To What Extent did Monetary Policy Contribute Towards the Recent Financial Crisis and Subsequent Recession in the US and UK?

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Abstract

This essay researches the question, "To what extent did monetary policy contribute towards the recent financial crisis and subsequent recession in the US and UK?" This article begins by demonstrating monetary policy's role in guiding the economy's development under different economic fundamentals. Then the essay puts forward the existence of possibility that monetary policy may cause potential dangers for the economy. In the next chapter, the essay illustrates the guideline for monetary policy namely Taylor rule and economists' arguments and explanations for the US monetary policy in the past decade. In chapter 3, this article estimates the nominal interest rates for both the US and the UK based on Taylor rule for different periods and illustrates influences of monetary policy actually taken for each country in different periods. In chapter 4, the article tests the relationship between monetary policy's deviations from Taylor rule and financial imbalances by using the OLS method and explains results. Finally, in chapter 5, the article concludes that in some degree monetary policy's deviations from Taylor rule prescriptions contribute to a build-up of financial imbalances.

Keywords: Taylor rule, deviations, imbalances, bubbles, and regulations

1. Introduction

Monetary policy plays an important role in guiding the economy's activities according to different economic fundamentals. An appropriate set of policy rate can stimulate the economy's biggest potential, which is potential GDP. Potential GDP is a country's gross domestic product when it produces at full employment and utilizes its all resources. However over the past two decades, the world economy suffered several crises originated from different sectors and areas. From the Asian financial crisis to the Internet bubble, and to the most recently, the American subprime mortgage crisis, it seems that the world economy falls into the recession-recovery cycle. Viewing the development of the world economy, we can find that during the period from the mid 1980s to 2000, the US economy developed quite well with low volatility of real GDP growth and low inflation. We may call this period the Great Moderation. For awakening the deteriorative economy, analyzing what we had done during the Great Moderation and learning from it may be an effective method. By comparing the monetary policy between the Great Moderation and in recent years, we find that monetary policy may cause dangers for the economy unintentionally. In other words, monetary policy during the past decade aimed at reaching stable inflation rate, while it also buried a time bomb for the economy. Thus analyzing the relationship between monetary policy and financial crisis is quite important and useful for further economic analyses and decision makings.

2. Literature Review

2.1 Introduction of Taylor Rule

Monetary policy is a quite important and useful instrument for policy makers to adjust the nation's economy situation for both current and future. The Taylor rule has become the key benchmark for the central banks to regulate the economy through the interest rate instrument during the past decades. John B. Taylor first proposed the rule in 1993. It prescribes a simple rule for policymakers to change the nominal interest rate in response to the gap between actual inflation and target inflation as well as the output gap. Taylor (2008) concludes that there is a host of advantages originating from making the monetary policy based on a simple rule such as the Taylor rule. Two of them are more or less essential for central banks to consider. First, the simple rule helps policymakers to be easier to communicate with the public about how and why their decisions are made. Second, the simple rule helps ensure that policymakers' short-run actions are consistent with their long-run goals, which

are stable inflation rate and low volatility of real GDP growth rate. These advantages help policymakers to build trust between the general public and the government as well as anchoring inflation expectations. Diamond (2007) points out that distrust may cause alienation and make the general do not follow the government's guidance. Furthermore, it is hard for government to mobilize all national resources to develop the economy. OECD points out that trust is necessary to increase confidence of investors and consumers; trust is essential for key economic activities, especially finance. Besides the trust, inflation expectations are anchored by conducting the simple rule. Taylor rule recommends a relatively higher nominal interest rate when inflation is above its long run target or when GDP is above potential GDP. For example, when inflation rate is 1 percent higher than the inflation target, Taylor rule recommends the nominal interest rate to be raised more than 1 percent. Since the real interest rate equals the nominal interest rate minus inflation rate, the real interest rate is increased when inflation rate increases. Then the increase of the real interest rate tightens economic activities. For the next period, the inflation rate is expected to reduce. Therefore, for the long run, the public's expectations of inflation rate are anchored to the long run inflation target.

2.2 Supports for Taylor Rule Deviations Contribute to Financial Crises

Kahn (2010) points out that during the Great Moderation the actual federal funds rate closely matched the rate prescribed by Taylor rule. While from late 1990s until now, there is a great deviation between the actual federal funds rate and the prescribed rate. If the deviation from the Taylor rule is small and temporary, it may represent an appropriate and reasonable adjustment to the unexpected economic and financial circumstances. If the deviation from the prescribed rule is large and lasting, it may contribute to facilitating the financial imbalances. Theses imbalances might force a buildup of financial bubbles that will eventually end up with the crises. Taylor (2010) argues that the great deviation plays a significant role in contributing the recent financial crises. Compared with the policy taken during the Great Moderation, the policy now becomes more interventionist and less predictable. The central bank should make decisions that will help to achieve the long-term goals rather than too many interventions that only consider about the current economic and financial conditions. If central banks take too many actions only based on current concerns, it might make the actual funds rate deviate from the Taylor rule prescribed rate inadvertently.

Taylor (2010) argues that the interest rate came down in 2001 due to the recession that was acceptable and reasonable, but then the interest rate kept low for a long time before rising. According to principles followed during the Great Moderation, interest rates should have returned much sooner to the neutral level. Thus big deviations were formed during this period. Taylor (2010) states that the low interest rate contributed to the appreciation of housing price. In Taylor (2007), he built a model to test the connection between the low interest rates and housing boom. The results showed that a higher federal funds rate would reduce much of the boom in housing price.

Start from early 2000s, the policy rates have been globally below the rate prescribed by the Taylor rule. From Bernanke (2010) speech, we can find that countries like the US, Canada, Greece, Spain, Ireland and Italy deviated from Taylor rule prescriptions for more than 2 percent. Other developed countries like the UK, Australia, Germany and Japan did not deviate much from Taylor rule prescriptions, but their economies were still heavily hit by the 2008 crisis. There is no doubt that when the US economy goes into recession, these countries closely connecting with the US economy will go into recession too. According to Kahn's (2010) view, a persistent low level of policy rate would potentially form a strong incentive to purchase assets through short-term borrowing among investors. Moreover, it might increase the leverage ratio, risk-taking and speculation among different financial markets. Systematically, this may lead to assets prices and other financial variables deviating from their long-term historical trends persistently. This is the so-called financial imbalance. White (2006) illustrates the opinion in the BIS Working Papers that the modern financial system is inherently procyclical. For example, after a recession, the government might choose a relative low level of policy rate to recover the economy. As a result, the leverage ratio, risk taking and speculation among financial markets may increase. Under this situation, a piece of good news could boost optimism among investors. Thus, it is quite easy to form a bubble in financial markets. Eventually, the bubble bursts, while the economy falls into the recession again. Kahn (2010) estimates the relationships between the deviation of the actual federal funds rate from the prescription of Taylor rule and the financial indicators including changes in the S&P tech stock price index, the house price-to-rent ratio, the broker-dealer leverage ratio and changes in the commodity price index. In his estimation positive deviations mean the actual policy rate is higher than the prescribed rate, vice versa. The results show that except the changes in the S&P tech stock price index, other three financial indicators show an inverse relationship between Taylor rule deviations. Despite the fact that the relationship between the tech stock prices and Taylor rules deviation is positive rather than inverse, we still can broadly conclude that Taylor rule deviations contribute to

the financial imbalances in some degree. Therefore, is our monetary policy that only focuses on inflation and real output contribute to this procyclical financial system? Some economists suggest that monetary policy should not only concern about inflation and real output but also need to do something to prevent the bubbles or crises. But Taylor (2010) argues that monetary policy during the Great Moderation did not take actions to prevent bubbles and the economy developed quite well with stable inflation rate and stable real GDP growth rate. Bullard and Schaling (2002) state that if we try to use monetary policy to pop bubbles, the harm may be more than good.

2.3 Against Judging Taylor Rule Deviations as the Core Causation of a Bubble in House Prices

As mentioned above, some economists such as George Kahn and John Taylor claimed that the too accommodative monetary policy by the Federal Reserve was a key causation of the house prices bubble in 2008. In contrast, others stated the opposite opinions that monetary policy during the past decade was appropriate under those economic situations, and that judging monetary policy as a main cause of housing bubble was lack of a comprehensive principle. Bernanke (2010) explains why monetary policy from 2002 to 2006 was appropriate given that period's macroeconomic conditions. After the end of recession caused by Internet bubble, the US economy's recovery was very weak and slow. Considering the high rate of unemployment, a relative low policy rate was needed to boost real gross domestic product, and then to halt the increase in unemployment rate. Another factor the Federal Reserve concerned about was a possible deflation after the recession. In order to counter the risk of suffering pains from deflation as Japan, the Federal Reserve needs to lower the policy rate.

