Taylor Rule Deviations and Financial Imbalances

By George A. Kahn

Over the last quarter century, the U.S. economy has faced a number of financial shocks originating in a variety of sectors and locations around the globe. These shocks include the high-tech stock market crash, the Asian financial crisis, the Russian debt default, and most recently, the U.S. housing price collapse and subsequent global financial crisis. While the U.S. economy weathered most of these shocks with little or no impact on economic activity, it fell into its worst recession since the Great Depression as a result of the 2008 global financial crisis.

The causes of these crises are as diverse as the nature of the crises themselves. To some extent, however, a buildup of financial imbalances preceded each crisis. In some cases, asset prices rose to unsustainable levels inconsistent with market fundamentals. In other cases, a buildup of foreign debt precipitated a currency crisis. A key question for policymakers is whether policy actions taken in the period leading up to the crisis leaned against, or contributed to, the building imbalances. In particular, did monetary policies targeting stable inflation and sustainable

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long-term economic growth inadvertently exacerbate these imbalances by keeping policy-controlled interest rates too low for too long?

Answering this question requires first defining what "too low for too long" means. This article uses deviations from systematic or rule-like behavior in the setting of policy rates as an indicator of whether policy was too easy or, for that matter, too tight. In particular, deviations are measured as departures from various versions of the Taylor rule, which prescribes a systematic setting for the policy rate based on inflation relative to an inflation target and real output relative to potential output. Such deviations—especially if they are small and temporary—may represent an appropriate and desirable response to unusual economic or financial conditions. Larger and more persistent deviations, however, may contribute to a buildup of financial imbalances.

A second issue that must be addressed to determine whether monetary policy contributed to financial imbalances is to define what is meant by an imbalance. In this article, an imbalance is defined as a persistent deviation in an asset price or other financial variable from its long-run historical trend. A variety of empirical measures of imbalances are identified in four broad areas—housing markets, stock prices, leverage, and commodity prices. While each measure is an imprecise indicator of a particular imbalance, collectively they may provide insight into the relationship of Taylor rule deviations to building pressures in key sectors of the economy.

The article concludes that, while there does appear to be statistically significant relationships between Taylor rule deviations and a number of financial indicators, their economic significance is mixed. The strongest and most robust relationship is between house price indicators and Taylor rule deviations. In other cases, the relationship is economically weak and sometimes goes in the wrong direction in the sense that interest rates below the prescription of the Taylor rule are associated with smaller rather than larger imbalances. The fragility of the results likely stems from the inherent difficulty of identifying financial imbalances, combined with the irregular emergence of imbalances in different sectors at different times.

The first section of the article describes how deviations from systematic policy are measured and identifies episodes over the last 25 years where these deviations have occurred. The second section explains how

these deviations may have contributed to financial imbalances. The third section provides evidence on the relationship between deviations in policy from rule-like behavior and the buildup of financial imbalances.

I. TAYLOR RULE DEVIATIONS

The Taylor rule has become a key guidepost for monetary policy at the Federal Reserve and other central banks (Asso, Kahn, and Leeson). While there are many specifications of the Taylor rule, virtually all of them—to varying degrees—characterize monetary policy as too accommodative from 2003 to 2006.

The Taylor rule as a normative guide to policy

Since the mid-1980s, Federal Reserve monetary policy has conformed fairly closely and systematically to simple rules relating the Federal Open Market Committee's (FOMC) target for the federal funds rate to a few factors that broadly characterize the state of the economy. One such rule, the original Taylor rule, fit the data particularly well during the late 1980s and early 1990s, a period of generally favorable economic performance. Because this rule also performed well in a variety of macroeconomic models, keeping the volatility of inflation and output relatively low, the rule over time became viewed as a normative prescription for how policy should be set, conditional on a few current economic indicators.

A policy that systematically responds to economic conditions based on a simple rule such as the Taylor rule offers a number of advantages (Taylor 2008). First, it describes how policymakers should respond to changing economic circumstances. Second, it commits policymakers to achieving an inflation objective over the long run. Third, it helps policymakers communicate the rationale for, and data-dependent nature of, their decisions to the public. Fourth, it helps ensure that policymakers will take actions in the short run that are consistent with their long-run goals. Fifth, it reduces uncertainty about how policy rates are set today and in the future. And sixth, it helps the public hold policymakers accountable for their actions.

But there are also reasons why policy may occasionally deviate from systematic rules. Liquidity crises that require a temporary injection of reserves by the central bank may represent one reason why it might be

desirable to temporarily lower the policy rate below the level prescribed by a simple rule. Another reason for deviating from rule-like behavior might be a shock to the aggregate price level. Such a shock might normally call for a tightening of policy, but if the shock is seen as transitory, with no impact on inflation expectations, it might not require the response prescribed by a rule.[1] Finally, policymakers may respond to economic indicators other than those incorporated in the simple rule. In short, a simple rule may simply not capture all of the contingencies that might confront policymakers.[2]

This article examines four versions of the Taylor rule to identify episodes of "off-rule" behavior. The rules are normative prescriptions for policy that have been proposed in the economics literature, as opposed to rules that are estimated to fit as closely as possible the actual behavior of the policy rate. The rules' prescriptions are calculated with the latest available vintage of data as opposed to "real-time" data; that is, data available to policymakers at the time decisions were made. The purpose of this analysis is not to identify policy mistakes, which would require an evaluation with real-time data, but rather to examine the extent to which the resulting monetary conditions—with 20/20 hindsight—contributed to a buildup of financial imbalances.

All of the rules take the following general form:

$$i_t = rr^* + \pi_t + \beta(\pi_t - \pi^*) + \gamma(y_t - y_t^*),$$

where i_t represents the recommended policy rate as measured by the federal funds rate; rr^* represents the equilibrium real interest rate; $(\pi_t - \pi^*)$ represents the deviation of the inflation rate (π_t) from its long-run target (π^*); and $(y_t - y_t^*)$ represents the output gap—the level of real GDP (y_t) relative to potential GDP (y_t^*). With the exception of π^*, which is assumed equal to 2 percent at an annual rate for all variations of the rule, all of the other parameters vary depending on the particular rule being examined.

Intuitively, the rule prescribes that the federal funds rate be set equal to the equilibrium nominal interest rate $(rr^* + \pi_t)$ when inflation is at its target of 2 percent and real GDP is equal to potential GDP. When inflation deviates from target or real GDP deviates from potential, the rule prescribes that the funds rate be adjusted. In particular, the rule prescribes an increase in the funds rate when inflation is above the target or real GDP is above potential, and a decrease in the funds rate when inflation is below target or real GDP is below potential.

Table 1
TAYLOR RULE PARAMETERIZATIONS

	*rr**	β	γ
Rule 1	2	0.5	0.5
Rule 2	2	0.5	1.0
Rule 3	2.5	0.5	1.0
Rule 4	2.5	0.5	0.5

Table 1 identifies the four specifications of the Taylor rule to be examined. Rule 1 is the original version of the Taylor rule introduced by John Taylor in 1993. It assumes an equal response of the policy rate to inflation and the output gap. Rule 2, proposed by Ball in 1997, places a higher weight on output than the original Taylor rule. In some macroeconomic models, the higher weight on output results in lower variation in output and inflation than the original rule. Rule 3 assumes a higher equilibrium real rate of 2.5 percent compared with Taylor's original assumption of a 2 percent equilibrium real rate, while maintaining Rule 2's higher weight on the output gap. Rule 4 assumes the higher equilibrium real rate of Rule 3 but Rule 1's lower weight on the output gap.[3]

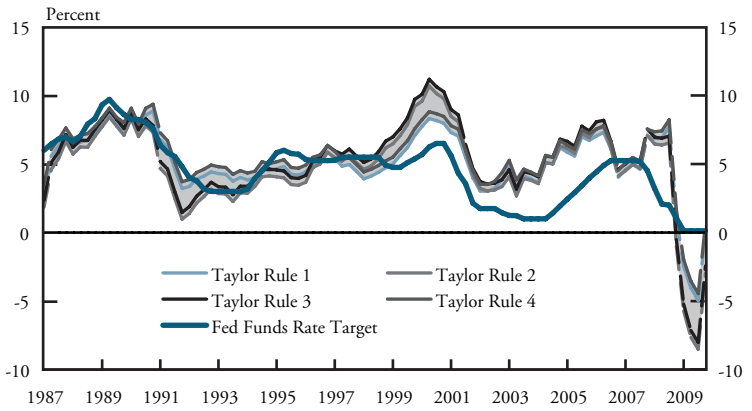
All of the rules adhere to the "Taylor principle," which argues that policymakers should adjust the nominal federal funds rate more than one-for-one with an increase in inflation relative to target. This response ensures that the real rate rises when inflation goes up so that monetary policy leans against inflationary pressures. It also ensures that the inflation target is achieved over time and therefore, in theory, helps anchor inflation expectations at the inflation target.

