

Erler, Alexander; Drescher, Christian; Krizanac, Damir

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University of Bayreuth  
Faculty of Law and Economics

# The Fed's T R A P: A Taylor-type Rule with Asset Prices

Christian Drescher, Alexander Erler, and Damir Križanac

Christian Drescher  
University of Bayreuth  
Chair of Economics I  
95440 Bayreuth

Tel.: +49 (0)921 55 29 13  
Fax: +49 (0)921 55 29 49  
christian.drescher@uni-bayreuth.de

Alexander Erler  
University of Bayreuth  
Chair of Economics I  
95440 Bayreuth

Tel.: +49 (0)921 55 29 13  
Tel.: +49 (0)921 55 84 29 05  
alexander.erler@uni-bayreuth.de

Damir Križanac  
University of Bayreuth  
Chair of Economics II  
95440 Bayreuth

Tel.: +49 (0)921 55 35 16  
Tel.: +49 (0)921 55 84 29 05  
damir.krizanac@uni-bayreuth.de

## Abstract

This paper examines if US monetary policy responds to asset prices. Using real-time data we estimate a Taylor-type rule with an asset price variable. This variable refers to real estate prices, considering that those exhibit an important share in households' asset portfolio. Moreover, especially real estate prices seem to have a close connection to monetary conditions. To analyze this link we describe price movements in the real estate price index by using a specific cycle dating procedure. The resulting variable indicates quasi real time bull and bear markets, and helps to evaluate the link between real estate market cycles and monetary policy. Our full-sample estimation results give reason to suppose that the US monetary policy responds in a pro-cyclical way to real estate prices. This result is supported by our rolling sub-sample estimations. Additionally, these also point to decelerating countermeasures of the Fed previous to asset price peaks.

**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 most industrialized economies have been subject to low levels of consumer price inflation. While monetary policy focuses particularly on consumer price inflation there has been an remarkable increase in asset price inflation. Considering that asset price inflation is a challenge for future monetary policy, since asset prices are claims on future goods and services (e.g. [Greenspan, 1996](#)). It should come as no surprise, therefore, that former Federal Reserve Chairman Alan Greenspan remarked already 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? Are stability of these prices essential to the stability of the economy?”

This paper examines if US monetary policy responds to asset prices by employing a monetary reaction function. Using real-time data we estimate a Taylor-type rule as shown e.g. in [Clarida et al. \(1998\)](#) and [Orphanides \(2001\)](#). In contrast to other contributions (e.g. [Bernanke and Gertler, 2000](#)) we suppose, that monetary policy targets medium-term asset price developments.<sup>1</sup> To take account of these asset price developments we extend a Taylor-type rule with an asset price variable considering asset price cycles.<sup>2</sup> This asset price variable refers to real estate prices, considering that those exhibit an important share in households’ asset portfolio. Moreover, our focus lies on medium-term asset price developments. Especially real estate prices seem to have a close connection to monetary conditions ([Deutsche Bundesbank, 2007](#), pp.19). Therefore we use real asset prices since we are interested in cycles of relative real estate prices. By applying real asset prices we attempt to extract the

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<sup>1</sup> Rationales against asset price targeting can be found in [Bernanke and Gertler \(2000\)](#) and [Bernanke and Gertler \(2001\)](#), whereas [Cecchetti \(2001\)](#) gives reasons for asset price targeting.

<sup>2</sup> It is crucial to note, that we do not refer to asset price bubbles.

effect of asset price developments that are idiosyncratic for the asset class in question and can not be attributed to general price developments.<sup>3</sup>

This paper is organized as follows. Section 2 describes the dating cycle procedure used to obtain the asset price 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 the subsequent Section 4. In Section 5 we draw some concluding remarks.

## 2 Cycle Dating Procedure

To analyze the link between real estate prices and monetary policy we need a way to describe price movements appropriately. Since growth rates primarily mirror short-term movements we employ a cycle dating procedure to take medium- and long-term developments into account. In order to reveal the impact of real estate market cycles it is necessary to identify bull and bear markets. In asset market terminology, a bull (bear) market refers to periods of generally increasing (decreasing) market prices. This definition is similar to the one used to describe expansions and contractions in the real economy. Given this it is essential to determine turning points — peaks and troughs — in the real estate price index. Following [Pagan and Sossounov \(2003\)](#) and [IMF \(2003\)](#) our 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 of this cycle dating procedure are crucial. Similar to [Pagan and Sossounov \(2003, pp. 24\)](#) we do not use smoothed data and do not remove outliers

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<sup>3</sup> Real asset prices indicate the development of relative prices between the asset in question and the underlying items of the deflator. The applied consumer price index (all items) is used as a proxy for the economy-wide price developments.

