The Fed's TRAP: A Taylor-type Rule with Asset Prices

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Abstract

The paper examines if US monetary policy implicitly responds to asset prices. Using real-time data and a GMM framework we estimate a Taylor-type rule with an asset cycle variable, which refers to real estate prices. To analyze the Fed's responses we describe real estate price movements by means of an asset cycle dating procedure. This procedure reveals quasi real-time bull and bear markets. Our analysis yields two main findings. Firstly, the Fed does implicitly respond to real estate prices. Secondly, these responses are pro-cyclical and their intensity changes over time.

Key words: Fed, Monetary Policy, Taylor Rule, Asset Price Cycles, Real Estate

JEL classification: E52, E58

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1 Motivation

During the Great Moderation the US, like most developed economies has been subject to modest consumer price inflation. While this development conforms with one of the Fed's goals, as these focus on consumer price inflation, there has also been an increase in asset price inflation. Since asset prices are claims on future goods and services, it should come as no surprise that former Federal Reserve Chairman Alan Greenspan already asked in 1996:

> "But where do we draw the line on what prices matter? Certainly prices of goods and services now being produced – our basic measure of inflation – matter. But what about futures prices or more importantly prices of claims on future goods and services, like equities, real estate, or other earning assets?"

Economic literature on this topic is ambiguous. Bernanke and Gertler (2000) and Bernanke and Gertler (2001) argue that explicit asset price targeting should not be part of a central bank's monetary policy. In contrast, Cecchetti (2001) gives reasons to take these into account.

Since to date the Fed does not conduct explicit asset price targeting, this paper examines if US monetary policy implicitly responds to asset prices. Using real-time data and a GMM framework we estimate a Taylor-type rule as shown in Clarida et al. (1998) and Orphanides (2001). To take account of asset price developments we extend a Taylor-type rule by an asset price variable which mirrors asset price cycles.[1] This asset price variable refers to real estate prices, which take up an important share in households' asset portfolio. Moreover, real estate prices seem to have a close connection to monetary conditions (Deutsche Bundesbank, 2007, pp. 19). By applying real asset prices we attempt to extract shifts in relative prices with respect to consumer prices.[2]

[1] It is crucial to note, that we do not refer to asset price bubbles.

[2] Real asset prices indicate the development of relative prices between the asset in question and the underlying consumer price index. The applied consumer price index (all items) is used as a proxy for economy-wide price developments.

The paper is organized as follows. Section 2 describes the asset cycle dating procedure that we use to obtain the asset cycle variable. The empirical framework which consists of a modified Taylor Rule with Asset Prices (TRAP) is given in section 3. The results of our estimations are discussed in section 4. Our main findings are summarized in section 5.

2 Asset cycle dating procedure

To analyze the reaction function of the Fed on real estate prices we need an approach to capture price movements. We suppose that monetary policy targets medium-term asset price developments. In contrast to, e. g. Bernanke and Gertler (2000), we employ a cycle dating procedure, instead of growth rates of asset prices which primarily mirror short-term movements.

Following Pagan and Sossounov (2003) and IMF (2003) asset price cycles are identified using a modified Bry-Boschan cycle dating procedure (Bry and Boschan, 1971). Since the characteristics of asset price cycles are different from those of real business cycles some modifications are necessary. Asset price cycles seem to be more volatile and frequent than real business cycles. Similar to Pagan and Sossounov (2003, pp. 24) we do not use smoothed data and do not remove outliers to consider unusual movements in the series (e. g., stock market crash in 1987).

The main characteristics of our procedure can be summarized in two steps. Firstly, we identify the initial local extrema by searching the input data for peaks and troughs in a rolling five quarter window. Secondly, pairs of peaks and troughs are chosen to meet the constraints for minimal duration of cycles (four quarters) and phases (two quarters). Since we use quarterly data the minimal duration of cycles and phases are the shortest possible duration constraints. A cycle denotes the period from one peak to another peak and a phase describes the period between a peak and a trough.