The Taylor rule in practice

The Taylor rule can be used to evaluate the stance of monetary policy. The top panel of Chart 1 shows the historical prescriptions from the four specifications of the Taylor rule, along with the actual federal funds rate target. All of the specifications use the consumer price index (CPI) as the measure of inflation and the Congressional Budget Office's (CBO) estimate of potential GDP in calculating the output gap.[4]

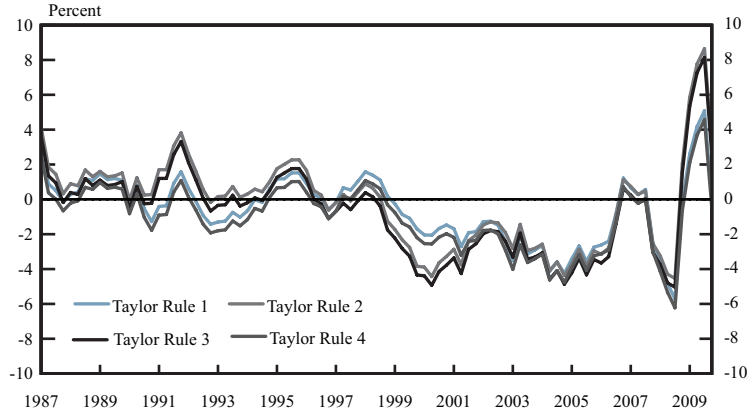
Chart 1

PANEL A
TAYLOR RULE PRESCRIPTIONS AND THE FEDERAL FUNDS RATE TARGET



Sources: Bureau of Economic Analysis, Congressional Budget Office, Bureau of Labor Statistics, Federal Reserve, and author's calculations. Taylor rules calculated as described in text with inflation measured by the 4-quarter rate of change in the CPI and the output gap measured as the log ratio of real GDP to the CBO estimate of potential.

PANEL B
TAYLOR RULE DEVIATIONS



Sources: See Chart 1 Panel A.

(Appendix 1 shows the sensitivity of the Taylor rule to alternative measures of inflation.) All data are the latest vintage available.[5] The shaded area is the envelope of Taylor rule prescriptions from the four specifications. As shown in the chart, the actual path of the funds rate closely follows the prescriptions of the Taylor rules from 1987 to 1997. From 1998 to 2008, however, the funds rate fell frequently and persistently below the prescriptions of all of the specifications of the Taylor rule.[6] As shown in the lower panel of Chart 1, the deviations from the Taylor rule over this period ranged from roughly two percentage points below the Taylor rule prescription to roughly six percentage points, depending on the particular rule examined.[7]

Two episodes in which the funds rate deviated persistently from Taylor rule prescriptions stand out. The first episode is in the period from late 1998 through 2000. At the beginning of this period, the Federal Reserve lowered the funds rate in response to a liquidity crisis stemming from the Asian financial crisis in 1997, the Russian debt default in 1998, and finally the collapse of the Long-Term Capital Management hedge fund. According to the FOMC statement accompanying the first cut in the funds rate, "the action was taken to cushion the effects on prospective economic growth in the United States of increasing weakness in foreign economies and of less accommodative financial conditions domestically."[8] In retrospect, over this period, the U.S. economy expanded briskly, leading to an ex post Taylor rule prescription that the funds rate should be raised, not lowered. Moreover, as the FOMC reversed course in June 1999 and began tightening policy, it moved the funds rate up at a slower pace than suggested by the Taylor rule.

The second episode occurred in 2002-06 as the economy recovered only gradually from the 2001 economic recession. During this period, the FOMC cut the funds rate to a low of 1 percent and held it there for a year. In doing so, the FOMC was responding to two concerns. One was that the unemployment rate remained high well into 2003 and real GDP growth was sluggish. In addition, the Committee was concerned that inflation was falling below desired levels. For example, real-time data on inflation as measured by the core personal consumption expenditure price index—an inflation indicator followed closely by the FOMC—fell below 1 percent. Although this measure was subsequently

revised up, most Committee members viewed the real-time inflation rate as undesirably low.

In late 2002 and 2003, some Committee members voiced concerns about a possibility, though remote, of deflation. Although the baseline forecasts of most models were not predicting deflation, the Committee maintained an accommodative monetary policy to limit the risk of deflation. In May 2003, the FOMC statement explicitly pointed to the risk of an "unwelcome substantial fall in inflation." Clearly, concern that the United States could experience the same kind of deflationary episode experienced by Japan in the previous decade weighed heavily on policymakers' minds.

Not only did policymakers dramatically lower rates, they also provided explicit "forward guidance" about the likely future course of rates. In its August 2002 statement, the FOMC indicated risks "are weighted mainly toward conditions that may generate economic weakness," indicating that a future rate decrease was more likely than an increase. In 2003, the risk of inflation becoming undesirably low prompted the FOMC to provide even more direct guidance about the future path of the policy rate. In its August statement, the Committee indicated it "believes that policy accommodation can be maintained for a considerable period," suggesting that the policy rate was likely to remain at a historically low level for an unsually long time. Then, in January 2004, the Committee said it "believes that it can be patient in removing its policy accommodation." Finally, as the Committee contemplated raising its policy rate later that year, it said it "believes that policy accommodation can be removed at a pace that is likely to be measured," suggesting a gradual upward trajectory for the funds rate target.

All of these statements contributed to a view among investors that a low level of rates relative to fundamentals would likely persist. In retrospect, rates remained persistently well below the prescription of the Taylor rule. They potentially fostered the financing of asset purchases with short-term borrowing, feeding a buildup of financial imbalances. In addition, they may have contributed to increased leverage, greater risk-taking, and speculation in commodity markets.[9]

II. FINANCIAL IMBALANCES IN A LOW INTEREST RATE ENVIRONMENT

Over the last 25 years, monetary policy has been largely successful in achieving and maintaining a low and stable inflation rate. Inflation expectations have become better anchored, helping keep inflation stable even when monetary policy has been eased (Mishkin). However, while the overall price level as measured by various indexes of final goods and services prices has been relatively stable, various classes of asset prices have climbed to unsustainable levels and subsequently crashed. Has monetary policy, in spite of its success in controlling inflation, played a role in the boom–and–bust cycle of asset prices? More generally, has monetary policy contributed to a buildup of financial imbalances, defined here as significant and sustained deviations of asset prices and other related economic indicators from longer-run trends?

Economists at the Bank for International Settlements (BIS), among others, have argued that our modern financial system is inherently procyclical. For example, a liberalized financial system can create an endogenous cycle in which a piece of good news leads to an increase in the demand for and supply of credit. Asset prices and spending rise as a result, further boosting optimism as well as collateral for new loans. The process is potentially aided by a monetary policy that focuses on inflation and real output and not on the financial imbalances themselves, especially if policy rates are low and expected to remain low. The cycle continues until asset prices and credit extension exceed the levels justified by the initial piece of good news. Eventually, the bubble bursts, and the cycle goes into reverse. Asset prices fall, and deleveraging takes place (Borio and White; White). In the United States over the last 25 years, such boom-and-bust cycles have been evident in a number of markets and financial indicators, including stocks, housing, leverage, and commodities.

Stock prices

One example of a boom-and-bust cycle during the last 25 years has been the stock market, particularly, in the high-tech sector. Ironically, the success of the Federal Reserve in responding to the 1987 stock market crash and the aftermath of the 1998 Asian financial crisis may have contributed to a view among investors that the stock market repre-

sented a one-way bet. In both cases, the Federal Reserve lowered interest rates aggressively and pumped liquidity into the banking system (Miller, Weller, and Zhang). The prevailing view at the Federal Reserve—articulated by Chairman Greenspan himself—was that policymakers were ill-equipped to identify or counter asset price bubbles as they are forming. However, monetary policy could be effectively deployed to limit the adverse effects of a bubble when it burst (Greenspan 2002).