Besides explaining the suitability of monetary policy made during 2002 and 2006, Bernanke (2010) presents his doubts about Taylor rule. First, Bernanke points out that the values for the coefficients a and b in the standard form of Taylor rule are not appropriate given some empirical and simulation evidence. In the standard form of Taylor rule, values for a and b are both calibrated to equal 0.5. However, Ball (1997) firstly suggests us that the coefficient for output gap b should be higher than 0.5. Thus, during recessions the recommended policy rate will be lower, given higher value of b. Second, different measurements for inflation gap and out gap will lead to different recommendations. In standard Taylor rule, inflation is measured by CPI index. However, Bernanke (2010) argues that measuring inflation by the price index for personal consumption expenditures (PCE) is more appropriate, because PCE is less influenced by the imputed rent of owner-occupied housing than CPI. Besides inflation, the potential real GDP is hard to measure and does not have a standard principle to measure it in real time. Using different techniques, we may get various potential real GDP that will significantly influence Taylor rule's prescription. Third, the standard Taylor rule measures inflation gap and output gap by using current values rather than forecast values. However, in real time, monetary policy works with a lag, while decisions made to influence next period should base on forecasts for next period rather than current conditions. If the increases in inflation are expected to be temporary, the monetary policy should respond less to them. The results show that the alternative Taylor rule that replaces current values of inflation with forecast values of inflation, prescribes a path for policy rates that is much closer to the actual policy rates than the standard Taylor rule.

Bernanke (2010) also estimates the relationship between monetary policy and house price appreciation. However, the results show that the relationship is statistically insignificant and economically weak. In contrast, the estimation about the relationship between capital inflows from emerging markets to industrial countries and house price appreciation shows both statistically and economically significant. Besides capital inflows, Bernanke (2010) illustrates that the increasing use of more exotic types of mortgages and a lack of financial regulation and supervision are main factors contributing the housing bubble.

2.4 Potential Explanations for the Global Deviation From the Taylor Rule

Hofmann (2012) concludes several explanations for the global deviation from the Taylor rule since early 2000. An asymmetric response between financial busts and financial booms may lead to the Taylor rule deviation. In core advanced economy monetary policy will make adjustments when financial busts occur. However, it will only respond to financial booms that are associated with perceived risks. Start from early 2000, policy rates in core-advanced economies fell dramatically due to the recession. Whereas when the economy started recovering, little responses were made.

Unwelcome capital inflows from emerging market economies may cause core-advanced economies lowering their policy rates. Such as the US, Bernanke (2010) argues that capital inflows from developing countries in the US soared from 2000 to 2008. Once the US lowers the interest rate, other advanced economies and emerging market economies need to avoid the risk of large exchange rate movements, so they will tie policy rates to those prevailing in core advanced economies.

There are some factors that may drive the long-run real interest rates below the expected growth trends. High saving rates and fast development of financial markets in emerging market economies such as China may cause

this phenomenon. Furthermore, the high capital assets price risk originated from the boom-bubble-recession cycle in the US since the late 1990s may also drive down the long-run real interest rates.

3. Taylor Rule Calibration

3.1 Taylor Rule Equations

This article calibrates four versions of Taylor rule and compares prescriptive rates with the actual funds rates. The Taylor rule's general form is:

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

where i_t represents the target short-term nominal interest rate that is the federal funds rate in the US or the Bank of England base rate in the UK; rr^* represents the equilibrium real interest rate; π_t represents the inflation rate in time period t; π^* is the target long-run inflation rate; y_t is the logarithm of real GDP; y_t^* represents the logarithm of real potential GDP; β and γ are coefficients for inflation gap and output gap. There are many versions of Taylor rule differing from the value of the equilibrium real interest rate and the values for parameters β and γ. In all specifications of Taylor rule, the target long-run inflation rate π^* is assumed equal to 2 percent at annual rate. This article will use following four versions of Taylor rule:

	rr^*	β	γ
Taylor rule 1	2	0.5	0.5
Taylor rule 2	2	0.5	1.0
Taylor rule 3	2.5	0.5	1.0
Taylor rule 4	2.5	0.5	0.5

Taylor rule 1 is the original version of Taylor rule that John Taylor introduced in his article in 1993. This version of Taylor rule places equal weights for inflation gap and output gap. However, according to the empirical evidences, it suggests that the coefficient for output gap should be higher than that for inflation gap. So Ball (1997) proposes the Taylor rule 2 that the coefficient for output gap is 1.0 while the coefficient for inflation gap is 0.5. Afterwards, Taylor (1999) also modifies the coefficient of output gap to 1.0. Meyer (2009) uses a rule with an equilibrium real interest rate of 2.5 percent. Thus Taylor rule 3 increases the value of equilibrium real interest rate to 2.5 percent and remains the changes for coefficients in Taylor rule 2. Taylor rule 4 only increases the equilibrium real interest rate to 2.5 percent based on the original Taylor rule. According to the Taylor rule equations, we can find that if the inflation rate is above the target rate, the nominal interest rate increases more than 1 percent when the inflation rate increases 1 percent. It helps to effectively reduce the inflationary pressures when the inflation rate is high. Besides, this rule helps to anchor the inflation expectations at the target rate in the long run.

3.2 Calibration of Taylor Rule in the US

This article calibrates the inflation rate for the US by using CPI index and PCE index. Because Bernanke (2010) argues that PCE is less influenced by the imputed rent of owner-occupied housing than CPI. The inflation rate in period t is measured as the 4-quarter rate of change from period $t-1$ to period t in the CPI index. The measurement is the same when using the PCE index. The output gap is measured by using the log ratio of the real GDP to the potential real GDP. The data used in the estimations is the seasonally adjusted data.
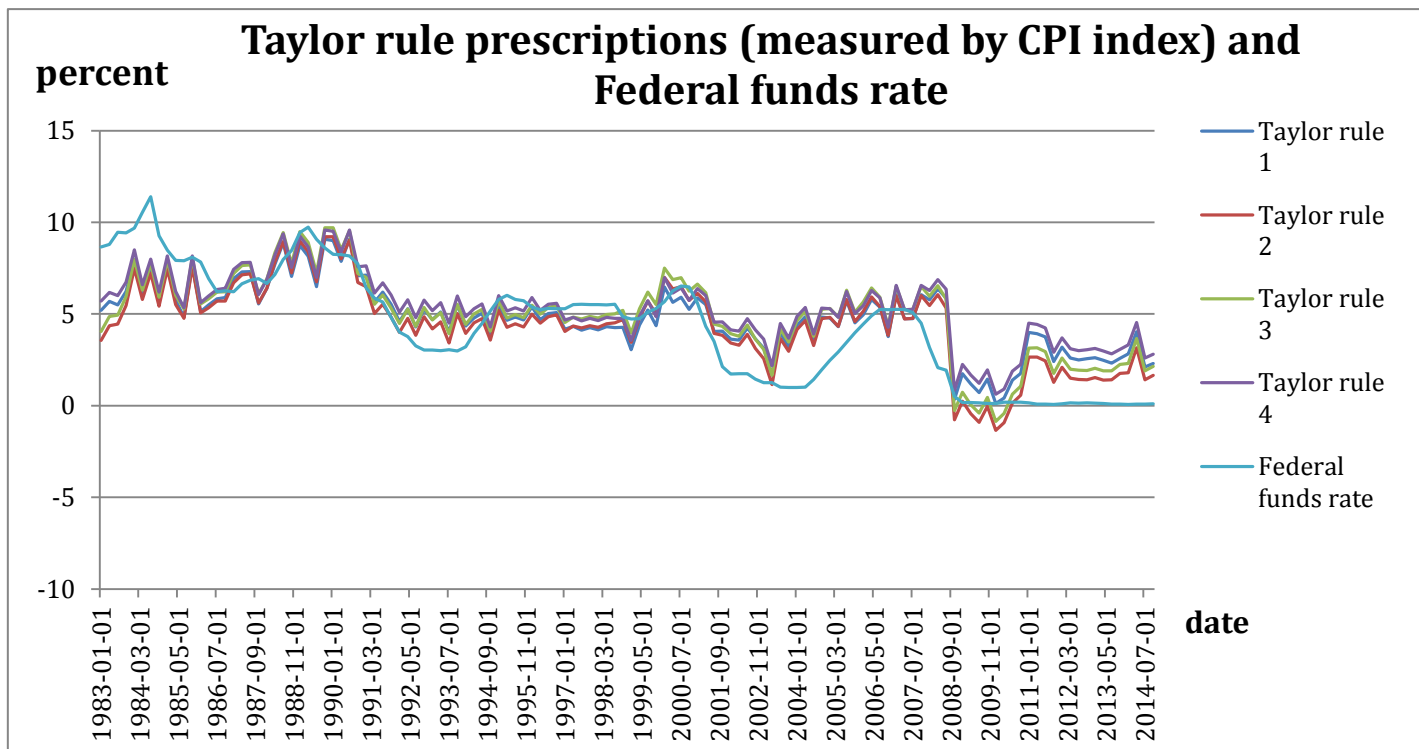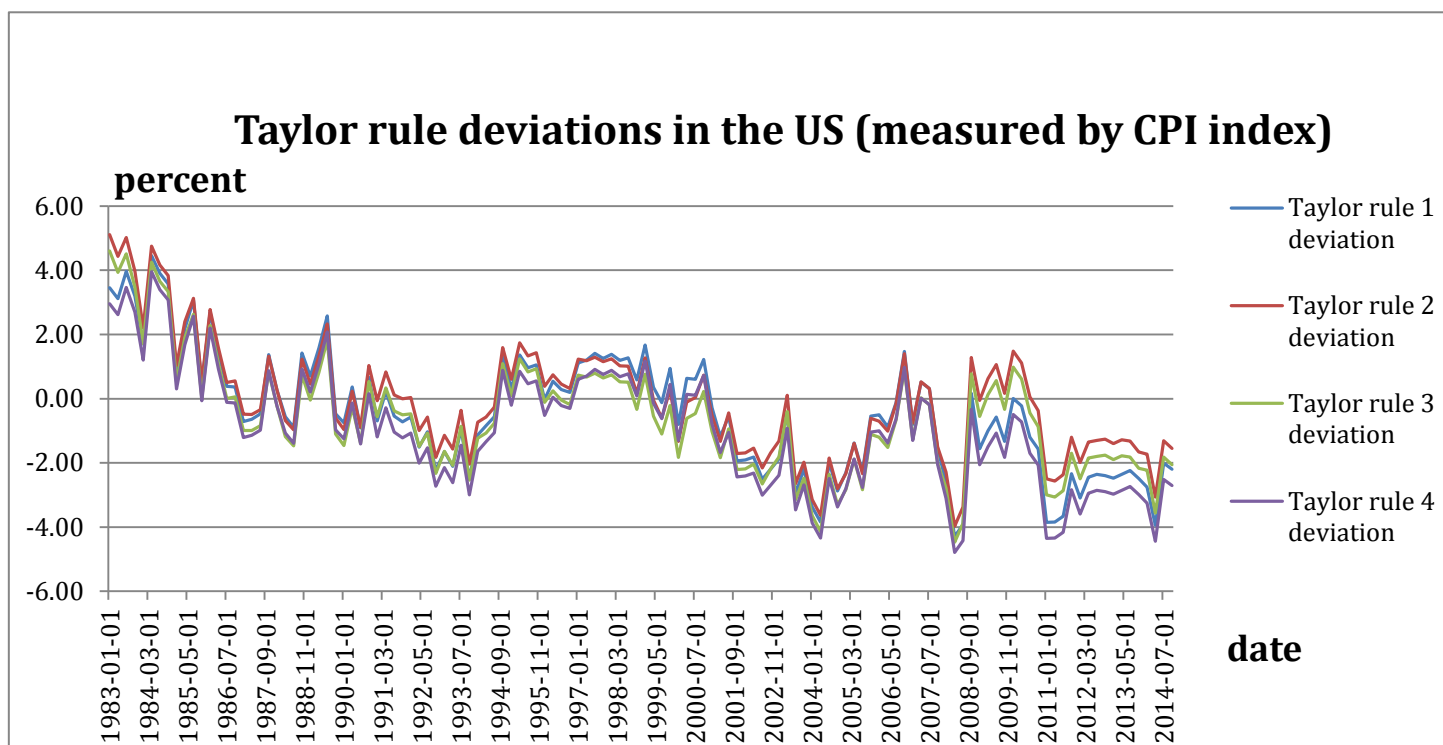
Taylor rule prescriptions (measured by CPI index) and Federal funds rate

