1967 to 180 in the last quarter of 2011.

Table 1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
DFF	180	6.001111	3.582015	.07	17.79
CPIAP	180	1.078333	.7945537	-2.3	3.9
RGDP	180	8217.549	3066.881	3915.4	13429.9
PGDP	180	8300.775	3142.899	3767.6	14207.5
SP500	180	534.5924	481.8057	69.38	1497.18
CPIH	180	121.851	60.33884	30.5	220.425
CPIA	180	123.414	59.64312	32.967	226.95
YGAP	180	-.7787566	2.602789	-7.616229	4.44623
RSP500	180	3.575735	2.035818	1.165077	8.531676
LRCPIH	180	-.0234801	.0289608	-.0852333	.021937
res	180	2.16e-09	1.817284	-3.479745	6.49126
time	180	90.5	52.10566	1	180
LRSP500	180	1.116345	.5630615	.1527875	2.143786
residual	180	3.36e-09	1.784283	-3.579501	6.562787
LRGDP	180	8.941955	.3853948	8.272673	9.505239

[2] Data from the Board of Governors of the Federal Reserve System, retrieved through Federal Reserve Economic Data

Table 2: Graphical Representation of Variables Versus Quarter in Time Series



5.1 Inflation Targeting and the Output Gap

To represent the two generally accepted variables, inflation and output gap, this model uses *CPIAP* and *YGAP* based on Taylor (1993). *CPIAP* represents the Consumer Price Index for all urban consumers and all items in percentage change to present inflation, and it uses an Index with 1982-84 = 100 that is seasonally adjusted.[3] *YGAP* represents the output gap and is constructed by taking the difference between actual real GDP and the real potential GDP and dividing by the real potential GDP: $100*(Y_{RGDP} - Y_{PGDP})/Y_{PGDP}$.

Specifically, Y_{RGDP} represents the real GDP to 1 decimal place in billions of chained 2005 dollars.[4] $Y_{RGDP} = RGDP$ uses a seasonally adjusted annual rate and represents the inflation adjusted value of the goods and services produced by labor and property in the U.S. Y_{PGDP} represents real potential GDP in billions of chained 2005 dollars.[5] Y_{PGDP} =

[3] Data from the U.S. Department of Labor: Bureau of Labor Statistics
[4] Data from the U.S. Department of Commerce: Bureau of Economic Analysis
[5] Data from the U.S. Congress Congressional Budget Office

PGDP represents the CBO's estimate of the output the economy would produce with a high rate of use of its capital and labor resources, adjusted to remove the effects of inflation.[6]

5.2 Asset Prices

To represent asset prices, this model uses *RSP500* and *LRCPIH*. *RSP500* represents the inflation adjusted Standard and Poor 500 Index, which includes 500 leading companies in leading industries of the U.S. economy that are publicly held on either the NYSE or NASDAQ, and covers 75% of U.S. equities. To find the real effects, the S&P 500 index is divided by the *CPIA* from the same quarter: *SP500/CPIA*. *LRCPIH* represents the logarithm of the real Consumer Price Index for housing prices. *LRCPIH* is calculated by using the *CPIH*, which is an Index with 1982-84 = 100 that is not seasonally adjusted: log(*CPIH/CPIA*).[7]

6. Initial Results

The prescribed model with the chosen representative variables appears to be appropriate for the data, as shown in the results of the OLS regression model (Table 3a).