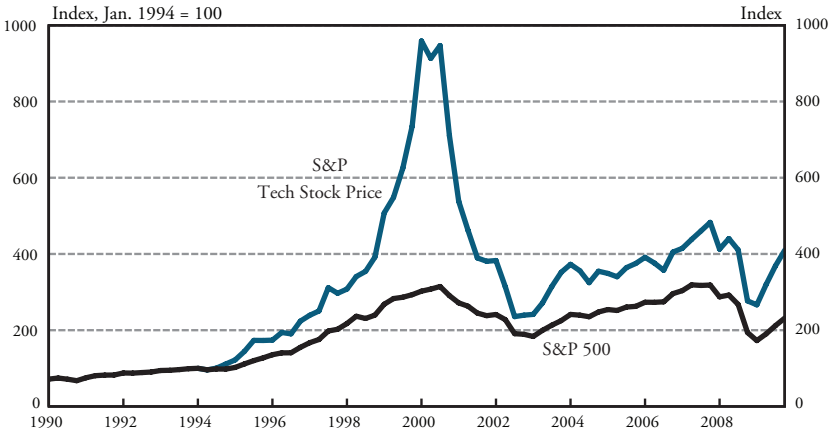
These factors may have contributed to the run-up in high-tech stock prices in the late 1990s. In particular, when optimism over the prospects for the Internet fostered large-scale investment in the high-tech sector, investors rushed in and pushed up high-tech stock prices. The low interest rate environment in the post-1998 period contributed to a search for yield in general and enthusiasm for the high-tech sector in particular. The so-called "Greenspan put" made the investment appear to be a one-way bet, particularly in a low-inflation environment (Miller, Weller, and Zhang). From 1997 to 2000, the overall stock market as measured by the S&P 500 stock price index almost doubled in value, while the S&P tech stock price index rose almost fivefold (Chart 2).

When prices finally collapsed in 2000-01 and the economy entered recession, the Fed again lowered rates. The federal funds rate target declined from 6.5 percent in 2000 to 1 percent in 2003. Moreover, the FOMC signaled in its statements that rates would remain low, first indicating that policy accommodation could be maintained for a "considerable" period and then suggesting that it could be removed at a "measured" pace. This period of low rates, in turn, may have set the stage for another, much more severe financial crisis—the 2008 global financial crisis that began in the U.S. subprime mortgage market.

Housing

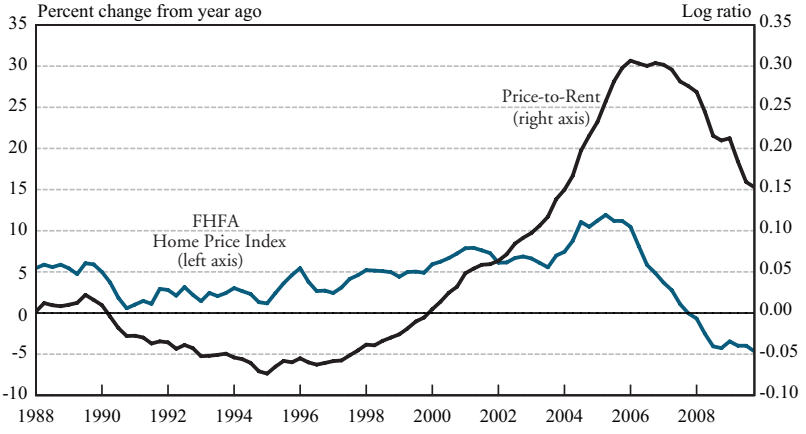
The recent experience in the housing market is the most obvious U.S. example of the boom-and-bust cycle. John Taylor has argued that easy monetary policy from 2003 to 2006 helped generate the boom in the demand for housing and the resulting run-up in housing prices. Over that period, the funds rate was held well below the prescription of the original 1993 specification of the Taylor rule. "With low money market rates, housing finance was very cheap and attractive—especially variable-rate mortgages with the teasers that many lenders offered. Housing starts

Chart 2
STOCK PRICES



Source: Standard & Poor's

Chart 3
HOME PRICES AND THE PRICE-TO-RENT RATIO



Sources: Federal Housing Finance Agency, Bureau of Labor Statistics, and author's calculations. Price-to-rent ratio measured as the log ratio of the FHFA Home Price Index to the CPI Owner's Rent Equivalent.

jumped to a 25-year high by the end of 2003 and remained high until the sharp decline began in early 2006" (Taylor 2007, p. 465).

At the same time, house prices rose rapidly (Chart 3). For example, according to the Federal Housing Finance Administration's (FHFA) house price index, prices accelerated sharply in 2003 and increased at an annual rate of over 10 percent in 2005. Subsequently in 2006, the pace of house price increases began to slow, and in 2008 prices collapsed.[10] In addition, the house price-to-rent ratio—a measure of house prices relative to fundamentals similar to a stock price-earnings ratio—climbed to unsustainable levels.[11] The (log) ratio of the FHFA's home price index to the CPI's measure of owner's equivalent rent increased roughly 35 percent from its low in the 1990s to its peak in 2005-06.

The increase in house prices fed on itself through a number of mechanisms before the bubble eventually burst. According to Taylor,

> With housing prices rising rapidly, delinquency and foreclosure rates on subprime mortgages also fell, which led to more favorable credit ratings than could ultimately be sustained. As the short-term interest rate returned to normal levels, housing demand rapidly fell, bringing down both construction and housing price inflation. Delinquency and foreclosure rates then rose sharply, ultimately leading to the meltdown in the subprime market and on all securities that were derivative from the subprimes (Taylor 2007, p. 465).

To establish the effect of low policy rates on housing, Taylor simulated a simple model of housing starts in which the federal funds rate was the explanatory variable. The simulations assumed two alternative paths for the funds rate—the path that the funds rate actually followed and an alternative path in which the funds rate followed a Taylor rule. While the actual funds rate fell from 2 percent in 2002 to 1 percent in 2003 before gradually rising to 5 ¼ percent in 2006, the funds rate in the alternative path rose steadily from 2 percent in 2002 to 5 ¼ percent in 2005. Taylor showed that the housing boom would have been less excessive in terms of housing starts had the federal funds rate followed the path prescribed by the Taylor rule instead of its actual path. In addition, he suggested the subsequent collapse of housing activity would have been less severe.

Taylor's views are not universally held, however. Most prominently, Federal Reserve Chairman Ben Bernanke argued in an address to the American Economic Association that a low target federal funds rate from 2003 to 2006 had only a small impact on housing activity and prices.[12] Bernanke based his view, in part, on a relatively simple statistical model that incorporated seven variables—including measures of economic growth, inflation, unemployment, residential investment, house prices, and the federal funds rate—estimated with data from 1977 to 2002. Based on this model, the actual behavior of the funds rate from 2003 to 2008 was well within historical norms. However, despite the model's ability to explain the behavior of the funds rate, and taking the actual behavior of the funds rate into account, the model could explain only a small part of the increase in house prices.[13] Bernanke concluded that although the behavior of the funds rate was well within historical norms based on actual macroeconomic conditions, the rise in house prices was "well outside the predictions of the model" (p.14). The implication was that some other factor drove up house prices.

Bernanke also presented international evidence on the relationship between monetary policy and house prices. He showed that a number of other countries that experienced greater inflation-adjusted house price appreciation than the United States from 2002:Q1 to 2006:Q3 ran *less* accommodative monetary policies, as measured by Taylor rule deviations, than the Federal Reserve.[14] Moreover, the statistical relationship between house price appreciation and the stance of monetary policy was quite weak, and monetary policy differences across countries explained only about 5 percent of the variation in house price appreciation.

Bernanke argued that instead of monetary policy, the boom in housing prices in the industrial countries is explained by a global savings glut. "[C]apital inflows from emerging markets to industrial countries can help to explain asset price appreciation and low long-term real interest rates in the countries receiving the funds…" (p. 18).[15] Bolstering this global savings glut hypothesis is a strong statistical relationship across countries between the deterioration in a country's current account balance as a percent of GDP from 2001:Q4 to 2006:Q3 and the associated increase in real house prices.