to consider important movements in the series (e.g. stock market crash in 1987). Further modifications take account of two important issues. Firstly, our procedure identifies the initial turning points by searching the input data for local minima and maxima in a rolling five quarter window. Secondly, the pairs of peaks and troughs are chosen to meet the constraints for minimal duration of cycles (four quarters) and phases (two quarters).<sup>4</sup>

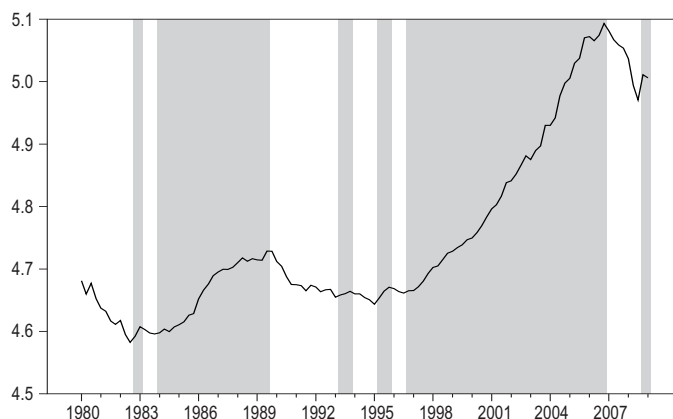


Figure 1: Ex post bull markets in US real estate prices

After determining all turning points 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.<sup>5</sup> Some summary statistics on the identification of real estate market cycles are given in Table 1. In the ex post series we find six bull markets 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.

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<sup>4</sup> Since we use quarterly data our minimal duration of cycles (four quarters) and phases (two quarters) are the shortest possible duration constraints. This is in line with [IMF \(2003\)](#).

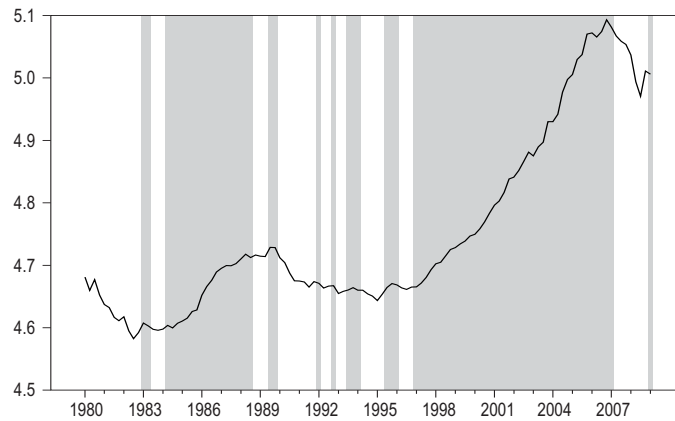
<sup>5</sup> For further details on the algorithm scheme see Appendix B in [Pagan and Sossounov \(2003\)](#).

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

	<b>Bull</b>	<b>Bear</b>
Number	6	7
Average duration	14	7
Average amplitude	12.91 %	-5.54 %

To assess whether the Fed responds to real estate market cycles, it is important to rely only on data available to the Fed at time of decision making (see [Orphanides, 2001](#)). Hence we make an additional modification of our cycle dating procedure. While the algorithm is based on ex post US real estate prices, the peaks and troughs are obtained recursively, i. e., by only using data up to the corresponding real time data point.

The resulting binary variable indicates quasi real time bull and bear markets (see Figure 2), and is implemented in a Taylor-type monetary policy rule in order to evaluate the link between real estate market cycles and US monetary policy. By comparing both figures the aspect of uncertainty becomes obviously as the real time figure exhibit more and smaller phases.



*Figure 2: Real Time bull markets in US real estate prices*

### 3 Empirical framework

To estimate the monetary policy reaction function of the Fed we employ a Taylor-type rule.<sup>6</sup> The original Taylor rule is modified by a smoothing term to capture monetary policies' gradual interest rate adjustments (Goodfriend, 1987). Since it is our purpose to figure out whether the Fed reacts on asset prices — as it does on inflation gap and output gap — we additionally implement the previously derived asset price variable. To account for the insights obtained by Orphanides (2001) that monetary policy decisions based on ex post revised data may differ from those based on data available at the moment of decision making, we employ real-time data for our estimations. Our Taylor-type rule is given by:

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

where  $i$  is the effective federal funds rate and  $\rho$  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  $\Delta y^*$  and its estimated relation parameter  $\gamma$ .<sup>7</sup> The inflation target  $\pi^*$  is designed to be time-varying<sup>8</sup> and is approximated by real-time 10 year ahead inflation forecasts (FRBP, 2007). 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 fil-

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<sup>6</sup> The original Taylor rule, 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.

<sup>7</sup> Since the equilibrium real interest rate is an unobserved variable it needs to be estimated. We use the economic postulate that in a market equilibrium real interest rates should conform with the economy's marginal productivity of capital.