Table 3a: Results for 1967:1 – 2011:4 With Asset Prices

DFF	Coef.	Std. Err.	t	P>|t|
CPIAP	2.38408	.2056258	11.59	0.000
YGAP	.1480859	.0744496	1.99	0.048
RSP500	.6248893	.1908174	3.27	0.001
LRCPIH	82.50865	8.517625	9.69	0.000
RGDP	-.0023548	.0004471	-5.27	0.000
time	.064804	.0254999	2.54	0.012
_cons	16.73407	1.245305	13.44	0.000

Number of obs	=	180
F(6, 173)	=	87.37
Prob > F	=	0.0000
R-squared	=	0.7519
Adj R-squared	=	0.7433
Root MSE	=	1.815

[6] Data from the Budget and Economic Outlook
[7] Data from the U.S. Department of Labor: Bureau of Labor Statistics

All of the t-statistics of the variables are greater than the absolute value of 2, with the exception of output gap, which is extremely close to 2. Conventionally in macroeconomic literature, an absolute value of the t-statistic above 2 is statistically significant, which signals that the value of the variable in the equation is significantly different from zero and that the variable plays a role in the model.[8] The p-values for the model estimates are consistent with the evidence generated by the t-statistics. The F-statistic is statistically significant as well and indicates that at least one of the independent variables explains a significant portion of the variation of the dependent variable. All of the above support the claim that the model is appropriate for the data.

7. Robustness Check and Empirical Strategy

Given the set of data, to ensure the accuracy and reasonability of the results, a robustness check is necessary. Major issues to consider include multicollinearity, heteroskedasticity and serial correlation.[9] As a result of examining and correcting for these issues, this model will be refined so that it remains valid and effective under different assumptions.

7.1 Multicollinearity

To prevent potential issues of multicollinearity, this model uses as many data points as possible, which in this case would be all available quarterly data from 1967 to 2011. In addition, manipulations of asset prices data are made with respect to real GDP to take out the effect of changes due to fluctuations in output and inflation. Furthermore, to

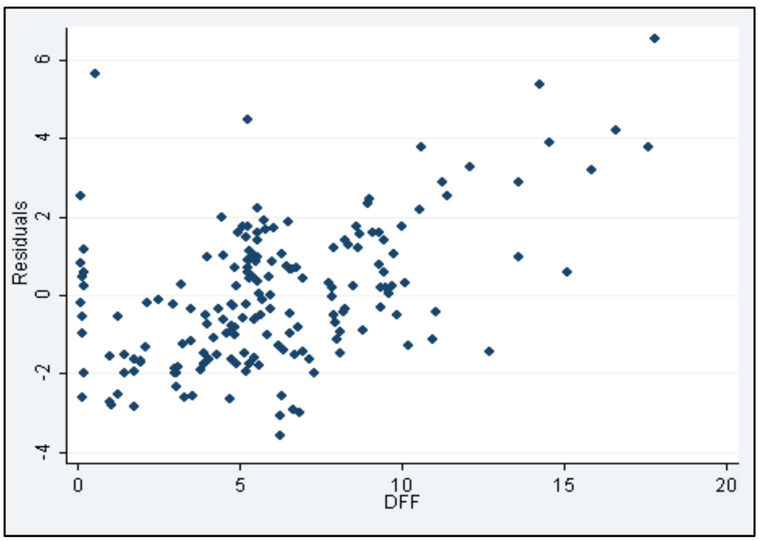
[8] Information obtained through personal conversations with Professor Eichengreen.
[9] Information obtained through personal conversations with Professor Eichengreen.

account for potential effects of a time-series trend, the variable *Time* is included. Although asset prices are likely co-vary with output and inflation, multicollinearity is not an issue in this model. This is supported by the t-tests, as none of the individual coefficients' t-statistic is significantly different than zero while the F-test is statistically significant and the R^2 is high.

7.2 Heteroskedasticity

Heteroskedasticity exists in the residuals of the prescribed model (Table 4).

Table 4: Scatter Plot of Model (With Asset Prices) Residuals Vs Dependent



The effects of heteroskedasticity must be corrected for in the results by calculating robust standard errors, or White-corrected standard errors. These robust standard errors can then be used to recalculate the t-statistics using the original regression coefficients, as heteroskedasticity often results in smaller standard errors, larger t-statistics and unrealiable F-tests. However, it is important to note that the coefficient estimates of the variables in the momdel are not affected by heteroskedasticity, and thus, no changes to the independent variables are necessary.