Leverage

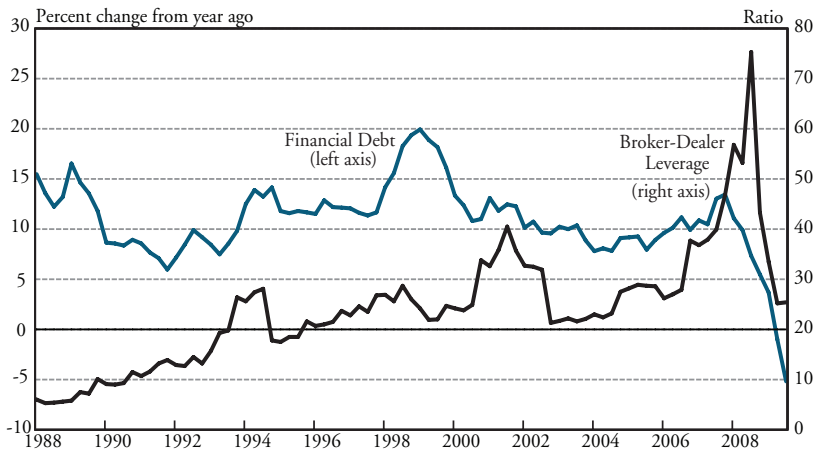
Economists have also argued that a low interest rate environment may have contributed to an unsustainable buildup of leverage among financial and nonfinancial businesses. For example, Adrian and Shin present evidence that leverage of financial institutions is procyclical, meaning that these institutions increase their leverage in boom times and reduce it in downturns. Moreover, these institutions adjust their leverage by collateralized borrowing and lending in the market for repurchase and reverse-repurchase agreements. In the "repo" market a firm borrows funds using securities as collateral. In the "reverse repo" market a firm lends funds against securities as collateral.

Liquidity—defined by Adrian and Shin as the growth rate of financial intermediaries' balance sheets—amplifies the credit cycle. "When monetary policy is 'loose' relative to macroeconomic fundamentals, financial institutions expand their balance sheets through collateralized borrowing; as a consequence, the supply of liquidity increases. Conversely, when monetary policy is 'tight,' institutions shrink their balance sheets, reducing the stock of repos and the overall supply of liquidity" (p. 2). The effect is more pronounced at security broker/dealers, whose assets are largely marketable short-term claims that are marked to market, than at bank holding companies whose assets are largely loans carried at book value.

Adrian and Shin suggest that the policy rate, which directly affects the cost of leverage, "may be an important determinant of the expansion and contraction of balance sheets and the liquidity of the financial system" (p. 7). By implication, holding the policy rate "too low for too long" risks an unsustainable buildup of leverage at financial institutions, in general, and at broker/dealers in particular.[16] As shown in Chart 4, growth in debt held by financial institutions was rapid from the late 1980s—especially from 1998 to 2000—up until the recent recession.[17] Moreover, the importance of balance sheet developments for economic activity is apparent in the lead-up to, and aftermath of, the 2007-08 global financial crisis. As also shown in Chart 4, leverage of securities broker/dealers—defined as the ratio of total financial assets to total financial assets less total financial liabilities—grew at a rapid and accel-

Chart 4

FINANCIAL DEBT AND LEVERAGE AT BROKER-DEALERS



Source: Federal Reserve Flow of Funds.

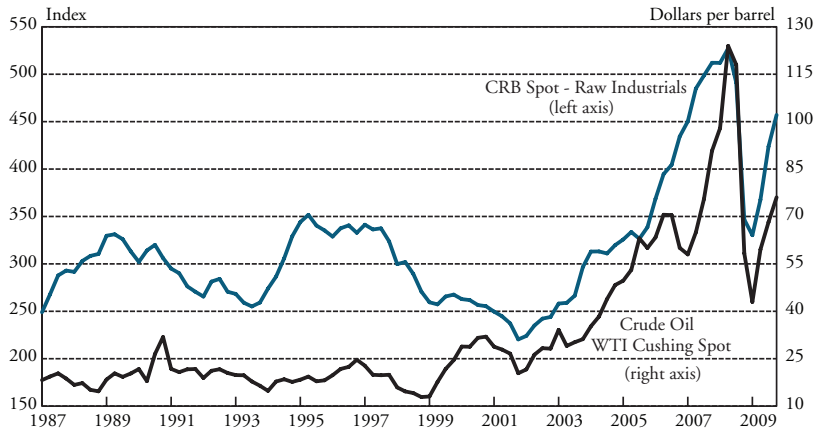
erating pace from 2003 to 2007, when the federal funds rate fell below the prescriptions of the Taylor rule. As the U.S. economy fell into a deep recession in late 2007, firms began to rapidly shrink their balance sheets and deleverage. Leverage ratios fell precipitously.

Commodities

The commodity market has also experienced considerable volatility in the last few years. This volatility may be another symptom of financial imbalances. James Hamilton, citing research by Tang and Xiong, has noted that since 2004 investors have made greater use of commodities as a hedge against rising inflation and a possible depreciation of the dollar. Moreover, because an increase in commodity prices, especially oil prices, is often associated with a slowdown in economic activity, commodities might also represent a hedge against declining equity prices. He notes that the incentive to hoard commodities as an investment is particularly strong when interest rates are low (*www.econobrowser.com/archives/2009/11/commodity_infla.html*).

Chart 5 shows the behavior of an index of commodity prices and the spot price of oil since 1987. From 2002 to 2007, crude oil prices rose from under $25 per barrel to roughly $120 per barrel. Over the same period, the Commodity Research Bureau's raw industrial price index increased roughly 133 percent. While the low interest rate en-

Chart 5
OIL AND COMMODITY PRICES



Source: Commodity Research Bureau, Bloomberg.

vironment is one possible factor explaining these developments, other possible contributing factors include rising global demand for commodities—particularly from Asia—and the depreciation of the foreign exchange value of the dollar.

III. TAYLOR RULE DEVIATIONS AND FINANCIAL IMBALANCES: EVIDENCE

Clearly, interest rates are an important factor in explaining economic and financial developments. Low interest rates stimulate economic activity and encourage borrowing. If interest rates are kept too low for too long, inflation is ultimately the result. But can other problems arise from a low interest rate environment, even if inflation appears subdued and is expected to remain subdued? This section examines evidence on the relationship between persistently low policy rates—as measured by Taylor rule deviations—and the various measures of financial conditions examined in the previous section. The evidence is derived from examining the correlation and lead-lag relationships between Taylor rule deviations and financial conditions from 1987 to 2009—a period of relatively low and stable inflation.

Correlations

A starting point for the analysis is the correlation between Taylor rule deviations and measures of financial conditions. Chart 6 shows scatter plots of four measures of financial conditions against deviations from Taylor Rule 1 as defined in the first section.[18] The horizontal axes show deviations from the Taylor rule, where a negative number means that the actual funds rate fell below the prescription of the Taylor rule. The vertical axes show changes in the S&P tech stock price index in panel A, the house price-to-rent ratio in panel B, the broker-dealer leverage ratio in panel C, and changes in the commodity price index in panel D.[19] In each panel of the chart, a regression line is drawn showing the overall relationship between financial conditions and Taylor rule deviations.

The regression lines show inverse relationships between Taylor rule deviations and three of the four measures of financial conditions—the house price-to-rent ratio, the leverage ratio, and commodity price inflation. Thus, in these cases, the farther the funds rate falls below the Taylor rule prescription, the greater the indicator of financial imbalance. However, the strength of the relationship is mixed. It is statistically significant as determined by the t-statistic on the slope coefficient on the Taylor rule deviation for the house price-to-rent ratio and the leverage ratio, but insignificant for commodity price inflation.[20] Moreover, the relationship between tech-stock prices and Taylor rule deviations is positive and significant rather than inverse. Overall, this evidence suggests that Taylor rule deviations have somewhat variable explanatory power across the financial indicators examined.