Chart 1

Taylor rule deviations in the US (measured by CPI index)

Chart 2

the US real GDP growth rate

Chart 3
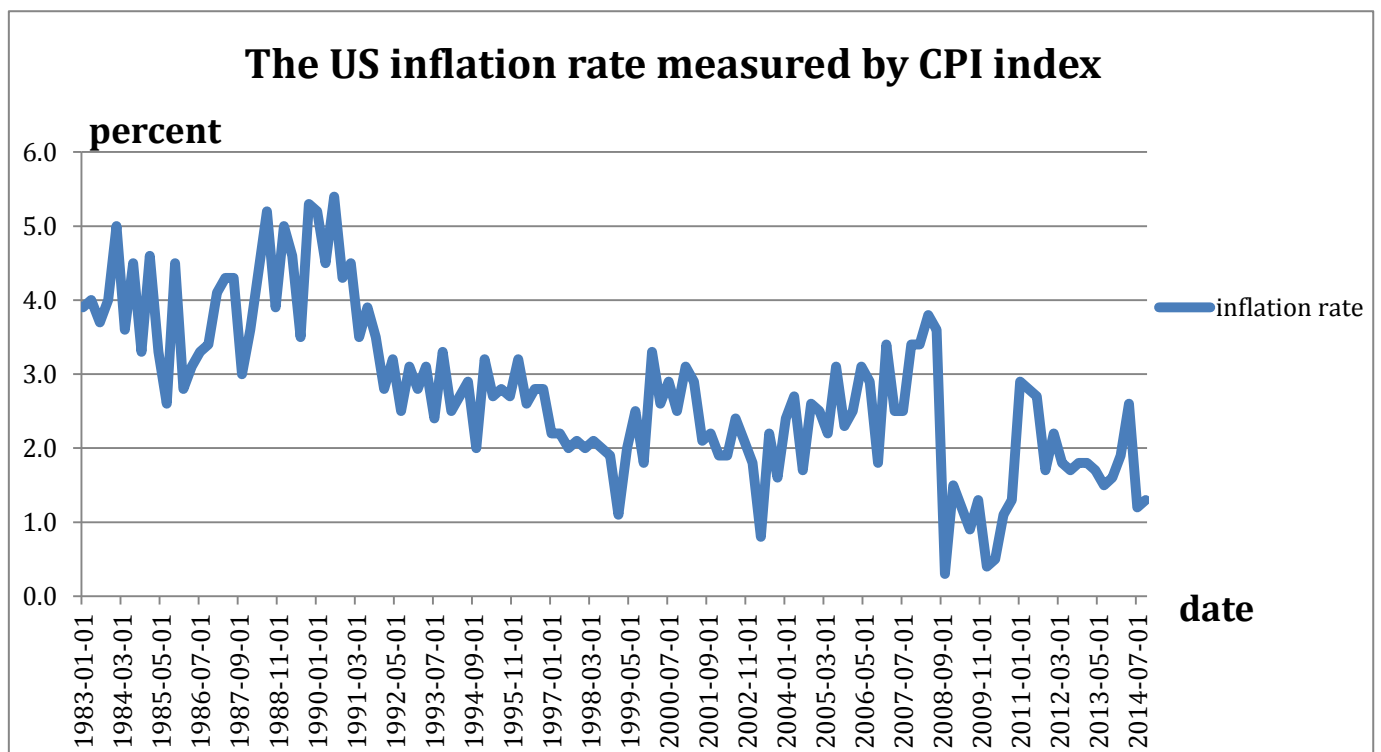
The US inflation rate measured by CPI index

Chart 4

Chart 1 shows four versions of Taylor rule prescriptions and the actual federal funds rate from 1983 to 2014. As shown in the chart, the actual federal funds rate's path closely matches the Taylor rule prescriptions from mid