Recalculating the standard errors and t-statistics in fact yields much more optimistic results (Table 3b). The new adjusted model with robust standard errors in fact keeps low standard errors while yielding higher t-statistics, low p-values and a high F-statistic, all of which indicate that the independent variables included in the model are statistically significant.

Table 3b: Results for 1967:1 – 2011:4 With Asset Prices and Robust Standard Error

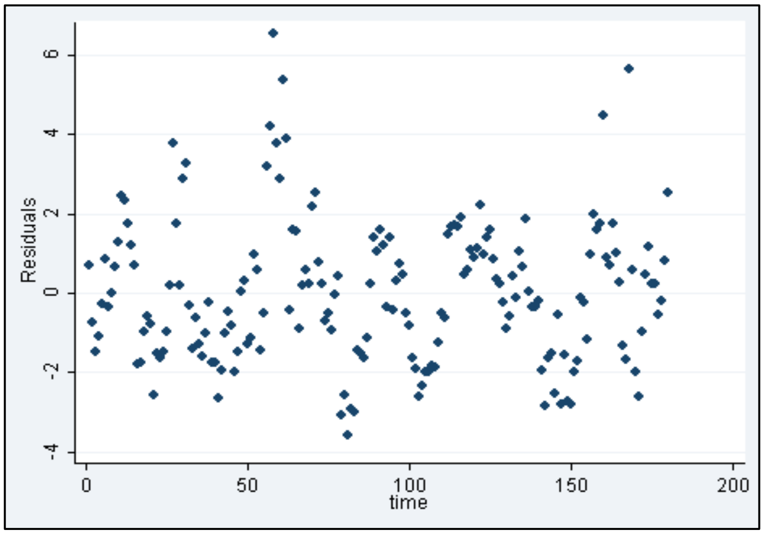
DFF	Coef.	Robust Std. Err.	t	P>|t|
CPIAP	2.38408	.3030617	7.87	0.000
YGAP	.1480859	.0723568	2.05	0.042
RSP500	.6248893	.1879577	3.32	0.001
LRCPIH	82.50865	10.19573	8.09	0.000
RGDP	-.0023548	.0004553	-5.17	0.000
time	.064804	.0251399	2.58	0.011
_cons	16.73407	1.188019	14.09	0.000

Number of obs	=	180
F(6, 173)	=	66.21
Prob > F	=	0.0000
R-squared	=	0.7519
Root MSE	=	1.815

7.3 Serial Correlation

The residuals of the variables in this model appear to display patterns that are indicative of positive serial correlation (Table 5).

Table 5: Scatter Plot of Model (With Asset Prices) Residuals Vs Time



Rudebusch (1995) provides empirical evidence of the serial correlation, also known as autocorrelation, in interest rates. Similarly, monetary economic literature warns of potential issues of serial correlation with macroeconomic variables. One way to identify serial correlation is through observing a scatter plot of the residuals of a model to search of patterns. If a positive residual tends to be followed by another positive residual, then there exists positive serial correlation, as shown in the aforementioned graph (Table 5).

To remedy the issue of serial correlation, Goodfriend (1991) and Sack (1998) provide theoretical justification that one lag is sufficient to smooth interest rates. For instance, the one lag can represent the Fed's hesitation to constantly move interest rates. However, in this model, the inclusion of one lagged value of *DFF* and the according use of an autoregressive model is not appropriate, despite the fact that the addition of this additional variable significantly increases the R^2. This is due to the fact that the Fed takes many, if not most, of the same variables into consideration in immediately adjacent time periods. As a result, the inclusion of a one period lagged variable of *DFF* can overwhelm the variation in other variables (Horne 2009).

The inclusion of a one period lagged variable of *DFF* can also result in a situation in which the model is unable to show the full impact of each variable that the Fed considers in the current period (Robertson and Tallman 1999).[10] Moreoever, the addition of a lagged value of *DFF* would in fact cause other issues with the resulting test statistics (Table 3c).