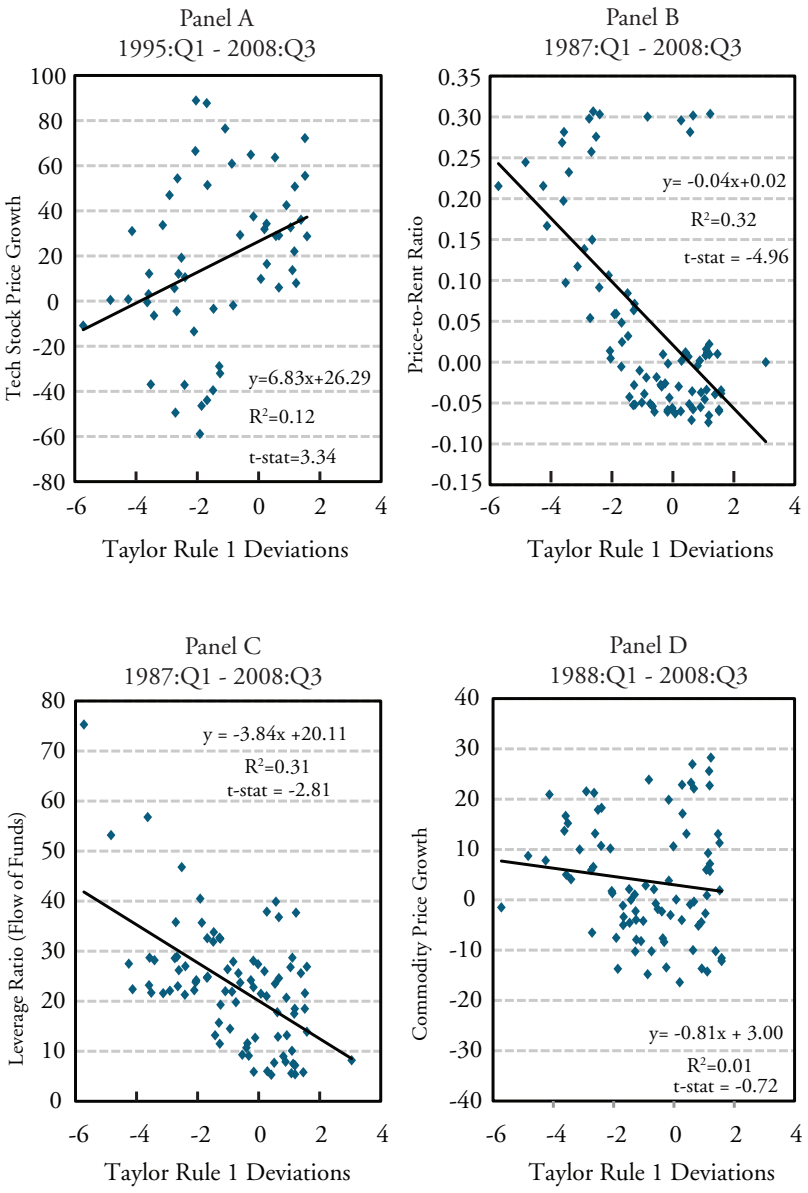
Lead/lag relationships

While the evidence supporting a contemporaneous correlation between various measures of financial condition and Taylor rule deviations is mixed, a more complicated dynamic relationship may be at work. In fact, most of the "stories" blaming financial imbalances on interest rates being "too low" also assert that they were too low for "too long." Thus, the level of interest rates several quarters ago may help predict the extent of a financial imbalance today.

To determine these lead/lag relationships, an atheoretical statistical model was estimated consisting of two equations—one describing various financial conditions and the other describing Taylor rule

Chart 6

TAYLOR RULE DEVIATIONS VS. FINANCIAL INDICATORS



Sources: See charts 2-5, author's calculations.

deviations. The financial conditions equation took the following form:

$$A_{it} = Constant1 + \Sigma_{j=1}^{4} a_{1j} A_{i,\,t-j} + \Sigma_{j=1}^{4} b_{1j} TR_{k,t-j} + \Sigma_{j=1}^{4} c_{1j} TRDEV_{k,t-j} + e_{1t}, \quad (1)$$

where A_{it} is the asset price or financial indicator i in quarter t; $TR_{k,t-j}$ is the prescription of Taylor Rule k in quarter t-j; $TRDEV_{k,t-j}$ is the deviation of the federal funds rate from the prescription of Taylor Rule k in quarter t-j; and $Constant1$, a_{1j}, b_{1j}, and c_{1j} are parameters to be estimated. Finally, e_{1t} represents the regression residual. A second equation, which is described in Appendix 2, is estimated to determine whether financial indicators help predict Taylor rule deviations.

Both the Taylor rule prescription and its deviation are included in the financial imbalances equation to distinguish between the effects of interest rate changes that are prescribed by the Taylor rule from interest rate changes that deviate from the rule. The key test is whether the coefficients on $TRDEV_{k,t-j}$ are jointly statistically significant. In this sense, the test determines whether Taylor rule deviations affected asset prices and other financial indicators.

In estimating the model, a variety of measures of Taylor rule deviations and financial variables are used. For Taylor rule deviations, the equations are estimated for each of the four Taylor rules specified in the first section. In addition, the deviations themselves are calculated in a number of different ways. First, as originally defined, they are calculated as the simple difference between the actual federal funds rate target and the prescription of each of the four Taylor rules ($TRDEV_1$ to $TRDEV_4$). Second, the simple deviations are squared ($TRDEVSQ_i$), allowing for the possibility of a nonlinear relationship between Taylor rule deviations and financial conditions; that is, the possibility that large deviations are much more important determinants of financial imbalances than small deviations. And third, the simple Taylor rule deviations are cumulated over time so that the Taylor rule deviation in period t is equal to the sum of Taylor rule deviations from the first period up to period t ($TRSUM_i$). The purpose of this variation is to capture the idea that the cumulative effect of low interest rates over time drives financial imbalances.[21]

A number of variables are considered as indicators of financial imbalances. For the housing sector, these include prices as measured by the FHFA home price index and the home price-to-rent ratio. Stock price measures include the S&P 500 stock price index, the S&P high-tech

stock index, and the price-earnings ratio. Measures of leverage include total debt of financial institutions, the ratio of total financial assets to total financial equity for security dealers, and the ratio of total assets to total stockholders' equity at the five largest investment banks before the collapse of Bear Stearns and Lehman Brothers. Commodity prices include the Commodity Research Bureau's (CRB) index of raw industrial commodities and the spot price of crude oil.[22]

Table 2 shows the results from regressions of the various measures of financial imbalances on lagged values of financial imbalances, lagged values of Taylor Rule 1 prescriptions, and lagged values of Taylor Rule 1 deviations ($TRDEV_1$) as in equation 1. Entries in the table indicate whether the coefficients on the lagged Taylor Rule deviations are jointly significantly different from zero and, therefore, help predict the various measures of financial imbalance. A "yes" entry indicates rejection of the hypothesis that a Taylor rule deviation does not help predict a financial imbalance at either the 1, 5, or 10 percent significance level. Appendix 3 shows corresponding results for Taylor rules 2 to 4.

Results are mixed. All three variants of the Taylor rule 1 deviations helped predict home price growth and the home price-to-rent ratio. Two of the three variants helped predict the change in the S&P 500 stock-price index, the stock price/earnings ratio, growth in SEC leverage, growth in financial debt, and growth in commodity prices. Taylor rule deviations were less consistently helpful in predicting the other financial variables; and, in the case of tech stock prices, none of the Taylor rule deviations were statistically significant. The tech stock bubble—confined as it was to the one narrow sector—may have been more about euphoria over the Internet and other technological developments than a low interest rate environment.

Economic significance

While evidence suggests that financial conditions are statistically related to Taylor rule deviations, the *economic* significance of this relationship is less clear.[23] One approach to examining the economic significance of the relationship is to use the estimated parameters from equation 1 to predict financial conditions under two scenarios. In one scenario, the estimated equation is forecast with the actual Taylor rule prescriptions and deviations plugged in on the right-hand side. In the

Table 2

DO TAYLOR RULE DEVIATIONS HELP PREDICT FINANCIAL IMBALANCES?

	Housing		Stock Prices			Leverage			Commodity Prices	
	Home Price Growth	Price-to-Rent Ratio	Stock Price Growth	Tech Stock Growth	PE Ratio	SEC Leverage Growth–five largest investment banks	FoF Leverage Growth–Securities Dealers	Financial Debt Growth	Oil Price Growth	Comm. Price Growth
TRDEV1	yes***	yes***	yes***	no	no	yes**	no	no	no	yes***
TRDEVSQ1	yes**	yes**	no	no	yes***	yes**	yes**	yes***	yes***	no
TRDEVSUM1	yes***	yes***	yes***	no	yes*	no	no	yes**	no	yes***

*** significant at 1%; ** significant at 5%; * significant at 10%

Sources: Federal Housing Finance Agency; Bureau of Labor Statistics; Standard and Poor's; Securities and Exchange Comission; Federal Reserve Flow of Funds; Commodity Research Bureau; Bloomberg; author's calculations.

other scenario, the Taylor rule deviations are set equal to zero. The difference in the two forecasts and their ability to "predict" the actual path of the various financial variables provide an indication of the contribution Taylor rule deviations make in explaining financial conditions. The forecasts are dynamic in the sense that forecasts of the financial variables are plugged back into the right-hand side instead of actual values.