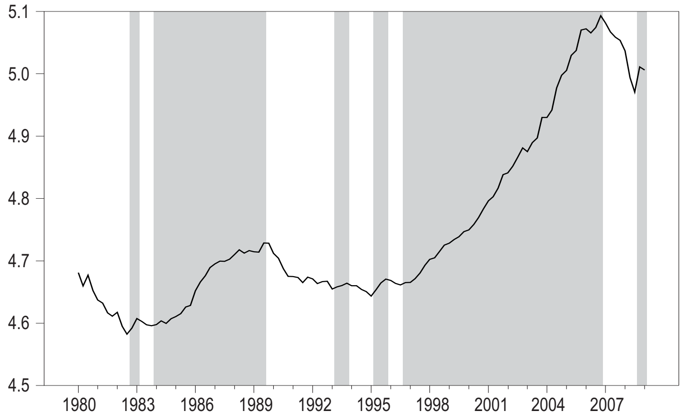


Figure 1: Ex post bull markets in US real estate prices

Phases from troughs to peaks refer to bull markets (increasing asset market prices), whereas phases from peaks to troughs refer to bear markets (decreasing asset market prices).

After determining peaks and troughs we summarize our results in a binary variable. This variable takes on the value one if a bull market exists at time t and zero otherwise. Some summary statistics on the identification of real estate market cycles are given in table 1.

Table 1: Statistics on ex post bull and bear markets in US real estate prices 1975q1–2009q1

	Bull	**Bear**
Number	6	7
Average duration	14	7
Average amplitude	12.91 %	–5.54 %

In the ex post series we identify six bull and seven bear markets (see figure 1). The average duration of bull markets is two times longer than the duration of bear markets. Bull markets also have a two times higher amplitude. To assess whether the Fed responds to real estate market cycles, it is important to rely only on data that were available to the Fed at the time of decision making (see Orphanides, 2001). Hence, we make an additional modification to our cycle dating procedure. While

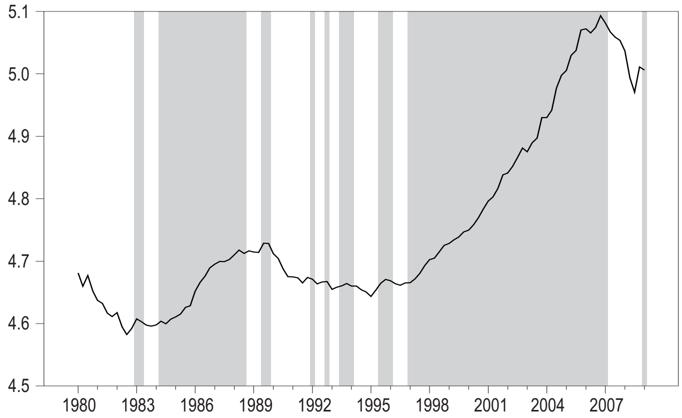


Figure 2: Real-time bull markets in US real estate prices

the algorithm is based on ex post US real estate prices, the peaks and troughs are obtained recursively, i. e. by using only data up to the corresponding real-time data point. The resulting binary variable indicates quasi real-time bull and bear markets (see figure 2). By comparing figure 1 (ex post cycles) and figure 2 (quasi real-time cycles) the aspect of uncertainty in decision making of monetary policy becomes obvious as the real-time figure exhibits more and smaller phases.

3 Empirical framework

To estimate the monetary policy reaction function of the Fed we use a Taylor-type rule.[3] The original Taylor rule is modified by a smoothing term to capture monetary policy's gradual interest rate adjustments (Goodfriend, 1987). Since it is our purpose to estimate whether the Fed responds to real estate prices – as it does on inflation gap and output gap – we additionally implement the previously derived real estate price variable. Following Orphanides (2001) we use real-time data for our estimations.

[3] The original Taylor rule, as proposed by Taylor (1993), is given by $r = p + 0.5y + 0.5(p - 2) + 2$ where r is the federal funds rate, p is a proxy for the expected inflation rate and y is the output gap. The inflation target and long-term real interest rate are assumed to be constant and appraised to be 2.