1980s until the late 1990s. While during 1990 to 1993, there was a very small deviation from the Taylor rule prescriptions, but this deviation was temporary, not lasting too long. From the fourth quarter in 1993, the federal funds rate started getting back on the track of Taylor rule prescriptions. As shown in chart 3, the US economy developed quite well from mid 1980s to 2000 with stable real GDP growth rate. During this period, the growth rate was average at approximate 4 percent at annual rate. From late 1990, the real GDP turned up a negative growth rate. This is due to the 1990 oil price shock arisen from Iraqi invasion of Kuwait. Then the oil price surged around 50 percent. Consequently, the price level increased 1 percent so did the inflation rate at that time. The increase of price level could potentially lower the real GDP. As is well known, monetary policy should tighten when the price level soars in order to reduce the inflationary pressure and to keep the stability of the economy. However, Federal Reserve did not decide to raise the federal funds rate and chose to maintain the interest rate in 1990. From 1991 to 1993, Federal Reverse lowered the funds rates, which were more or less matched Taylor rule prescriptions in spite of very small deviations. As a result, the real GDP growth rate recovered since the end of 1990. As for the inflation rate showed in chart 4, it was controlled at approximate 2.5 percent during this period. Thus, we can regard this period's monetary policy as a success and this short time deviation as an appropriate adjustment for unusual economy conditions. Because during this period, monetary policy broadly followed Taylor rule prescriptions, so we can conclude that Taylor rule is a suitable and useful guideline for monetary policy decisions, to some degree. However, from 2000 to 2014, the actual federal funds rate fell dramatically and frequently below the prescriptive funds rates of all versions of estimation. Here we define Taylor rule deviations as the actual interest rates minus Taylor rule prescriptive rates. As shown in chart 2, deviations from Taylor rule were persistent from 2000 until the burst of 2008 subprime mortgage crisis. During this period, the average deviation from Taylor rule prescriptions was around two percentage points. Despite the fact that the development of economy is good with stable inflation rate at approximate 2.5 percent during this period, we can find that the real GDP growth rate was average 2 percent, which was lower than the Great Moderation period's average 4 percent. We could not find evidence to support that it is due to deviations from Taylor rule prescriptions, but as mentioned before keeping policy rates too low for too long time may cause a build-up of financial imbalances. In this scenario, it is the housing price bubble. The cut of federal funds rate in 2000 was reasonable, because it was necessary for the recovery from recession cause by burst of Internet bubble in 2000. However, Taylor rule recommends the policy rate should be raised in 2003. Actually, Federal Reserve kept the low funds rate for one more year and started raising the funds rate in 2004. Moreover, the path of increase in federal funds rate is slower than the path of Taylor rule prescriptions from 2004 to late 2006. There is a potential space for investors and financial intermediaries to increase the risk taking and speculations because of the low interest rate persisting for a long time. We will discuss this topic in details later. One explanation mentioned in Taylor (2008) for such low funds rate from 2000 to 2004 is the global factors, which are out control of monetary policy. It argues that there is a global saving glut, which drove down the interest rate not only in the US but also other countries. The Federal Open Market Committee (FOMC) explained the low interest rate for two reasons. First, it was concern about the high rate of unemployment in 2003 and sluggish real GDP growth rate. Second, there was a potential for unwelcome deflation during that period. In order to avoid the same painful episode as Japan, the FOMC cut the federal funds rate to a very low point to counter the risk of deflation. Till 2008, the federal funds rate got back to the track of Taylor rule prescriptions. However, this did not last long, which was only two years. Start from 2011, Taylor rule recommends to raising the interest rate. Whereas, the FOMC has been keeping the low funds rate till now. According to Kahn's (2010) viewpoint, the liberalized financial system is a procyclical system, which may create a boom and burst cycle. A piece of good news can be over emphasized under the low interest rate environment. As a result, the optimism will prevalent among investors. Finally, a boom may arise in a specific area, which was Internet in 2000 and housing in 2008. Taylor (2008) argues that if there is no boom, there is no burst. We cannot predict whether there is another bubble in the future, but we need to increase regulations and rethink about the monetary policy decisions in order to avoid the next crisis.

This article also calibrates the four versions of Taylor rule in the US by using personal consumption expenditure (PCE) price index. Chart 5 and chart 6 show the results. The mainly difference between the two results is that the path of Taylor rule prescriptions of PCE index is smoother than that of CPI index. This prove the point proposed by Bernanke in 2010, PCE index is less dominated by the imputed rent of owner-occupied housing. The housing price appreciation during 2002 and 2007 increase this value, thus increasing the inflation rate measured by CPI index. The housing price change will make the change of inflation rate measured by CPI be more frequent than that measured by PCE. Therewith, the deviations of Taylor rule are smaller in this case relatively.
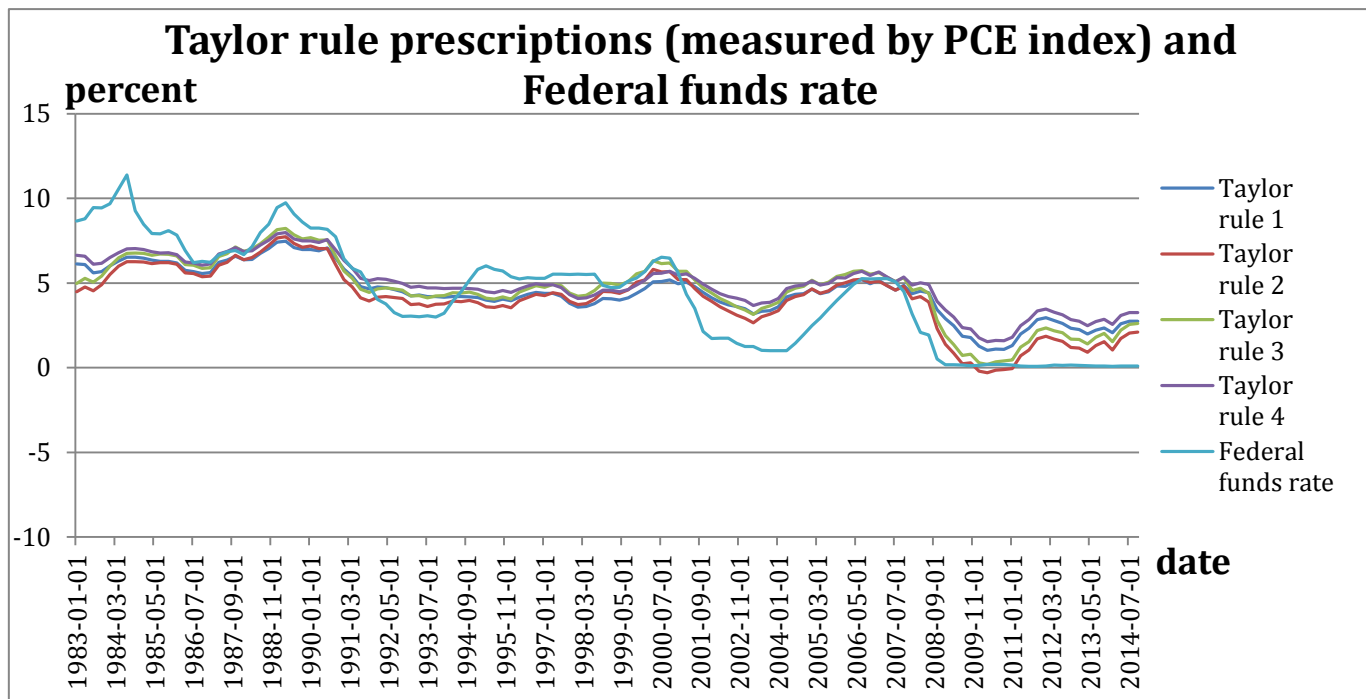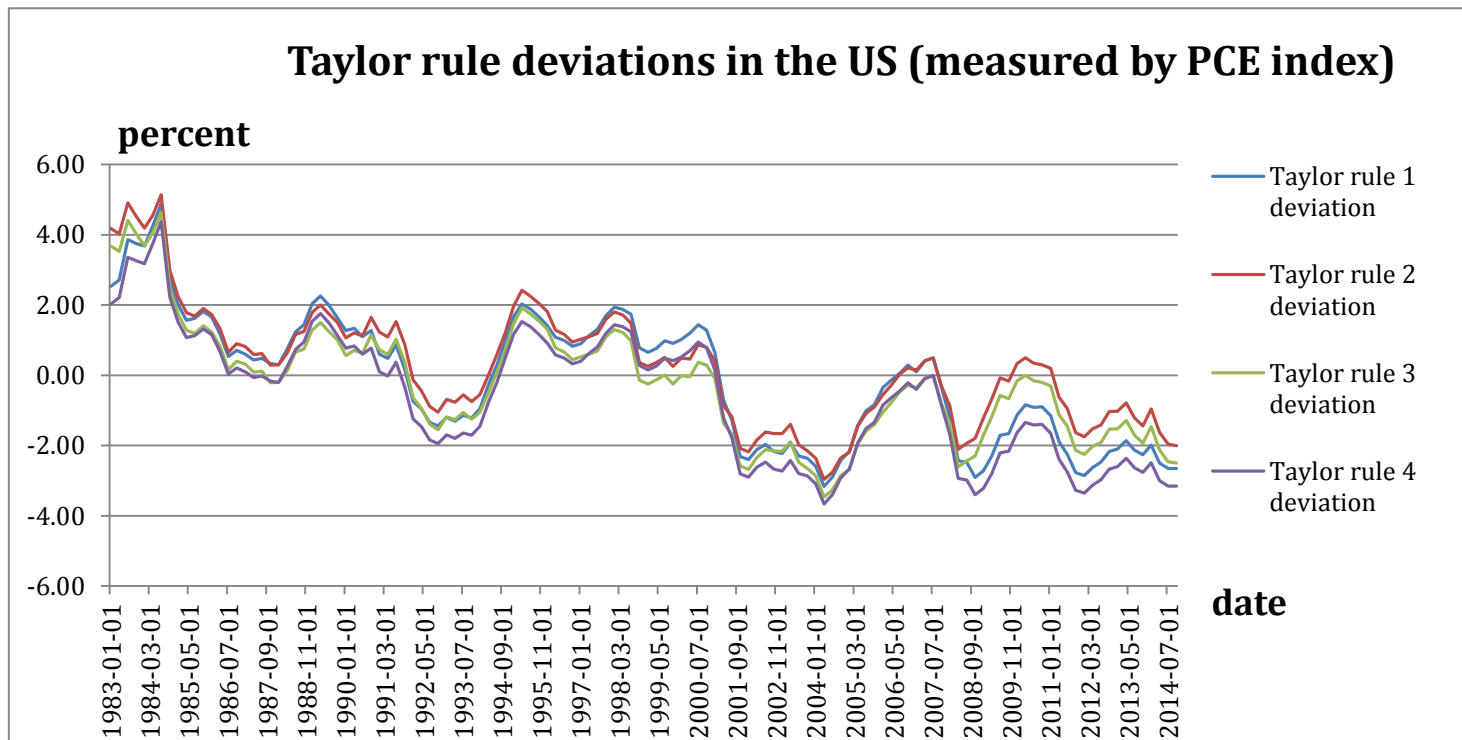
Chart 5

Chart 6

3.3 Calibrations of Taylor Rule in the UK

Because the UK has 2 percent CPI index inflation target, thus this article only uses CPI index to calibrate the four versions of Taylor rule in the UK. The data used is also seasonally adjusted. The measurement of inflation

rate in the UK by using the CPI index is the same as the measurement in the US. The output gap data for UK is from OECD.