Chart 7 shows the results of the exercise for a sample of four financial indicators (the same ones as in the previous chart). The dynamic forecasts begin in 1997:Q1 and run through the end of the sample in 2009:Q4. The blue lines show the actual path of the S&P tech stock price index in panel A, the house price-to-rent ratio in panel B, the leverage ratio in panel C, and the commodity price index in panel D. The grey line shows the forecasts of these variables based on equation 1 with lags of both the actual Taylor rule prescriptions and the Taylor Rule 1 deviations included on the right-hand side.[24] The black line shows the forecasts when the Taylor rule deviations are set equal to zero throughout the forecast period.[25]

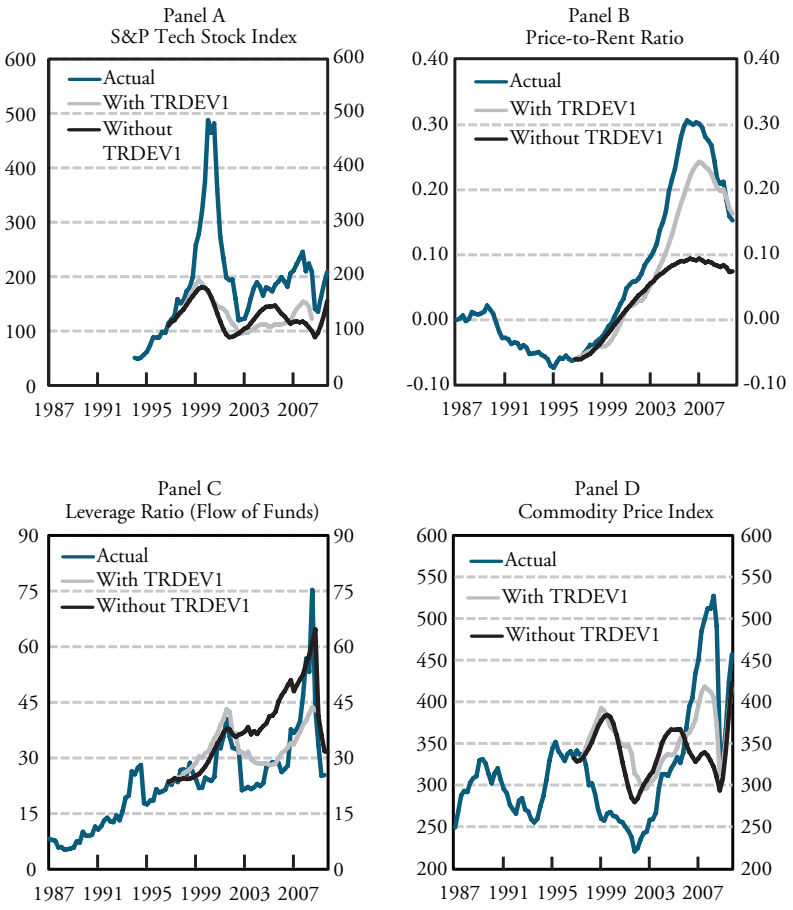
As in the earlier analysis, results are mixed.[26] In the case of the tech-stock price index, the inclusion of the Taylor rule deviations contributes very little to the forecast accuracy of the equation. In contrast, the Taylor rule deviations contribute considerably more to the forecast of the home price-to-rent ratio. In fact, the forecast based on both the lagged Taylor rule prescriptions and deviations tracks the upward movement in the ratio relatively closely, albeit with a lag. In addition, it tracks to a considerable degree the *extent* of the upward movement in house prices relative to rent. When the Taylor rule deviations are excluded from the forecasting equation, the bubble in housing prices looks more like a bump.

With respect to the leverage ratio, the equation including the lagged Taylor rule deviations appears to more closely track the path of leverage from 2001 to roughly 2006 than the equation excluding the deviations, but less closely from 2007 to 2009. Finally, with respect to commodity prices, neither specification does particularly well, although the equation including lagged deviations captures at least part of the upward movement in commodity prices from 2003 to 2007 as well as their subsequent fall.

In sum, evidence provides support for an economically meaningful effect of Taylor rule deviations on financial conditions in some sec-

Chart 7

PREDICTIVE POWER OF TAYLOR RULE DEVIATIONS



Sources: See charts 2-5, author's calculations.

tors but not in others. Of course, in each market, numerous special factors beside short-term policy rates are at work influencing financial conditions, and the empirical approach taken in this article is a vast simplification. For example, as suggested earlier, long-term rates play a key role in each of these sectors. And their behavior was unusual during 2004-06 when, by historical standards, they increased very little despite the FOMC's increase in the target federal funds rate from 1 percent to 5.25 percent.[27] Taking account of this behavior may be necessary to explain any imbalances that may have been building during this period.

In addition, the one-off nature of many of the financial imbalances, particularly the tech-stock price bubble in 1998-2000 and the commodity price surge in 2006-07, may be difficult to explain econometrically. In particular, without multiple observations of a phenomenon, it is difficult to rule out alternative explanations.

An additional complication is that, to the extent Taylor rule deviations preceded financial imbalances, the symptoms of the imbalances appeared at different times in different sectors. For example, the fact that a period of low policy rates may have engendered a tech-stock price bubble in one instance and a housing bubble in another makes it difficult to find a statistical relationship between low rates and any particular financial imbalance. In light of these difficulties and the simplicity of the empirical approach in this article, it is perhaps surprising that any statistically significant relationships would emerge between Taylor rule deviations and financial imbalances.

IV. CONCLUSIONS

The global economy has been buffeted by a number of financial crises over the last 25 years. The U.S. economy appeared to be relatively well-insulated from these crises until the U.S. housing bubble burst, leading to the worst economic downturn since the Great Depression. While the causes of the 2007-08 global financial crisis will undoubtedly be debated for decades to come, some economists have suggested that Federal Reserve monetary policy contributed to a buildup of financial imbalances that ultimately precipitated the crash. In particular, by keeping short-term interest rates too low for too long, policymakers may have fostered the emergence of a housing price bubble. In addition, low interest rates encouraged private investors to increase leverage

and invest in risky assets in pursuit of higher returns. When the housing bubble burst, the financial system nearly collapsed.

Other economists argue that monetary policy was appropriate given economic fundamentals and that other factors were more important in precipitating the crisis. For example, a global savings glut may have led to growing demands for relatively safe U.S. assets, keeping long-term interest rates low. Moreover, detecting and leaning against growing financial imbalances may be difficult or impossible to do in real time. Still, the question remains whether a monetary policy that successfully stabilized inflation contributed to a buildup of financial imbalances by maintaining short-term interest rates at very low levels for prolonged periods of time.

To address this question, this article examined the relationship between short-term interest rates and a variety of financial indicators designed to capture growing imbalances. While individually these indicators may contain limited information, collectively they potentially provide insight into whether low short-term interest rates contributed to a buildup of financial imbalances. Interest rates were considered "too low" if they deviated from the prescriptions of various versions of the Taylor rule. Because a variety of Taylor rules have been proposed in the literature, the analysis considered a variety of Taylor rule specifications.

The article concludes that, while there appears to be a statistically significant relationship between Taylor rule deviations and a number of financial indicators, their economic significance is mixed. With 20/20 hindsight, lagged Taylor rule deviations appear to help predict the housing bubble and, to a lesser extent, commodity price movements. Taylor rule deviations are much less useful in explaining the bubble in tech-stocks or the rise in broker/dealer leverage. A key challenge in finding a robust relationship between Taylor rule deviations and financial imbalances is that the imbalances appeared in different sectors at different times.

Even so, the evidence suggests that policymakers should monitor financial conditions for signs that imbalances are building. These imbalances may indicate that interest rates are too low even when real-time inflation and output data suggest low rates are warranted. Moreover, policymakers should be cautious in deliberately maintaining rates below Taylor rule prescriptions. Although policymakers may have many reasons to deviate from simple rule-like behavior, they should be alert to unintended consequences from maintaining rates too low for too long.

APPENDIX 1

TAYLOR RULES WITH ALTERNATIVE MEASURES OF INFLATION

The prescription of the Taylor rule depends not only on the chosen parameters of the rule but also importantly on the measure of inflation.[28] In his original 1993 specification, Taylor measured inflation with the GDP deflator. Given the data available at the time, his specification closely tracked the FOMC's funds rate target from 1987 to 1993. Since the time Taylor proposed his rule, data on the GDP deflator have been revised. Taylor rule prescriptions using the latest vintage data on inflation as measured by the GDP deflator no longer track the funds rate target as closely as Taylor rule prescriptions using early 1990s vintage data. As a result, an alternative inflation measure was used in this article.