Our Taylor-type rule is given by:

$$i_t = \rho i_{t-1} + (1-\rho)[\gamma \Delta y_t^* + \pi_t^* + \delta(E_t \pi_{t+4} - \pi_t^*) + \beta(y_t - y_t^*) + \phi ac_t] + \epsilon_t,$$

where i_t is the effective federal funds rate and ρ is its monetary policy smoothing parameter. The equilibrium real interest rate is approximated by the product of the first-order difference of real-time output potential Δy^* and its estimated relation parameter γ.[4] The inflation target π_t^* is designed to be time-varying and is approximated by real-time 10 year ahead inflation forecasts (FRBP, 2007).[5] The output gap is based on the difference between the real-time real output y and its long-term potential y^*. The long-term real output potential is estimated by means of the HP-filter and is based on the real-time series of real output (see Hodrick and Prescott, 1997).[6] The real output is extended by 12 quarter forecasts obtained from an autoregression.[7] We add these to the real output to cope with the end-of-sample problem of the HP-filter (Baxter and King, 1995, pp. 18). The inflation gap is given by the difference between the real-time 4 quarter ahead inflation forecast $E_t \pi_{t+4}$ and the time-varying inflation target π_t^*. Our asset cycle variable introduced in section 2 is denoted by ac_t. The error term ϵ_t is i. i. d. The indices $t + x$ represent the period in question and E_t is the expectation operator. The sources of our data are given in table 4 (see appendix).

In general, the estimation of monetary policy reaction functions is subject to the methodical challenge of endogeneity since the left-hand and right-hand variables

[4] Since the equilibrium real interest rate is an unobserved variable it needs to be estimated. Our estimations build on the economic postulate that in a market equilibrium real interest rates should be conform with the economy's marginal productivity of capital.

[5] Reasons and consequences of a time-varying inflation target are given by Ireland (2007).

[6] As it is common with data that come with a quarterly frequency the smoothing parameter is choosen to be $\lambda = 1,600$ (see, e. g., Baxter and King, 1995).

[7] The first five forecasts are taken from the Philadelphia Fed's real-time data set. The optimal lag length of the autoregression is determined by step-wise least squares estimations with a maximum lag length of 8 and approved p-values up to 10 %.

are interdependent and simultaneously determined in the same period. The reverse causality from the federal funds rate to the explanatory variables violates the essential assumption for least squares regressions of contemporaneously uncorrelated explanatory variables and error terms since the explanatory variables are not exogenous.[8] As a result the estimated parameters would be endogeneity biased and inconsistent. For instance, the asset price variable should be affected by changes in the federal funds rate – given validity of the present value theory – since its underlying asset price is subject to a change in the discount factor of its expected income stream. To account for this problem the explanatory variables are instrumentalized and estimated by the generalized method of moments (GMM). As instruments we use the own lagged realizations since these should be uncorrelated with the error term and highly correlated with their future realizations.[9] The optimal weighting matrix is used to obtain the iterated GMM estimator (Hall, 2005).

4 Estimation results

We estimate parameters for the full sample and for rolling subsamples since we are interested in the general Fed's reaction function as well as its changes over time. The full sample covers the period from 1985q1–2007q1. The starting point of the sample is choosen with respect to the constrained availability of real-time data and the beginning of the Great Moderation (Stock and Watson, 2002).

The upper part of table 2 illustrates the parameters of the Taylor-type rule for the full sample estimation. The full sample estimates of the baseline policy rule indicate that the Fed responds strongly to expected inflation gap ($\delta = 6.90$) and output

[8] By definition, explanatory variables x_t are said to be endogenous if they are correlated with the equation's error term ϵ_t.

[9] The high correlation between the own realizations reduce the standard errors compared with other less correlated variables (Wooldridge, 2002, pp. 101). The GMM provides the additional benefit that it also accounts for measurement uncertainties to which our estimation is subject to.