Chart 7 shows the results of calibrations of Taylor rule in the UK and the UK official bank rate. From 1991 to 1992, the UK was in the recession mainly originated from the high interest rate, falling of house price and overvalued exchange rate. As shown in chart 7, we can find that from 1992 to 2001, there are also Taylor rule deviations in the UK, but these deviations are opposite to deviations in the US. In other words, in the US the federal funds rate was below the Taylor prescriptions from 2000 to 2008, while in the UK the official bank rate was above Taylor rule prescriptions from 1992 to 2001. During this period, the UK's economy development was good with average 1 percent real GDP growth rate and effectively reducing inflation rate from 7 percent to about 2 percent. In 1997 the Bank of England was eventually given the control over setting interest rate. The government hoped the independent Bank of England could set the interest rate based on long-run goals and use monetary policy to avoid the boom and bust cycles. This can explain the high interest rates for the UK from 1992 to 2001 to some degree. In fact, the results illustrate effects. After 1992, the UK's inflation rate decreased from around 7 percent to 2 percent in 1993 and persisted at approximate 2 percent from 1993 to 2005. Compared with the US, the UK real GDP growth rate from 1993 to 2007 was quite stable with no negative growth rate. Despite the fact that the average real GDP growth rate in the UK is less than that in the US, the Bank of England's monetary policy was successful during this period. Moreover, in 2000 Internet bubble recession, the UK's economy was less influenced by that than the US. This shows the role of an independent monetary policy authority. Start from 2001 to 2007, the UK official bank rate was closely matched Taylor rule prescriptions. In the 2008, the UK also heavily suffered pains from the recession, but it might not be due to the monetary policy. This article will test this later.

To sum up, during period from 1993 to 2007, the Bank of England base rate followed the Taylor rule prescriptions from 2001 to 2007 and the UK's economy developed with low volatility of real GDP growth rate and stable inflation rate at approximate 2 percent. Therefore we may call this period the Great Moderation for the UK.
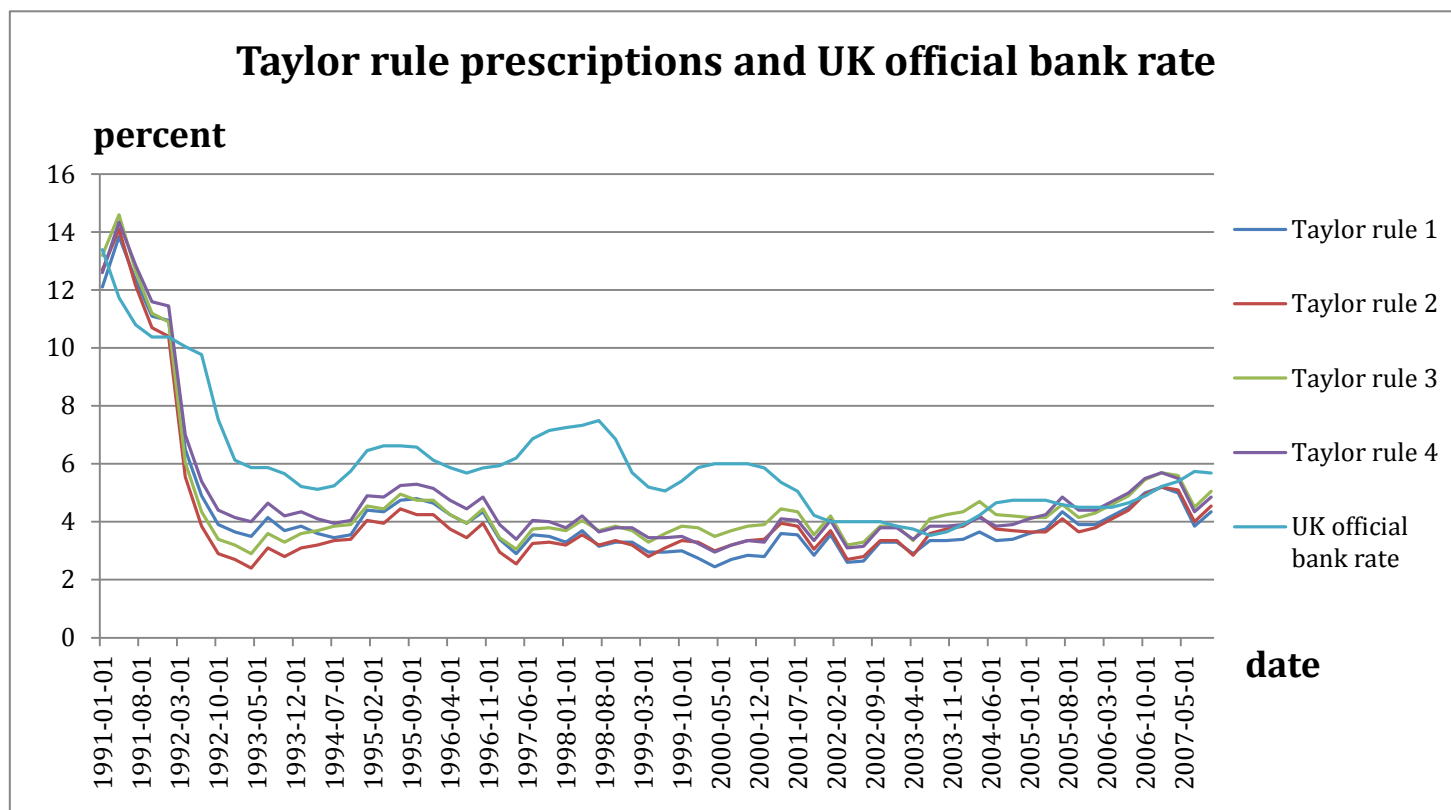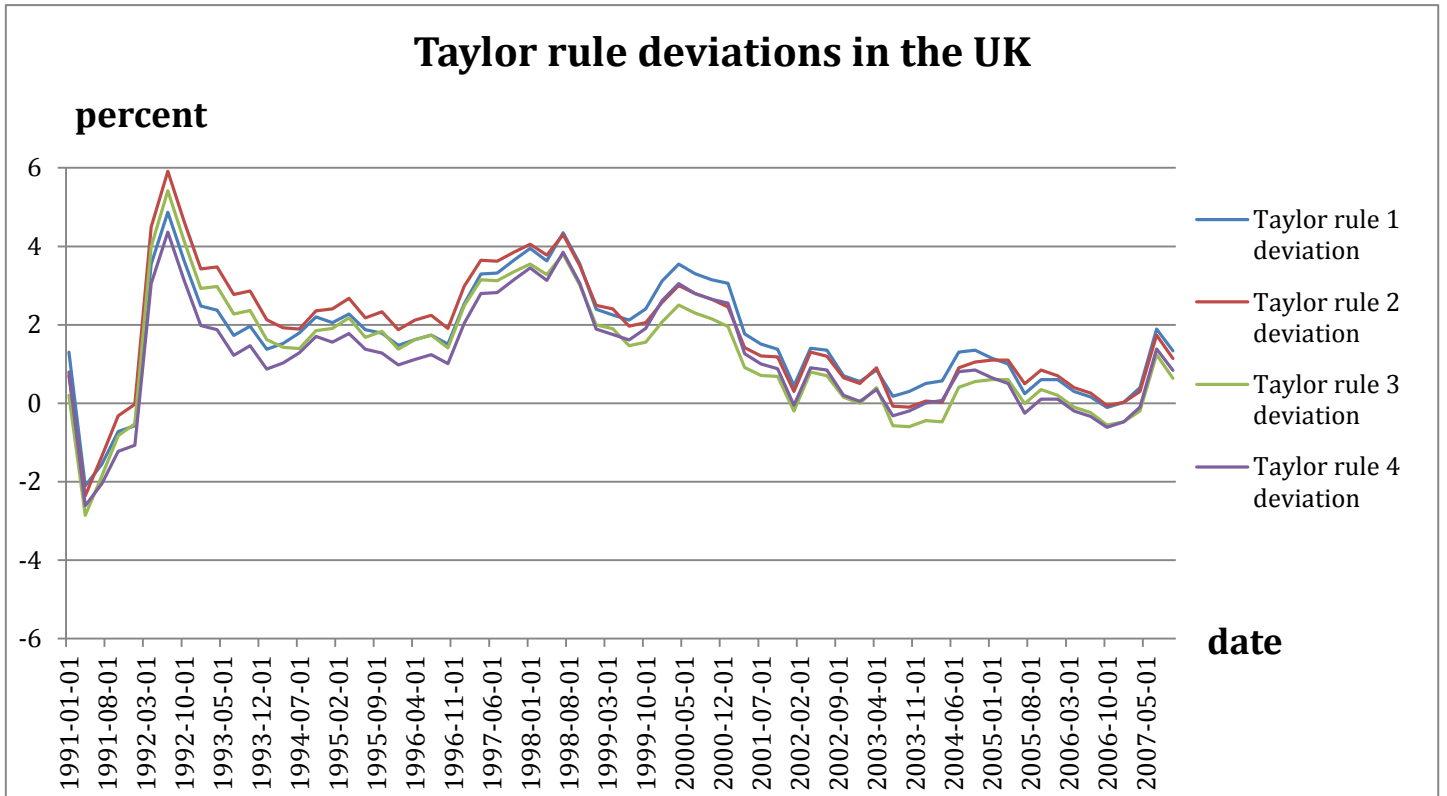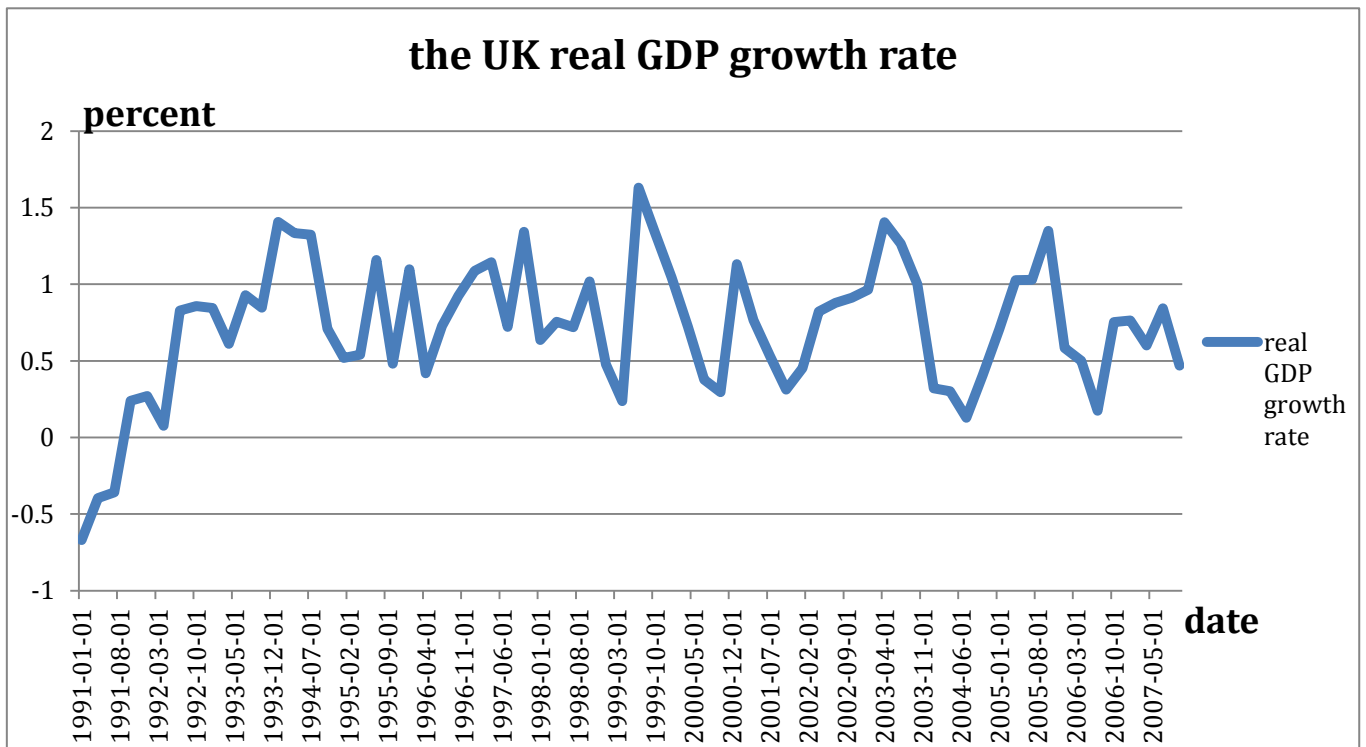