Table 3c: Results for 1967:1 – 2011:4 With Asset Prices and One Lagged Value of DFF

DFF	Coef.	Robust Std. Err.	t	P>|t|
lag1	.84289	.0537842	15.67	0.000
CPIAP	.5316062	.2186837	2.43	0.016
YGAP	.1762023	.0457373	3.85	0.000
RSP500	-.0993535	.0945618	-1.05	0.295
LRCPIH	5.317111	7.187967	0.74	0.460
RGDP	-.0003561	.0001867	-1.91	0.058
time	.0204739	.0085243	2.40	0.017
_cons	2.038729	1.00025	2.04	0.043

Number of obs	=	179
F(7, 171)	=	388.77
Prob > F	=	0.0000
R-squared	=	0.9399
Root MSE	=	.89825

Most notably, the addition of a one period lagged variable of *DFF* would significantly increase the serial correlation in the residuals and result in t-statistics that are not statistically significant. Thus, to correct for positive serial correlation, the Hansen method can be employed to adjust the coefficient standard errors and the model can be better specified by incorporating the time-series nature of the data. The former is already accounted for through the earlier calcuations of the robust standard error, and the latter is already included in the model with the variable *Time*. Quasi differencing is a method often employed to correct for serial correlation in macroeconomic literature. However, as

[10] Data retrieved from http://www.frbatlanta.org/filelegacydocs/wp9903.pdf

positive serial correlation typically has the same effects as heteroskedasticity, as is for this model, the previous corrections would be sufficient.[11]

8. Additional Considerations

Due to the nature of economics variables that are highly correlated and often causally related, such as inflation and asset prices, there exists various statistical issues to consider. For instance, as Rosa (2011) and other economic literature suggest, asset prices are affected by the Fed's announcements and discussions, particularly updates regarding the effective federal funds rate. As a result, there are various issues with multicollinearity, heteroskedasticity and serial correlation that have not been fully explained in earlier discussions.

This paper seeks to resolve these potential remaining issues through employing a quantitative approach to examine the primary source of information—the meeting minutes of the Federal Open Market Committee (FOMC).[12] In reading through the minutes, which is the most consistent and direct primary source of communication before the Fed's adoption of a more aggressive open communications policy in 2011 in holding regular press conferences, it is possible to gain some further insight into the considerations of the Fed.

This paper considers the minutes of all of the meetings of the Fed between the first quarter of 1967 and the last quarter of 2011 in order to collect quantatively the number of times the words "asset prices" and "interests rates" have been mentioned in the

[11] Information obtained through personal conversations with Professor Eichengreen.
[12] Data retrieved from http://www.federalreserve.gov/monetarypolicy/fomccalendars.htm (data for 2007 to 2011) and http://www.federalreserve.gov/monetarypolicy/fomc_historical.htm (data for 1967 to 2006).

appropriate context, as relating to these topics of interest. To represent the number of times the words “asset prices” have been mentioned in the Fed’s meeting minutes, the variable *Asset_Prices* is used. To represent the number of times the words “interest rate” have been mentioned in the Fed’s meeting minutes, the varialbe *Interest_Rate* is used. Using the variable DFF from the previous model, it would be possible to observe the relationship between the Fed’s effective federal funds rate and the FOMC’s discussion of asset prices and interest rates.

With this data, it appears that there is a negative relationship between the number of times the words asset prices have been mentioned and the Fed’s effective federal funds rate, which falls in line with the previous empirical findings. This data reveals that higher numbers of discussions of asset prices correlate with lower the effective federal funds rates (Table 6). This demonstrates that when the effective federal funds rate is low, the FOMC is more concerned about asset prices, which is reflected by the number of times they mention this topic. Although this may not be the most robust measure of the FOMC’s concern for asset prices, these meeting minutes is one of the most indicative official documents released regarding the substance of the FOMC’s discussions. At the very least, these findings are reflective of one climate of prevailing thought in the FOMC and demonstrates that when interest rates are low, asset prices are actively in the minds of members of the Fed who ultimately render policy decisions regarding the effective federal funds rate.