Table 2: Parameters of the Taylor-type rule for the full sample estimation

	ρ	γ	δ	β	ϕ
Baseline:					
Coefficient	0.80	0.90	6.90	0.78	–
Standard Error	0.02	0.05	0.62	0.17	–
p-value	0.00	0.00	0.00	0.00	–
Observations			89		
Standard Error of Estimate			0.35		
J-Statistic			11.24		
Baseline with asset prices:					
Coefficient	0.80	1.15	6.13	1.07	−0.90
Standard Error	0.01	0.10	0.68	0.18	0.37
p-value	0.00	0.00	0.00	0.00	0.01
Observations			89		
Standard Error of Estimate			0.33		
J-Statistic			11.08		

Notes: We take as instruments a constant, the first four lags of the federal funds rate, the first four lags of inflation, the first four lags of expected inflation, the first four lags of potential growth and the first four lags of the output gap. When estimating the Taylor-type rule with the asset cycle variable we furthermore add the first four own lags of this variable to the instrument set. The J-Statistic for both estimations takes either the value of 11.24 or 11.08 and does not reject the null of validity of instruments in each case.

gap ($\beta = 0.78$). The estimate of the interest rate smoothing parameter ($\rho = 0.80$) suggests that only one fifth of the federal funds rate is influenced by current inflation gap and output gap. The remaining part of the explained variation is determined by its previous realizations. The parameter of potential output growth ($\gamma = 0.90$) points to the Fed's perception of the equilibrium real interest rate, which is below but close to potential output growth. All parameters are highly statistically significant. Indeed, the inflation and output gap parameters differ from those proposed by Taylor (1993), but these parameters are reasonable and mirror the Taylor-principle after all. Particularly $\delta > 1$ ensures that the federal funds rate moves more than one-for-one with inflation. Otherwise, inflation could become highly volatile (Taylor, 1998).

The estimation results in the lower part of table 2 describe the Fed's reaction function with the real estate price variable. All estimated parameters are close to the baseline results and the asset cycle variable is statistically significant. The negative sign of the asset cycle variable parameter suggests that the Fed has set a lower federal funds rate in the presence of a bull market. If a bull market exists, then the federal funds rate would be 90 basis points lower in the long run than our baseline rule implies. Additionally, by considering the interest rate smoothing parameter the current level of the federal funds rate is set about 18 basis points below the estimated baseline rate.

If one expects the Fed to stabilize asset prices, then the obtained asset price coefficient seems to have the 'wrong' sign. Our results of the full sample estimation indicate that the Fed responds pro-cyclical and does not attempt to stabilize real estate market prices. Considering the 'wrong' sign of the asset cycle variable our results are similar to those of Bernanke and Gertler (2000), although they do not find any statistical significance.[10] However, our results raise a remarkable question: Did the Fed promote the real estate market by means of loose monetary policy in order to extend bull market phases?

So far, we have examined how monetary policy responds to asset price developments in general by considering the full sample. In the next step the focus of our analysis shifts from full sample to rolling subsamples. The estimations of rolling subsamples should give an indication when and to what extent changes in the monetary reaction function have taken place.

The subsamples cover the period from 1985q1–2007q1. Each subsample has a window of 10 years and moves on one period after every accomplished estimation. Table 3 reports summary statistics on the 50 realizations of the asset cycle variable. Out of the estimated 50 parameters 41 are significant at the 10 %-level, whereof 9 have a positive and 32 a negative sign. Considering their effective means[11] the estimation

[10] Bernanke and Gertler (2000) use in their Taylor-type rule growth rates of asset prices. In contrast, we suppose by means of a cycle dating procedure that monetary policy targets medium-term asset price developments.