Chart 7

Taylor rule deviations in the UK

Chart 8

the UK real GDP growth rate

Chart 9

the UK inflation rate measured by CPI index

percent

[Chart: line graph titled "the UK inflation rate measured by CPI index" showing inflation rate on y-axis (percent, 0.0 to 9.0) and date on x-axis (1991-01-01 to 2007-09-01). Legend: inflation rate]
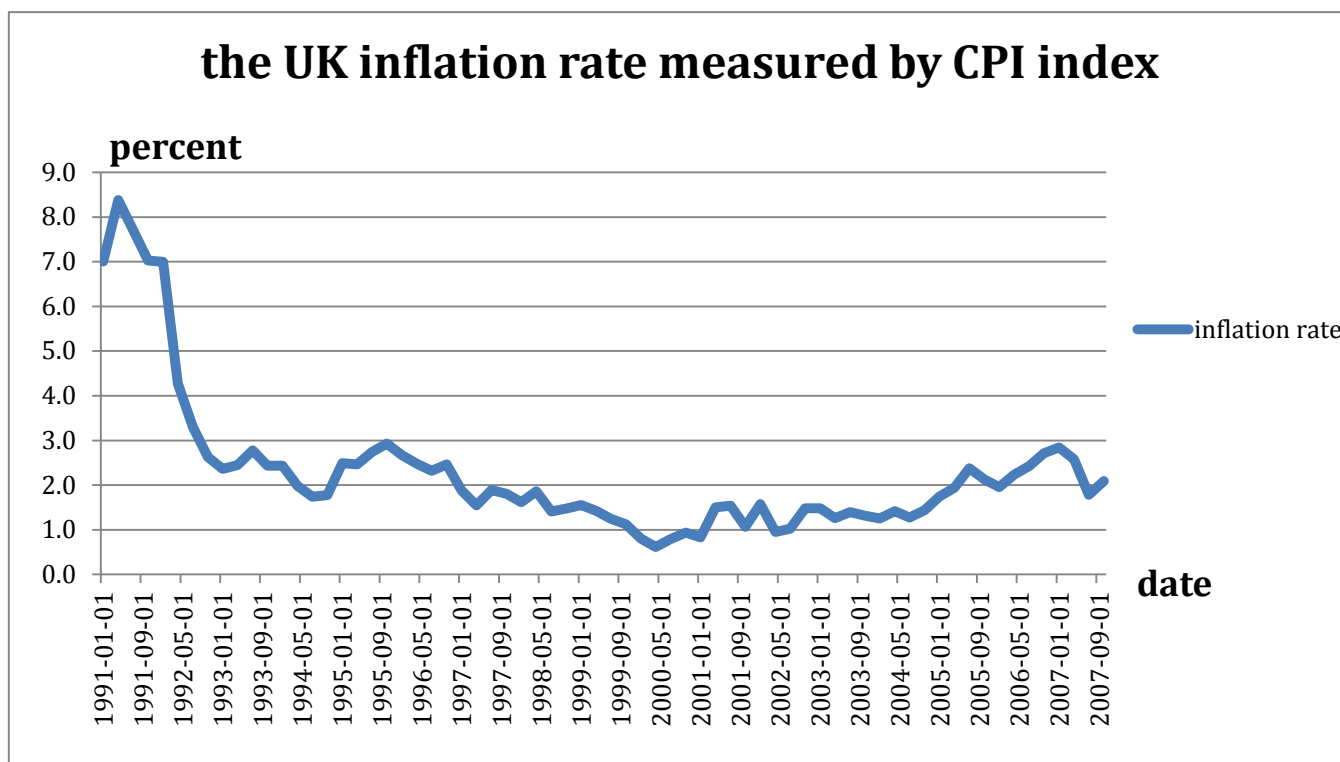
Chart 10

4. Estimate Relationship Between Taylor Rule Deviations and Financial Indicators

4.1 Introduction About the Regression Model and Financial Indicators to Be Estimated

In this chapter, the article wants to test whether deviations from Taylor rule contribute to financial imbalances. In order to test the significance between them, we need to choose some appropriate financial indicators.

Stock price index is a good indicator for testing the financial imbalances. Because of low federal funs rates from 2000, a one-way bet prevailed among investors. Thus it may cause the boom in assets prices. The recent 2008 recession is the most obvious example of boom and bust cycle under low interest rate environment. So housing price is an important financial indicator to be estimated. Then the high level of leverage ratio also brings huge financial risks. It may cause the liquidity problems and default risks. Finally, the commodity market also experienced great volatility in the past decade. It also reflects financial imbalances in some degree.