<sup>8</sup> Reasons and consequences of a time-varying inflation target are given by Ireland (2007).



ter introduced by [Hodrick and Prescott \(1997\)](#)<sup>9</sup> and is based on the time series of real output. The real output is extended by 12 quarter forecasts obtained from an autoregression.<sup>10</sup> 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 1 year ahead inflation forecasts  $E_t\pi_{t+4}$  and the time-varying inflation target  $\pi^*$ . Our binary variable introduced in Section 2 is denoted by  $ap_t$ . The error term  $\epsilon$  is i. i. d. and captures the unexplained deviations. The indices  $t+x$  represent the period in question and  $E_t$  is the expectation operator. The sources of our data can be taken from Appendix 5.

In general, the estimation of monetary policies' reaction functions exhibit the inherent methodical challenge of endogeneity since the left-hand and right-hand variables 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.<sup>11</sup> As a result the estimated parameters would be endogeneity biased and inconsistent. For instance, in our case the asset price variable is affected by any change in the federal funds rate — given validity of the present value theory — since its underlying asset price is subject to a change in the discounting factor of its expected income stream. To account for this econometric issue the explanatory variables are instrumentalized and estimated by means of the method of generalized

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<sup>9</sup> As it is common with data that come with a quarterly frequency the smoothing parameter is chosen to be  $\lambda = 1,600$  (see for instance [Baxter and King, 1995](#)).

<sup>10</sup> 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 %.

<sup>11</sup> By definition, explanatory variables  $x_t$  are said to be endogenous if they are correlated with the equation's error term  $\epsilon_t$ .

moments (GMM).<sup>12</sup> The variables are instrumentalized by their own lagged realizations since these should be uncorrelated with the error term and highly correlated with their future realizations.<sup>13</sup> 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 the rolling sub-samples since we are interested in the general monetary reaction function as well as their changes over time. The full-sample covers the period from 1985q1 – 2007q1. The starting point of the sample is chosen with respect to constrained availability of real time data and the beginning of the Great Moderation (Stock and Watson, 2002). Table 2 illustrates the parameters of the Taylor-type rule for the full-sample estimation.

The estimates of the baseline policy rule in the upper part of Table 2 indicate that the Fed responded strongly to the expected inflation gap ( $\delta = 6.90$ ) and output gap ( $\beta = 0.78$ ). The estimate of the interest rate smoothing parameter ( $\rho = 0.80$ ) suggests that only 20% 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 ( $\gamma = 0.90$ ) hints at 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

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<sup>12</sup> Generally, variables qualify as instrument variables by being correlated with the substituted endogenous variables and uncorrelated with the equation's error term.

<sup>13</sup> 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

	$\rho$	$\gamma$	$\delta$	$\beta$	$\phi$
<b>Baseline:</b>					
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		
<i>J</i> -Statistic:			11.24		
<b>Baseline with asset prices:</b>					
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		
<i>J</i> -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 price 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.

all. Particularly  $\delta > 1$  ensures that the federal funds rate moves more than one-for-one with inflation. If  $\delta < 1$  the real interest rate would fall rather than rise when inflation rose. This could result in highly volatile inflation (Taylor, 1998).

The estimation results in the lower part of Table 2 describe the Fed’s reaction function after adding the asset price variable to our Taylor-type rule. Whereas all other estimated parameters are close to the baseline results, the asset price variable is statistically significant. The negative sign of the asset price variable parameter suggests that the Fed has set a lower federal funds rate in the presence of a bull market. Since the asset price variable is one if a bull market exists (and zero otherwise), the “optimal” federal funds rate would probably be 90 basis points lower 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 “Taylor-optimum”.

If one expects the Fed to stabilize asset price markets the obtained asset price coefficient seems to have the “wrong” sign. Considering the “wrong” sign of the asset price variable our results are similar to those in [Bernanke and Gertler \(2000\)](#) and [Tatom \(2009\)](#), although [Bernanke and Gertler](#) do not find any statistical significance. However, the results raise a remarkable question: Did the Fed provide support by loose monetary policy in order to extend bull market phases or, put differently, did the Fed provide support for government plans to increase home ownership rate?<sup>14</sup> Even though there were signals of excessive lending in real estate markets, e. g. Alan Greenspan warned the congress in 2004 that Freddie Mac and Fannie Mae have reached too much market power — they are “too-big-too-fail” — and, therefore, needed more regulation ([Greenspan, 1993](#)). But the Fed has not undertaken explicitly actions or it did only increase interest rates modestly to prevent further overheating.<sup>15</sup> Hence, one could claim the presence of a so-called ‘Greenspan put’. Whether or not such a put was available, the Fed did not force bankers to buy riskier assets. But it increased incentives to buy riskier mortgage debt since monetary policy was too expansionary.<sup>16</sup> All things considered our results of the full sample estimation indicate that the Fed responds pro-cyclical and did not attempt to stabilize real estate market prices.