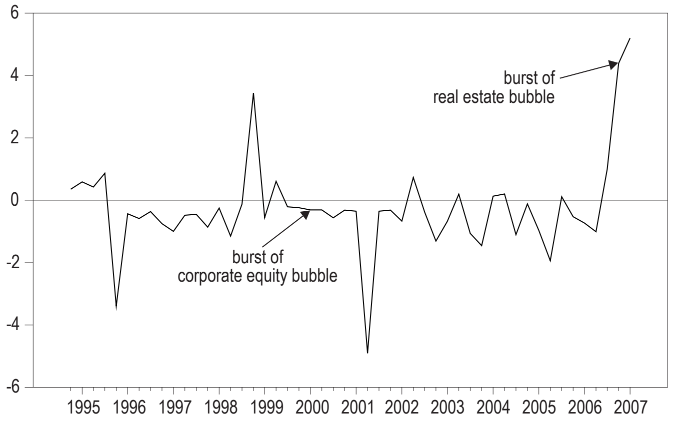
[11] 'Effective' refers to the product of the asset cycle coefficient ϕ and $(1-\rho)$, whereas ρ describes the interest rate smoothing paramter.

Table 3: Summary statistics on the bull market coefficient for the rolling subsample estimation

	Bull market parameter
Mean	−0.24
number of rolling windows	50
number of total sign.	41
MIN total sign.	−4.91
Mean total sign.	−0.39
MAX total sign.	5.20
effective MIN total sign.	−0.53
effective Mean total sign.	−0.04
effective MAX total sign.	1.61
number of pos.	14
number of sign. pos.	9
MIN sign. pos.	0.13
Mean sign. pos.	1.45
MAX sign. pos.	5.20
effective MIN sign. pos.	0.06
effective Mean sign. pos.	0.41
effective MAX sign. pos.	1.61
number of neg.	36
number of sign. neg.	32
MIN sign. neg.	−0.21
Mean sign. neg.	−0.91
MAX sign. neg.	−4.91
effective MIN sign. neg.	−0.04
effective Mean sign. neg.	−0.17
effective MAX sign. neg.	−0.53

results indicate that in case of a negative (positive) sign the Fed has set the federal funds rate on average 17 (41) basis points below (above) the level that would have been set without considering real estate prices. These figures point out that on average the Fed has responded stronger to asset price developments in case of an anti-cyclic monetary policy (parameter with a positive sign) than in case of a pro-cyclic monetary policy (parameter with a negative sign).

Given these results the question arises whether periods exist in which the Fed has responded in a pro-cyclic or anti-cyclic manner to asset prices. To obtain an impression of these periods figure 3 shows all estimated parameters of the asset cycle variable for each of the 50 subsamples. At a first glance, the parameters of subse-



Notes: For instance, the value shown for 1994q4 represents the estimated coefficient of the asset cycle variable for the rolling subsample from 1985q1–1994q4. All estimated parameters for the rolling subsample estimations are summarized in table 5 in the appendix.

Figure 3: Parameters of the Taylor-type rule for the rolling subsample estimations

quent subsamples appear to be clustered since positive and negative parameters are grouped together. Considering the signs and significance levels along the time line it is remarkable that both point to specific patterns. A few quarters previous to the peaks of corporate equity and real estate market bubbles the parameter of our asset cycle variable switches from significant negative to insignificant negative or even to significant positive. The observable clusters and patterns previous to the peaks in asset markets give reason to assume that – until a certain point in time – the Fed responds pro-cyclic to the real estate market. After this certain point in time the Fed takes anti-cyclic measures. By asking what determines this certain point in time one could, for instance, think of an event, such as a suddenly prevailing perception of the FOMC-members to face an asset market that has exceeded its sound fundamental level so far that it might evoke a negative feedback to the economy in a way that the achievement of the Fed's objectives would be undermined.

5 Conclusion

While consumer price inflation is modest, asset price inflation seems to be a challenge for monetary policy. The main objective of this paper is to assess a simple question: Does US monetary policy implicitly respond to asset price developments?