The regression model to be used in the estimation is the same as Kahn (2010):

$$A_{it} = Constant + a_i\sum_{j=1}^{4}TR_{t-j} + b_i\sum_{j=1}^{4}TRDEV_{t-j} + \mathcal{E}_t$$

where A_{it} represents the asset price or financial indicator i in quarter t; TR_{t-j} represents the Taylor rule prescription in quarter $t-j$; $TRDEV_{t-j}$ represents the deviation of the policy rate from the Taylor rule prescription in quarter $t-j$; and $Constant$, a_i, b_i are parameters to be estimated. Finally, $\mathcal{E}_t$ represents the regression residual. Because monetary policy works with a lag, the lagged value of Taylor rule prescriptions and deviations from Taylor rule prescriptions are chosen to test whether they have effects on assets prices and financial indicators. A number of economists complain that keeping the interest rate too low for too long time cause the financial bubbles. Therefore this article adds values of Taylor rule prescriptions and deviation from Taylor rule prescriptions in previous four quarters to estimate their effects on financial indicators in current quarter.

For the US, the data for indicator of total share prices for all shares in all stock markets for the United States from OECD is chosen to estimate in stock price sector. All-transactions house price index for the United States from US Federal Housing Finance Agency is used in housing price sector. The indicator of total credit market debt owed by domestic financial sectors from FRED is used in leverage part. Finally, producer price index for all commodities from US Bureau of Labor Statistics is chosen in commodity part.

As for the UK, the indicator of stock price is the same as the US, which is all share prices for all shares in all stock markets for the United Kingdom from OECD. Housing price indicator is residential property prices for United Kingdom from Bank for International Settlements. And the indicator of "amount outstanding of total debt securities for residence of issuer in United Kingdom" from Bank for International Settlements is used in leverage sector. Finally, this article chooses data of crude oil prices: Brent-Europe from US. Energy Information Administration to estimate in the commodity part. Thereby, comparing results we can find whether oil price is less dominated by interest rates than other raw materials.

4.2 Estimation Results for the US

This article uses ordinary least square (OLS) to estimate the coefficients between financial indicators and deviations from Taylor rule prescriptions as well as Taylor rule prescriptions. In this article, only Taylor rule 1 prescriptions and deviations are used in this part. Results are mixed, except stock price indicator, other three indicators show inverse relationships between Taylor rule deviations. This means that if the policy rate is below the Taylor rule prescriptions, assets prices or financial indicators will increase. As for the stock price indicator, the coefficient is very low, so we cannot conclude any relationship between stock prices and Taylor rule deviations. The following table shows the estimation result for the US.

	Share price	Housing price	Leverage	Commodity
$\sum_{j=1}^{4} TR_{t-j}$ Coefficient	-0.206533	-4.995050	3.826197	-3.054746
$\sum_{j=1}^{4} TRDEV_{t-j}$ Coefficient	0.272567	-5.753014	-5.330316	-1.680133
$\sum_{j=1}^{4} TR_{t-j}$ Stand Error	0.121450	1.089674	1.619714	0.379209
$\sum_{j=1}^{4} TRDEV_{t-j}$ Stand Error	0.107497	0.964485	1.433631	0.335643
$\sum_{j=1}^{4} TR_{t-j}$ t-Statistic	-1.700562	-4.583988	2.362267	-8.055582
$\sum_{j=1}^{4} TRDEV_{t-j}$ t-Statistic	2.535574	-5.964856	-3.718052	-5.005720
R-squared	0.052690	0.532601	0.106093	0.638229
Observations	120	120	120	120

We need to compare each result's t-Statistic value with critical values for the t distribution. In this case we choose 1, 5 and 10 percent significance level. The following table shows the result of significance.

	1 percent significance level	5 percent significance level	10 percent significance level
Share price result of $\sum_{j=1}^{4} TR_{t-j}$	Insignificant	Insignificant	Significant
Share price result of $\sum_{j=1}^{4} TRDEV_{t-j}$	Insignificant	Significant	Significant
Housing price result of $\sum_{j=1}^{4} TR_{t-j}$	Significant	Significant	Significant
Housing price result of $\sum_{j=1}^{4} TRDEV_{t-j}$	Significant	Significant	Significant
Leverage result of $\sum_{j=1}^{4} TR_{t-j}$	Insignificant	Significant	Significant
Leverage result of $\sum_{j=1}^{4} TRDEV_{t-j}$	Significant	Significant	Significant
Commodity result of $\sum_{j=1}^{4} TR_{t-j}$	Significant	Significant	Significant
Commodity result of $\sum_{j=1}^{4} TRDEV_{t-j}$	Significant	Significant	Significant

Despite the fact that the relationship between stock price and Taylor rule deviations is indistinct, we still can broadly conclude that Taylor rule deviations contribute to financial imbalances in some degree. The results are consistent with Khan (2010) and Taylor's (2008) conclusions. However, we do not deny Bernanke's (2010) point that the increase in global savings and unwelcome capital inflows cause the housing price appreciation. What I want to state is, though in 2008 the crisis was arisen from subprime mortgage and housing bubble, the financial imbalances in other sectors cannot be ignored. Even if the crisis does not burst in 2008, there might be the possibility that other financial imbalances will burst at a given time in the future.

4.3 Estimation Results for the UK

The results of estimation for the UK are more or less the same as the US. Except stock price indicator, other three indicators show inverse relationships between Taylor rule deviations. The following table will show results for the UK estimations.

	Share price	Housing price	Leverage	Commodity
$\sum_{j=1}^{4} TR_{t-j}$ Coefficient	0.085228	-2.028848	-14.09390	-0.981195
$\sum_{j=1}^{4} TRDEV_{t-j}$ Coefficient	0.097935	-4.286468	-23.94661	-2.921640
$\sum_{j=1}^{4} TR_{t-j}$ Stand Error	0.100350	0.288479	1.785495	0.257795
$\sum_{j=1}^{4} TRDEV_{t-j}$ Stand Error	0.160460	0.461281	2.855020	0.412216
$\sum_{j=1}^{4} TR_{t-j}$ t-Statistic	0.849309	-7.032904	-7.893552	-3.806108
$\sum_{j=1}^{4} TR_{t-j}$ t-Statistic	0.610340	-9.292533	-8.387545	-7.087643
R-squared	0.012672	0.611602	0.598860	0.453512
Observations	64	64	64	64

For the UK, this article also chooses 1, 5 and 10 percent significance level to test the statistic significant. The following table will show results of significant.

	1 percent significance level	5 percent significance level	10 percent significance level
Share price result of $\sum_{j=1}^{4} TR_{t-j}$	Insignificant	Significant	Significant
Share price result of $\sum_{j=1}^{4} TRDEV_{t-j}$	Insignificant	Significant	Significant
Housing price result of $\sum_{j=1}^{4} TR_{t-j}$	Significant	Significant	Significant
Housing price result of $\sum_{j=1}^{4} TRDEV_{t-j}$	Significant	Significant	Significant
Leverage result of $\sum_{j=1}^{4} TR_{t-j}$	Significant	Significant	Significant
Leverage result of $\sum_{j=1}^{4} TRDEV_{t-j}$	Significant	Significant	Significant
Commodity result of $\sum_{j=1}^{4} TR_{t-j}$	Significant	Significant	Significant
Commodity result of $\sum_{j=1}^{4} TRDEV_{t-j}$	Significant	Significant	Significant

Compared with the US results, we can find that the coefficient between leverage and Taylor rule deviation reaches a very high level -23.94661, which is far higher than that in the US. Thus, the leverage level in the UK is deeply influenced by the policy rate. In other words, a policy rate that is below the Taylor rule prescription for more than 2 percent, will lead the leverage ratio to an undesired high level. As shown in section 3.3, from 1991 to 2007, the average level of Bank of England base rate was higher than Taylor rule prescriptions, which is opposite to the US condition. Then the result still shows a negative coefficient between housing price and Taylor rule deviations in the UK. Thus the two results in both US and UK double demonstrate an inverse relationship between housing price and Taylor rule deviations. Besides these, we can find that the coefficient between crude oil price and Taylor rule deviations is higher than that between producer raw materials and Taylor rule deviations. In other words, crude oil price is more dominated by monetary policy than other commodities. Finally both UK and US state weak relationships between stock price index and Taylor rule deviations.

5. Conclusion

Over the last 30 years, the US monetary policy worked quite well with stable low inflation rate and low volatility of real GDP growth rate until the burst of 2008 subprime mortgage. According to researches, during the Great Moderation period, which started around mid 1980s, the actual federal funds rate was closely matched with Taylor rule prescriptions. Taylor rule is a simple rule prescribes the nominal interest rate based on inflation and output conditions. However, from 2000 to 2008, monetary policy in the US deviated from Taylor rule prescriptions for a long time. Some economists argue that the too accommodative monetary policy, which keeps the interest rate too low for too long time causes the housing price appreciation during 2000 to 2008. In addition, the accommodative monetary policy contributes to a build-up financial imbalance. Besides that, some economists suggests that Federal Reserve monetary policy prolonged the crisis before the final burst and made us miss the appropriate time to adjust the bad condition. Federal Reserve misdiagnosed the problem and took unhelpful strategies during the 2008 crisis.