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 sub-samples. This shift is motivated by the question

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<sup>14</sup> There have been many government actions to encourage home ownership, e. g. the Community Reinvestment Act in 1977, the American Dream Downpayment Act in 2003, the establishment of more or less government sponsored enterprises such as Freddie Mac, Fannie Mae, and Ginnie Mae.

<sup>15</sup> Subsequent increases in interest rates were more aggressive, though.

<sup>16</sup> Our Taylor-type rule is not able to explain deviations between the implied Taylor rate and actual federal funds rate in the period 2002 – 2005. The same is true for [Taylor \(2007\)](#) and others. The federal funds rate seems “too low for too long”.

whether the Fed’s responses to asset price developments have been systematic or discretionary over time. Accordingly, the estimations of rolling sub-samples should give an indication when and to what extent changes in the monetary reaction function have taken place.

The sub-samples cover the period from 1985q1 – 2007q1. Each sub-sample has a window of ten years and moves on by one period after every accomplished estimation. Table 3 reports summary statistics on the 50 realizations of the binary variable. Out of the estimated 50 parameters 41 are significant at the 10 %-level, whereof 9 have

*Table 3:* Summary statistics on the bull market coefficient for the rolling sub-sample estimation

	<b>Bull market parameter</b>
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

Notes: “effective” refers to the product of the asset price coefficient  $\phi$  and  $(1 - \rho)$ , whereas  $\rho$  describes the interest rate smoothing parameter.

Table 4: Parameters of the Taylor-type rule for the rolling sub-sample estimation

Sample Period	$\phi$	p-value	Sample Period	$\phi$	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)

a positive and 32 a negative sign. Considering their effective means, the estimation results indicate that in case of a positive (negative) sign the Fed has set the federal funds rate on average 41 (17) basis points above (below) the level that would have been probably set without the Fed considering real estate prices. These figures point out that the Fed has on average responded stronger to asset price developments in case of an anticyclic monetary policy (parameter with a positive sign) than in those of a procyclic monetary policy (parameter with a negative sign).

Given these results the question arises whether periods exist in which the Fed has responded in an accelerating or decelerating manner to asset prices. To get an impression of these periods Table 4 reports all estimated parameters of the binary variable for each of the 50 sub-samples. At the first glance, these parameters of subsequent sub-samples appear to be clustered as positive and negative parameters are grouped together. Considering the signs and significance levels along the time line it

is remarkable that both indicators point to specific patterns. A few quarters previous to the peaks of corporate equity and real estate market bubbles the parameter of the binary variable switches from significant negative to insignificant negative or even to significant positive. These findings hint to discretionary behavior. 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 accelerating to the real estate market. After this point in time the Fed takes countermeasures in order to decelerate the real estate market. By asking what determines this particular point in time one could, for instance, think of a specific 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 Feds objectives would be undermined.

## 5 Concluding Remarks

Facing low levels of consumer price inflation, especially asset price inflation seems to be a challenge for future monetary policy. The main objective of this paper is to assess a simple question: Does the US monetary policy respond to asset price developments?

Since real estate prices seem to have a close connection to monetary conditions we extend a Taylor-type monetary reaction function with a binary variable which considers real time peaks and troughs within real estate price cycles. This binary variable is created by a specific cycle dating procedure. It is important to note, that our procedure identifies the initial turning points by searching the input data for local minima and maxima 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. To figure out whether the Fed responds to asset prices we integrate

this binary variable into an empirical framework. In addition, the explanatory variables are instrumentalized by their own lagged realizations and estimated by means of the GMM. The GMM provides the additional benefit that it also accounts for measurement uncertainties to which our estimation is subject to.

Our full-sample estimation results give reason to suppose that the US monetary policy responds in a pro-cyclical way to real estate prices. This result is supported by our rolling sub-sample estimations. Additionally, these also point to decelerating countermeasures of the Fed previous to asset price peaks. These findings hint to discretionary behavior. However, our results should be interpreted cautiously since there is no common sense in regard of the method to identify real time cycles. Another issue not yet addressed here concerns the use of a broad set of asset classes with different term-structures. Besides, the empirical framework can be applied to analyze the policy of other monetary institutions such as the European Central Bank, the Bank of Japan, and the Bank of England. These issues provide the scope for further research.



## Appendix

Table 5: The data

<b>data</b>	<b>symbol</b>	<b>description</b>	<b>source</b>
Inflation target	$\pi_t$	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 $\lambda = 1600$ .	FRBP
Real estate price	–	FHFA real estate price index.	FHFA
Asset price deflator	–	First order difference of the logarithmic 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

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