We extend a GMM Taylor-type monetary reaction function with a binary variable which considers real-time bull and bear markets within real estate price cycles. This asset cycle variable is created by means of an asset cycle dating procedure. This procedure identifies initial local extrema by searching the input data for peaks and troughs in a rolling five quarter window. Moreover, the pairs of peaks and troughs are chosen to meet the constraints for minimal duration of cycles and phases. Our full sample estimation results give reason to suppose that in general US monetary policy responds pro-cyclic to real estate prices. This result is supported by most estimations of our rolling subsamples. Moreover, the subsamples do also point to changing responses on asset price cycles over time. These responses seem to follow specific patterns, as the Fed changes its responds on real estate prices previous to the peaks of asset price bubbles. These changes could be interpretated as part of a leaning against the wind strategy. Our findings give reason to suppose that the Fed faces a trap. The argument goes as follows: By implicitly supporting asset prices the Fed provides a medium for asset price bubbles. When a bubble bursts at some point in time, it will depress asset prices. In order to implicitly target asset prices a new monetary impulse is necessary to stabilize those. This stabilization is the first step into a next trap.

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Appendix

Table 4: The data

Data	**Symbol**	**Description**	**Source**
Inflation target	π_t	10 year ahead inflation expectations.	FRBP
Expected inflation	$E_t\pi_{t+4}$	One year ahead inflation forecasts from survey of professional forecasters.	FRBP
Federal Funds Rate	i_t	Effective federal funds rate.	BoG
Real-time output	y_t	Real time GNP/GDP in billions of real dollars.	FRBP
Potential output	y_t^*	Estimated by means of the Hodrick-Prescott filter with a smoothing parameter of $\lambda = 1,600$.	FRBP
Real estate price	–	FHFA real estate price index.	FHFA
Asset price deflator	–	First order difference of the logarthmic CPI (all items).	BEA

BEA: Bureau of Economic Analysis
BoG: Board of Governors of the Federal Reserve System
FHFA: Federal Housing Finance Agency
FRBP: Federal Reserve Bank of Philadelphia

Table 5: Parameters of the Taylor-type rule for the rolling subsample estimation

Sample Period	ϕ	p-value	**Sample Period**	ϕ	p-value
1985q01–1994q04	0.35	0.01	1991q02–2001q01	−0.35	0.00
1985q02–1995q01	0.59	0.00	1991q03–2001q02	−4.91	0.00
1985q03–1995q02	0.42	0.19	1991q04–2001q03	−0.35	0.00
1985q04–1995q03	0.86	0.01	1992q01–2001q04	−0.32	0.00
1986q01–1995q04	−3.39	0.00	1992q02–2002q01	−0.67	0.00
1986q02–1996q01	−0.43	0.01	1992q03–2002q02	0.73	0.00
1986q03–1996q02	−0.59	0.00	1992q04–2002q03	−0.38	0.09
1986q04–1996q03	−0.36	0.00	1993q01–2002q04	−1.31	0.00
1987q01–1996q04	−0.75	0.00	1993q02–2003q01	−0.68	0.00
1987q02–1997q01	−1.00	0.00	1993q03–2003q02	0.19	0.02
1987q03–1997q02	−0.48	0.00	1993q04–2003q03	−1.06	0.00
1987q04–1997q03	−0.45	0.00	1994q01–2003q04	−1.45	0.00
1988q01–1997q04	−0.86	0.00	1994q02–2004q01	0.13	0.06
1988q02–1998q01	−0.25	0.00	1994q03–2004q02	0.20	0.89
1988q03–1998q02	−1.15	0.00	1994q04–2004q03	−1.10	0.00
1988q04–1998q03	−0.12	0.30	1995q01–2004q04	−0.12	0.72
1989q01–1998q04	3.44	0.17	1995q02–2005q01	−0.97	0.00
1989q02–1999q01	−0.55	0.00	1995q03–2005q02	−1.94	0.00
1989q03–1999q02	0.61	0.01	1995q04–2005q03	0.11	0.68
1989q04–1999q03	−0.21	0.06	1996q01–2005q04	−0.52	0.52
1990q01–1999q04	−0.24	0.18	1996q02–2006q01	−0.73	0.00
1990q02–2000q01	−0.31	0.00	1996q03–2006q02	−1.01	0.00
1990q03–2000q02	−0.31	0.00	1996q04–2006q03	0.99	0.48
1990q04–2000q03	−0.56	0.00	1997q01–2006q04	4.39	0.02
1991q01–2000q04	−0.32	0.00	1997q02–2007q01	5.20	0.01

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