Chart A1 shows the historical prescriptions from Taylor rule 1 using 5 different measures of inflation—the GDP deflator, the consumer price index (CPI), the consumer price index net of food and energy prices (core CPI), the personal consumption expenditure (PCE) price index, and the PCE price index net of food and energy (core PCE price index).[29] The top panel of the chart shows the envelope of Taylor rule prescriptions with the alternative inflation measures relative to the actual path of the funds rate target. The bottom panel shows deviations of the actual funds rate from the Taylor rule prescriptions. While there is considerable variation in the prescriptions of the various Taylor rule specifications, they all track the actual path of the funds rate fairly closely—except from 2002 to 2006 when the actual funds rate fell persistently below the prescriptions of all of the Taylor rule specifications.

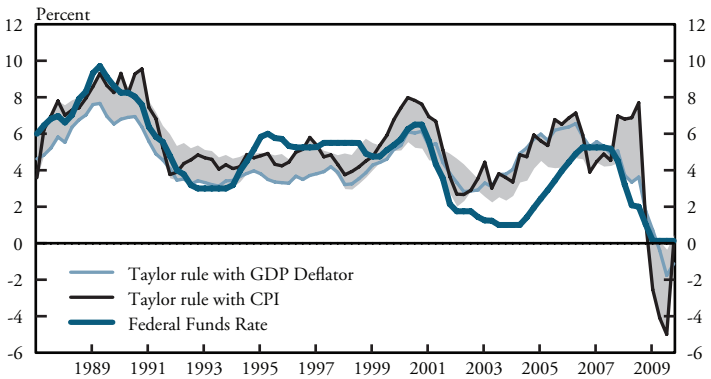
Over the period that Taylor examined—1987 to 1993—and through 1997, Taylor rule prescriptions based on the most recent, revised data for the GDP deflator deviate more from the actual path of the funds rate than Taylor rule prescriptions based on alternative measures of inflation. This suggests that an alternative measure of inflation is needed to track the funds rate as well as a Taylor rule based on early 1990s vintage data on the GDP deflator.

The analysis in this article uses Taylor rules with the CPI as the measure of inflation. Using CPI inflation in Taylor rule 1 results in smaller deviations from 1987 to 1997 than Taylor rules using alternative measures of inflation. In particular, the root mean square error of the deviations from the Taylor rule using CPI inflation over this period was smaller than for other inflation measures.

Chart A1

PANEL A

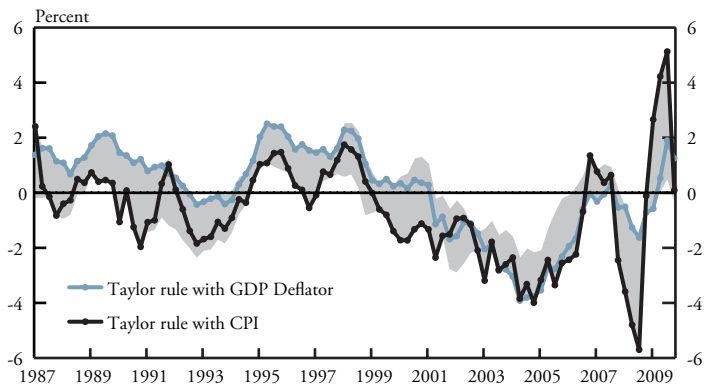
TAYLOR RULE 1 PRESCRIPTIONS WITH ALTERNATIVE INFLATION MEASURES



Sources: See Chart 1, Panel A.
Note: The shaded area is the envelope of Taylor rule 1 prescriptions with five alternative measures of inflation: GDP Deflator, CPI, Core CPI, PCE Price Index, and Core PCE Price Index.

PANEL B

TAYLOR RULE 1 DEVIATIONS WITH ALTERNATIVE INFLATION MEASURES



Sources: See Chart 1, Panel A.
Note: The shaded area is the envelope of Taylor rule 1 deviations with five alternative measures of inflation: GDP Deflator, CPI, Core CPI, PCE Price Index, and Core PCE Price Index.

APPENDIX 2

DO FINANCIAL IMBALANCES HELP PREDICT TAYLOR RULE DEVIATIONS?

Fully understanding the relationship between financial imbalances and Taylor rule deviations requires not only understanding the effect of Taylor rule deviations on financial imbalances but also the reverse effect. In other words, do lagged financial conditions help predict Taylor rule deviations? To address this question, a second equation was estimated that took the following form:

$$TRDEV_{it} = Constant2 + \Sigma_{j=1}^{4} a_{2j} A_{i,t-j} + \Sigma_{j=1}^{4} c_{2j} TRDEV_{k,t-j} + e_{2t}, \quad (2)$$

where *Constant2,* a_{2j}, and c_{2j} are parameters to be estimated and e_{2t} is the residual term.[30]

According to the Taylor rule, policymakers should respond directly only to deviations in inflation from target and real GDP from potential GDP. Evidence that the coefficients on lagged financial variables (a_{2j}) are jointly statistically significant might suggest that policymakers responded directly to financial conditions in setting policy rates. In this case, an estimated correlation between Taylor rule deviations and measures of financial imbalances may simply reflect the fact that financial conditions influenced the setting of the policy rate, not necessarily that Taylor rule deviations contributed to a buildup of financial imbalances.

Table A1 examines whether financial conditions help predict Taylor rule 1 deviations. Results for other Taylor rule specifications are shown in Appendix 3. Entries in the table, based on estimates of equation 2, indicate whether coefficients on the lagged financial conditions indicators are jointly significantly different from zero and, therefore, help predict the various measures of Taylor Rule 1 deviations. A "yes" entry indicates rejection of the hypothesis that a financial indicator does not help predict a Taylor rule deviation at the 1, 5, or 10 percent significance level. Here, the results appear more systematic across the sectors examined. The house price variables and commodity price variables help predict Taylor rule

Table A1

DO FINANCIAL IMBALANCES HELP PREDICT TAYLOR RULE DEVIATIONS?

	Housing		Stock Prices			Leverage			Commodity Prices	
	Home Price Growth	Price-to-Rent Ratio	Stock Price Growth	Tech Stock Growth	PE Ratio	SEC Leverage Growth	FoF Leverage Growth	Financial Debt Growth	Oil Price Growth	Comm. Price Growth
TRDEV1	yes**	yes***	no	no	yes***	no	no	no	yes**	yes***
TRDEVSQ1	yes***	yes***	no	no	no	no	yes**	no	yes***	yes*
TRDEVSUM1	yes**	yes***	no	no	yes**	no	no	no	yes**	yes***

*** significant at 1%; ** significant at 5%; * significant at 10%

deviations, while stock prices and leverage generally do not. This suggests that policymakers did not respond directly to stock market developments or leverage. However, policymakers did appear to respond to developments with housing prices and commodity prices—perhaps because they provided information about future inflation or real output that was not contained in the current inflation rate or real output gap.[31]

In summary, looking at the relationships from both directions, house prices and Taylor rule deviations generally appear to be jointly determined in that lags of each help predict the other. Similarly, commodity prices and Taylor rule deviations generally appear to be jointly determined. In contrast, Taylor rule deviations generally help predict stock prices and leverage, but stock prices and leverage do not generally help predict Taylor rule deviations. Thus, there is some evidence that Taylor rule deviations contribute in varying degrees to financial developments in all of the sectors examined, but less evidence that stock prices and leverage contribute to Taylor rule deviations.

Table A2

DO TAYLOR RULE DEVIATIONS HELP PREDICT FINANCIAL IMBALANCES?