To ensure that the FOMC’s discussion of asset prices are directly relevant to its discussions of interest rates, an analysis of the relationship between the number of times asset prices and interest rates are discussed is necessary. Data demonstrates that the more number of times asset prices are discussed, the more number of times that interest rate is discussed, and vice versa (Table 7 & Table 8), although the former is more revealing. The correlation between the number of times that interest rate and asset prices are discussed demonstrate that a significant portion of the aforementioned discussion of asset prices is related to considerations of interest rates, further supporting the empirical evidence in this paper of the existence of asset prices in the Fed's setting of monetary policy.

Table 6: Results for 1967:1 – 2011:4 of the Relationship between Asset_Prices and DFF

DFF	Coef.	Std. Err.	t	P>|t|
Asset_Prices	-.2084721	.033349	-6.25	0.000
_cons	6.612629	.2614349	25.29	0.000

Number of obs	=	180
F(1, 178)	=	39.08
Prob > F	=	0.0000
R-squared	=	0.1800
Adj R-squared	=	0.1754
Root MSE	=	3.2527

Table 7: Results for 1967:1 – 2011:4 of the Relationship between Interest_Rate and Asset_Prices

Interest_R~e	Coef.	Std. Err.	t	P>|t|
Asset_Prices	.4392984	.0780851	5.63	0.000
_cons	4.972503	.6121375	8.12	0.000

Number of obs	=	180
F(1, 178)	=	31.65
Prob > F	=	0.0000
R-squared	=	0.1510
Adj R-squared	=	0.1462
Root MSE	=	7.6161

Table 8: Results for 1967:1 – 2011:4 of the Relationship between Asset_Prices and Interest_Rate

Asset_Prices	Coef.	Std. Err.	t	P>|t|
Interest_R~e	.3436582	.0610851	5.63	0.000
_cons	.7816514	.6311637	1.24	0.217

Number of obs	=	180
F(1, 178)	=	31.65
Prob > F	=	0.0000
R-squared	=	0.1510
Adj R-squared	=	0.1462
Root MSE	=	6.7362

9. Conclusion

Comparing the results of a robust model with and without asset prices could yield insightful conclusions regarding the relevancy of such variables in the Fed's considerations in the setting of monetary policy. If the results of the model with asset prices is a better fit for the chosen data, it would suggest the existence of variables for asset prices in the Fed's policy rule. In the prescribed models for this paper, the comparative results between a model with asset prices (Table 3b) and a model without (Table 9) are informative and optimistic.

The model without asset prices appears to be a plausible model, with t-statistics above 2, p-values of 0, a high F-statistic and an acceptably small standard error for all of its coefficient estimates (Table 9). However, when compared to the model with asset prices, which also has high t-statsitics, p-values of 0, a high F-statistic and smaller standard errors, its adjusted R^2 value is much lower (Table 3c). This adjusted R^2 value indicates that in the model with asset prices, 75.19% of the variation in DFF is collectively eplained by all of the independent variables, but in the model without asset prices, only 61.72% of the variation is explained. In this case, the adjusted R^2 values is used as it accounts for upward bias due to the large set of independent variables in the model.