	Housing		Stock Prices			Leverage			Commodity Prices	
	Home Price Growth	Price-to-Rent Ratio	Stock Price Growth	Tech Stock Growth	PE Ratio	SEC Leverage Growth	FoF Leverage Growth	Financial Debt Growth	Oil Price Growth	Comm. Price Growth
TRDEV2	yes**	yes***	yes***	no	no	yes*	no	no	no	yes***
TRDEVSQ2	yes***	yes**	no	no	yes***	yes*	yes*	yes***	yes**	no
TRDEVSUM2	yes***	yes***	yes***	no	no	no	no	yes**	no	yes***
TRDEV3	yes**	yes***	yes***	no	no	yes*	no	no	no	yes***
TRDEVSQ3	yes***	yes**	no	no	yes***	yes*	yes*	yes***	yes**	no
TRDEVSUM3	yes***	yes***	yes***	no	no	no	no	yes*	no	yes***
TRDEV4	yes*	yes***	yes***	no	no	yes**	no	no	no	yes***
TRDEVSQ4	yes***	yes**	no	no	yes***	yes**	yes**	yes***	yes***	no
TRDEVSUM4	yes***	yes***	yes***	no	yes*	no	no	yes*	no	yes***

*** signifigant at 1%; ** signifigant at 5%; * signifigant at 10%

Table A3

DO FINANCIAL IMBALANCES HELP PREDICT TAYLOR RULE DEVIATIONS

	Housing		Stock Prices			Leverage			Commodity Prices	
	Home Price Growth	Price-To-Rent Ratio	Stock Price Growth	Tech Stock Growth	PE Ratio	SEC Leverage Growth	FoF Leverage Growth	Financial Debt Growth	Oil Price Growth	Comm. Price growth
TRDEV2	yes***	yes***	yes*	no	yes***	no	no	no	yes**	yes**
TRDEVSQ2	yes***	yes***	no	no	no	no	yes**	no	yes***	yes**
TRDEVSUM2	yes***	yes***	yes*	no	yes**	no	no	no	yes**	yes***
TRDEV3	yes***	yes***	yes*	no	yes***	no	no	no	yes**	yes**
TRDEVSQ3	yes***	yes***	no	no	no	no	yes**	no	yes***	yes**
TRDEVSUM3	yes***	yes***	yes*	no	yes**	no	no	no	yes**	yes***
TRDEV4	yes***	yes***	no	no	yes***	no	no	no	yes**	yes***
TRDEVSQ4	yes***	yes***	no	no	no	no	yes**	no	yes***	yes**
TRDEVSUM4	yes***	yes***	no	no	yes**	no	no	no	yes**	yes**

*** significant at 1%; ** significant at 5%; * significant at 10%

ENDNOTES

[1]Taylor (1993) suggests the oil price shock following the Iraqi invasion of Kuwait in 1990 was one such example.

[2]See Taylor (2008) for a discussion of the costs and benefits of deviating from rule-like behavior.

[3]In addition, a fifth rule was considered that was specified in first differences. In particular, the rule prescribed a *change* in the funds rate target based on the deviation of inflation from target and the *change* in the output gap. As in Rule 1, the weights on inflation and output were both set equal to 0.5. The advantage of the difference rule is that it does not depend on an estimate of the equilibrium real rate or the level of the output gap. When Rule 1 is expressed in first differences, the equilibrium real rate—which is assumed constant—drops out, and the output gap is replaced with its growth rate—which can arguably be estimated more accurately than the level of the output gap. Taylor (1993) suggested the possibility of a rule based on output growth. Orphanides specified such a rule and examined historical monetary policy using a difference rule, among others. The policy prescription from the first difference rule tracks the actual path of the funds rate more closely than the other rules because it depends, in part, on the actual level of the funds rate in the previous period. The first difference rule may have appeal in real time policymaking because it can be implemented without a prior estimate of the equilibrium real funds rate or the level of the output gap.

[4]Taylor (1993) used the GDP deflator as his measure of inflation and deviations of real GDP from a trend line as his measure of the output gap. Based on his 1993 rule and the latest vintage data available to Taylor at the time, the prescription of the rule closely matched the actual path of the federal funds rate from 1987 to 1992.

[5]The latest vintage data on the output gap differs from the real-time data policymakers had available at the time policy decisions were made. Because the CPI data are essentially not revised, the latest vintage data is the same as the data policymakers had in real time. This article uses latest vintage data rather than real-time data. The purpose is to assess the ex post impact of monetary policy on financial imbalances, not to evaluate whether policy was optimal given information available at the time policy decisions were made.

[6]The degree and persistence of the Taylor rule deviations over this period are reduced somewhat when core measures of inflation are used in the Taylor rule.

[7]Varying the parameters and inflation and output gap measures in the Taylor rule can produce a fairly wide range of prescriptions as Kozicki shows. Nevertheless, as Dokko, et al. show, the actual path of the funds rate falls below a wide range of Taylor rule prescriptions from 2003 to 2004.

[8]FOMC Statement, September 1998. See Blinder and Reis for further discussion of this episode.

[9]Altunbas, Gambacorta, and Marqués-Ibáñez examine the relationship between low interest rates and bank risk-taking. The next section discusses asset prices, leverage, and commodity prices.

[10]Other indexes of house prices, such as the S&P/Case-Shiller index, showed an even sharper boom-and-bust cycle.

[11]The rent a homeowner could receive by leasing his or her house is a fundamental determinant of the value of the house. When house prices are high relative to rent, future increases in house prices are more likely to be small. Thus, the price-rent ratio can be viewed as "an indicator of valuation in the housing market" (Gallin, p. 635).

[12]See also Del Negro and Otrok; Jarociński and Smets; Edge, Kiley, and Laforte; and Iacoviello and Neri.

[13]Bernanke refers to Dokko and others (2009) for details.

[14]Despite some countries having less-accommodative policies than the United States, essentially all of the 20 countries examined in Bernanke's sample had policy rates less than prescribed by the Taylor rule.

[15]See Bernanke (2007) for details.

[16]Adrian and Shin present evidence that, when Taylor rule deviations are negative, meaning that the federal funds rate is below the prescription of a Taylor rule, the growth rate of repos is higher than average (p. 6).

[17]Debt held by financial institutions "increasingly overstates the amount of borrowing associated with economic activity because a growing share of this total debt comprises claims issued by financial intermediaries jut to fund other debt" (Samolyk, p. 35). This measurement issue is not addressed in this article and could conceivably affect the results.

[18]Results are similar for deviations from Taylor rules 2-4.

[19]Financial indicator growth rates are calculated as four-quarter rates of change, and Taylor rule prescriptions are calculated with inflation measured by the four-quarter rate of change in the CPI.

[20]T-statistics are corrected for serial correlation using the Newey-West covariance matrix.

[21]Other variations were also considered. Reflecting the possibility that only negative deviations matter for financial imbalances (interest rates too low for too long, not too high for too long), deviations that are greater than zero were set equal to zero. In addition, the measure of strictly negative deviations was squared to allow for nonlinearity in the relationship. Results are qualitatively the same for these alternative measures.

[22]All of the variables except the house price-to-rent ratio were measured as annualized one-quarter rates of change. Other financial variables were also considered—including restricting growth in the S&P Case-Shiller national home price index to observations in excess of one standard deviation; growth in the S&P Case-Shiller index for Las Vegas, Phoenix, and San Diego; the share of

employment in the construction sector; S&P 500 stock price changes in excess of one standard deviation; stock price volatility as measured by the VIX; and nonfinancial debt growth.

[23]For example, while the coefficients on lagged Taylor rule deviations in equation 1 are, in many cases, jointly significantly different from zero, their *sum* is often insignificantly different from zero and sometimes carries the "wrong" sign. Moreover, plots of impulse response functions showing the effect of a shock to the Taylor rule deviation on financial conditions exhibit wide confidence bands that often indicate no statistically significant effect.

[24]Results for Taylor rule 2-4 deviations are similar.

[25]While the financial variables are generally specified as annualized one-quarter growth rates and forecast accordingly, the charts show the variables and forecasts converted back into levels.

[26]Results are sensitive to the estimation period and, in particular, depend on the inclusion of data from the post-2005 period.

[27]Then-Chairman Greenspan referred to this behavior as a "conundrum." See Backus and Wright for a discussion of possible causes.

[28]The choice of parameters and the inflation measure are, however, intertwined. Because some measures of inflation are persistently above or below others, they imply different values for the equilibrium real interest rate. For example, inflation measured with the CPI was consistently higher than inflation measured by the GDP deflator from 1987 to 2001. Thus, for a given average nominal funds rate over this period, the average ex post real rate would be lower as measured by the CPI inflation rate than as measured by inflation in the GDP deflator. See Kozicki for a detailed analysis of this issue.

[29]Other possible inflation measures, not considered here, are various forecasts of inflation. Evidence suggests that Taylor rules using (real time) forecasts of (PCE) price inflation lead to smaller Taylor rule deviations than Taylor rules using CPI inflation as currently measured (Bernanke).

[30]The error terms, e_{1t} and e_{2t}, are assumed to have zero mean and finite variance.

[31]If policymakers use a forward-looking framework in setting policy rates, variables that help forecast future inflation and output should help explain deviations in the policy rate from a Taylor rule based on current inflation and output.

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