Table 3b: Results for 1967:1 – 2011:4 With Asset Prices and Robust Standard Error (Repeat)

DFF	Coef.	Robust Std. Err.	t	P>|t|
CPIAP	2.38408	.3030617	7.87	0.000
YGAP	.1480859	.0723568	2.05	0.042
RSP500	.6248893	.1879577	3.32	0.001
LRCPIH	82.50865	10.19573	8.09	0.000
RGDP	-.0023548	.0004553	-5.17	0.000
time	.064804	.0251399	2.58	0.011
_cons	16.73407	1.188019	14.09	0.000

Number of obs	=	180
F(6, 173)	=	66.21
Prob > F	=	0.0000
R-squared	=	0.7519
Root MSE	=	1.815

Table 9: Results for 1967:1 – 2011:4 Without Asset Prices

DFF	Coef.	Robust Std. Err.	t	P>|t|
CPIAP	2.13069	.3082254	6.91	0.000
YGAP	.3257774	.082682	3.94	0.000
RGDP	-.0032221	.0003724	-8.65	0.000
time	.1687677	.0215853	7.82	0.000
_cons	15.16159	1.238328	12.24	0.000

Number of obs =	180
F(4, 175) =	55.11
Prob > F =	0.0000
R-squared =	0.6172
Root MSE =	2.2415

Therefore, the model with asset prices appears to have more explanatory power in predicting the Fed's effective federal funds rate (Table 3c). Compared to the model without asset prices (Table 9), the model with asset prices (Table 3b) indicate that inflation, the output gap, real GDP and time in fact play less of a role on the Fed's setting of the effective federal funds rate. This makes sense in the context of the increase in R^2 with the addition of variables representative of asset prices to the model, as this supports the claim that the model with asset prices is more descriptive of the Fed's setting of the effective federal funds rate. Thus, this comparison is initial empirical evidence that the Fed does take asset prices into consideration. Conclusively, the initial empirical evidence found by this paper supports the claim that asset prices have been considered in the setting of monetary policy by the Fed.

9. Insights for Future Research

It is important to keep in mind that the empirical results of this paper only suggest that the asset price augmented reaction function based on that of Taylor (1993) is a good fit for the given data. Whether it has additional explanatory power when compared to modernized versions of Taylor's rule (1993) or indicate a causal relationship between the effective federal funds rate and asset prices is still unclear. Due to the the length restraint of this paper, such discussions as well as considerations for the potential normative implications of asset price targeting should be included in a future paper. Research for a future paper should in particular augment other modernized reaction functions, such as Clarida et al. (2000), with asset prices to further observe the impact of asset prices on monetary policy under different assumptions. For instance, observing a backward-looking reaction function compared to a forward-looking reaction function could yield completely different results than those found in this paper.

Moreover, a future paper should include further research that simulates the macroeconomic impact of reaction functions that are and are not augmented with asset prices to better understand the direct effects of changes in asset prices on intrinsic economic variables such as output and inflation. This would allow for more insightful comparison between different reaction functions and yield deeper economic insights. For instance, the question of whether or not the Fed would be able to more effectively steer the economy out of an economic recession caused by a financial crisis if it practices asset price targeting would be interesting to explore. Conclusively, the model in this paper suggests that asset prices have been taken into consideration by the Fed in setting the monetary policy from 1967 to 2011. Nevertheless, further research should to be completed to refine this model and to develop other models to better understand the role of asset prices in monetary policy as well as in the macroeconomy.

10. Extended Discussion of Conclusion

As discussed in the conclusion, the results in this paper appear to be significant and relatively robust period by period, indicating that monetary policy responds not just to inflation and the output gap, but also to asset prices. This paper also considers additional topics for the purpose of guiding future research and of further refining the empirical model and qualitative analysis discussed above. However, it is important to conclude with a more extended discussion of the conclusion to consider some close corollaries. Thus, this paper further examines how much asset prices are influential to monetary policy as well as how the Fed may see its role in responding to asset prices in changing monetary policy.

First, by considering the magnitude to which asset prices are influential to monetary policy, this paper further examines the aforementioned empirical findings. Having already determined the level of robustness of these results, it is now possible to ask the following question: if the stock market were to rise by 10% without any changes in other factors—meaning no changes in the output gap or inflation—by how much would the Fed raise interest rates? By observing the coefficients in the results (*Table 3b*), it is possible to isolate the coefficient 0.62 for the variable RSP500, which represents asset prices in the stock market. This result indicates that that if the stock market were to rise by 10% without any other changes, the Fed would likely raise interest rates by a considerable 0.062%.

Table 3b: Results for 1967:1 – 2011:4 With Asset Prices and Robust Standard Error (Repeat)

DFF	Coef.	Robust Std. Err.	t	P>|t|
CPIAP	2.38408	.3030617	7.87	0.000
YGAP	.1480859	.0723568	2.05	0.042
RSP500	.6248893	.1879577	3.32	0.001
LRCPIH	82.50865	10.19573	8.09	0.000
RGDP	-.0023548	.0004553	-5.17	0.000
time	.064804	.0251399	2.58	0.011
_cons	16.73407	1.188019	14.09	0.000

Number of obs	=	180
F(6, 173)	=	66.21
Prob > F	=	0.0000
R-squared	=	0.7519
Root MSE	=	1.815

It is not necessary to consider the extent to which housing prices are influential to monetary policy separately as a corollary, seeing as changes in housing prices tend to occur over slightly longer periods of time, and are usually accompanied by other changes, such as inflation. Moreover, since this paper considers the variable LRCPIH, which represents housing prices using logarithms, it is more difficult to isolate the magnitude of the change in DFF given a specific change in LRCPIH.

Second, to determine how the Fed understands what it is doing by responding to asset prices via changes in monetary policy, this paper considers the public announcements made by the Fed. It is possible to analyze the announcements made and research conducted by individual members of the FOMC, who vote to determine monetary policy. However, each of the members is careful in making disclaimers when expressing their views to be clear that their opinions do not reflect those of the FOMC. Also, it is more reflective and representative to consider the announcements made in the name of the Fed. Seeing as the Fed publishes its minutes and has recently enhanced its open communications policies, it is realistic to look to those public announcements.

Observing some of the most recent announcements made by Ben Bernanke, the Chairman of the Fed, on behalf of the Fed, he explains how the Fed understands its role in responding to asset prices via changes in monetary policy. In gauging the success of the Federal Reserve Treasury bond buying program, or quantitative easing, which is an unconventional monetary policy, Fed officials including Ben Bernanke have pointed to a rising stock market as a sign of policy making success, as according to FOMC minutes. This indicates that asset prices are a main factor being considered in the setting of monetary policy.

Furthermore, during the most recent FOMC press conference, held on September 13 of 2012, in response to a question regarding the Fed's role in responding to asset prices via monetary policy, Ben Bernanke answers the following: "[t]he tools we have involve affecting financial asset prices, and … those are the tools of monetary policy. There are a number of different channels … [including] the prices of various assets, like, for example, the prices of homes … to the extent that home prices begin to rise, consumers will feel wealthier, they'll feel more—more disposed to spend. If house prices are rising, people may be more willing to buy homes because they think that they'll, you know, make a better return on that purchase. So house prices are one vehicle. Stock prices [is another vehicle that] generally will make people more willing to spend."

Although the Fed does not explicitly explain how it sees its role as being in responding to asset prices, Bernanke's aforementioned response is highly informative. In fact, Bernanke's statement indicates that the Fed see its role in responding to asset prices via monetary policy as affecting and responding to expectations. By considering asset prices as an indicator of consumer expectations, the Fed then makes the appropriate changes to monetary policy. Consequently, this paper is able to make inferences on the logic of the Fed by analyzing the minutes of meetings and press conferences held by the FOMC.

Overall, by examining how much asset prices are influential to monetary policy as well as how the Fed sees its role in responding to asset prices in changing monetary policy, this paper has considered close corollaries of its empirical findings. Hence, through this extended discussion of the conclusion, this paper finds initial evidence that asset prices have been considered the setting of monetary policy by the Fed, that the effect of this variable is considerable upon monetary policy, and that the Fed sees its role in responding to asset prices as reacting to consumer expectations.

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