Other economists argue that the US monetary policy was appropriate given economic conditions during 2000 to 2008. They illustrate that a global saving glut, unwelcome capital inflows from emerging market economies and

high saving rates and fast development of financial markets in developing economies may drive down the interest rate in the core advanced economies.

To research this question, this article collects datum for both the US and the UK including actual interest rates, CPI index, PCE index, real GDP, potential GDP, real GDP growth rates and use these datum to estimate Taylor rule prescriptions for each country. For the US, the result shows that from 1984 to 2000, the actual federal funds rate was more or less closely matched Taylor rule prescriptions. However, from 2000 to till now, the actual federal funds rate was below Taylor rule prescriptions at average approximate 2 percent. From 1984 to 2000, the US real GDP growth rate was stable and at average 4 percent. Start from 2000 until the burst of 2008 financial crisis, the real GDP growth rate was at average 2 percent, which is less than that during the Great Moderation period. From 2008 to 2010, the federal funds rate got back on the track of Taylor rule prescriptions. Thus, the economy started to recover. Nevertheless, the Federal Reserve lowered the funds rate again in 2011.

For the UK, the condition is opposite. In order to counter the high inflation rate during 1990s, the Bank of England chose to set the base rate above Taylor rule prescriptions. Then UK entered its "Great Moderation" with average 2percent of real GDP growth rate and stable 2 percent inflation rate until 2008. In 2008, UK's economy suffered huge damages, whereas it is not due to Bank of England's monetary policy. The so important role of the US in the world economy spread the effects to all over the world when the financial crisis burst.

Then the article estimates the relationships between Taylor rule deviations and financial imbalances for UK and US. The results are more or less the same in UK and US. Housing price, leverage ratio and commodities prices show a inverse relationship between Taylor rule deviations. The relationship between Taylor rule deviations and stock price index is weak.

Finally, the evidence suggests that we should increase financial regulations to avoid toxic investments. For policymakers, they should monitor financial conditions and take appropriate actions when there is a sign of building financial imbalances to avoid boom and burst cycles.

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Appendix 1

Scatter points and regression lines for estimations of the US, where LGSTRDEV represents lagged sum of Taylor rule deviations.
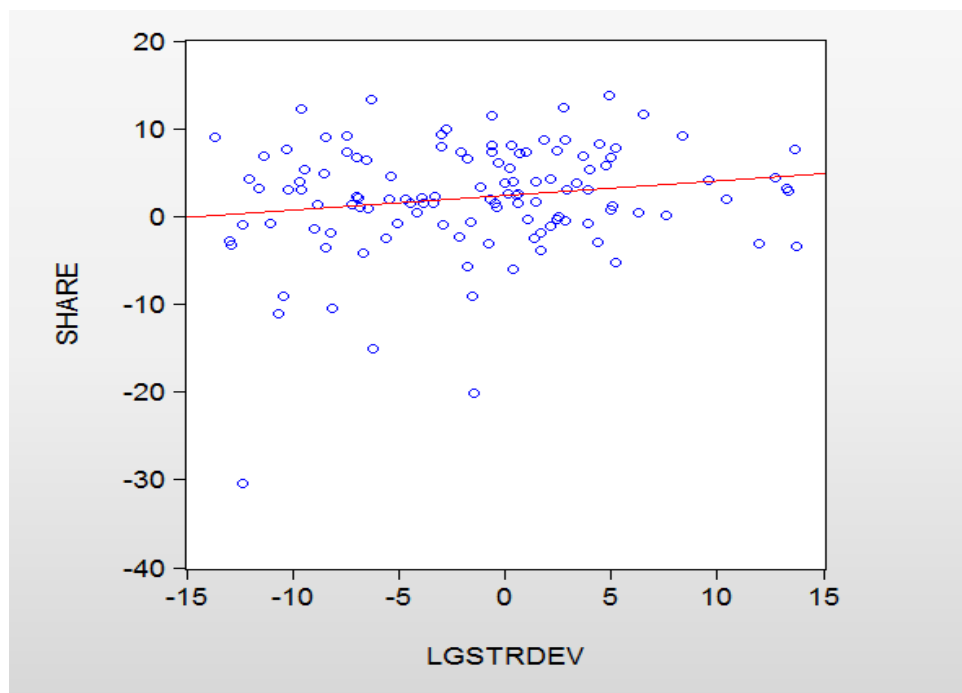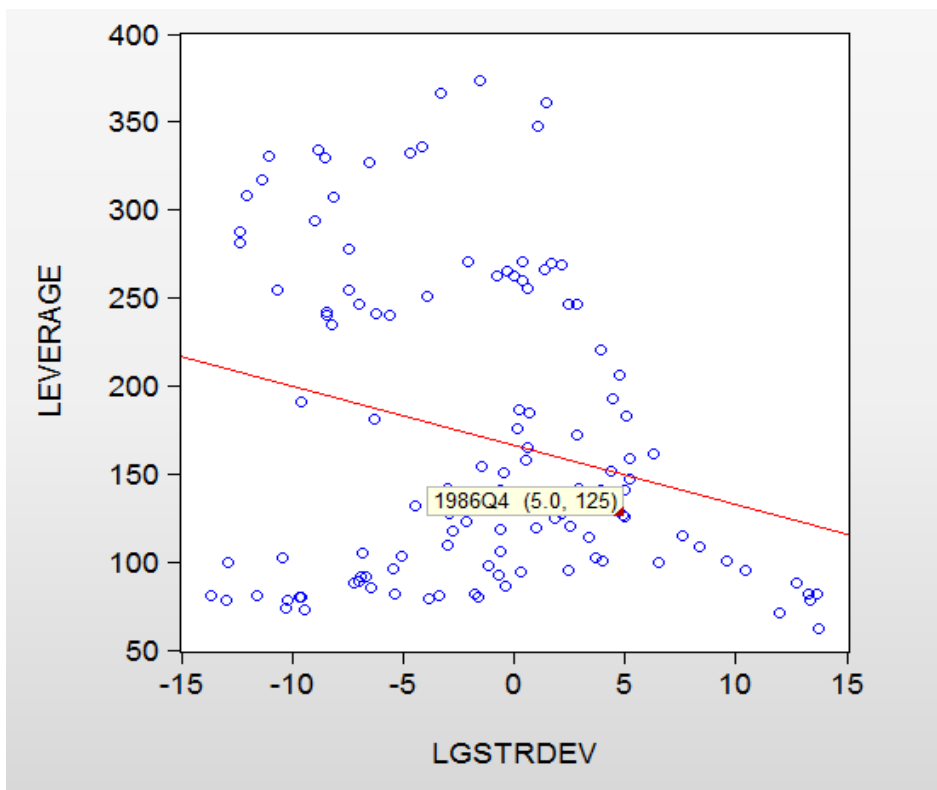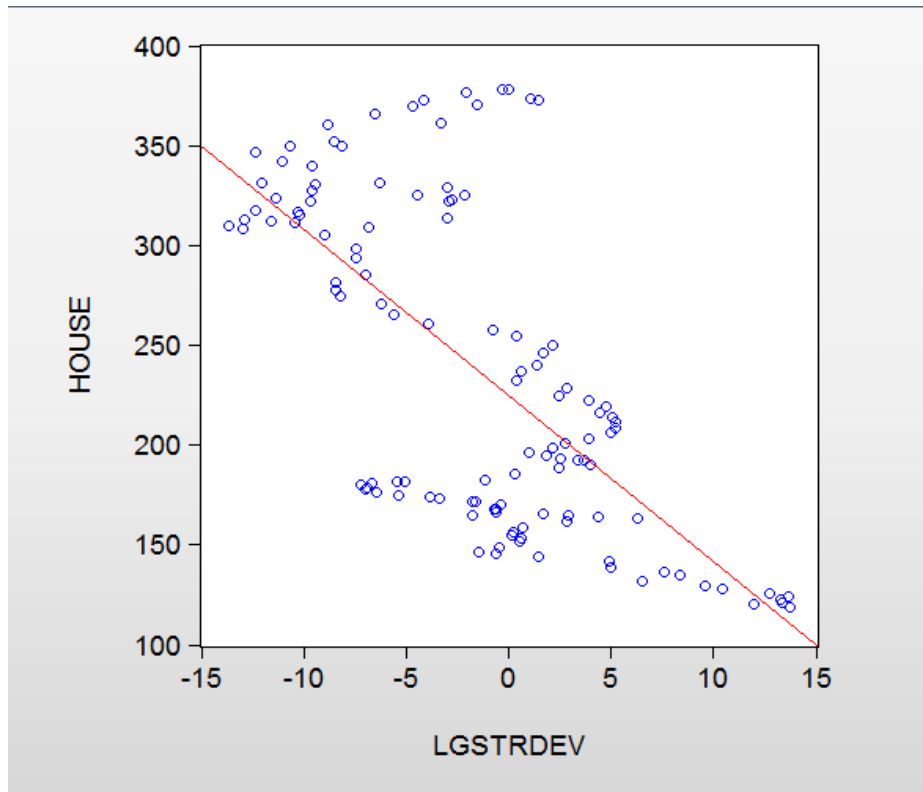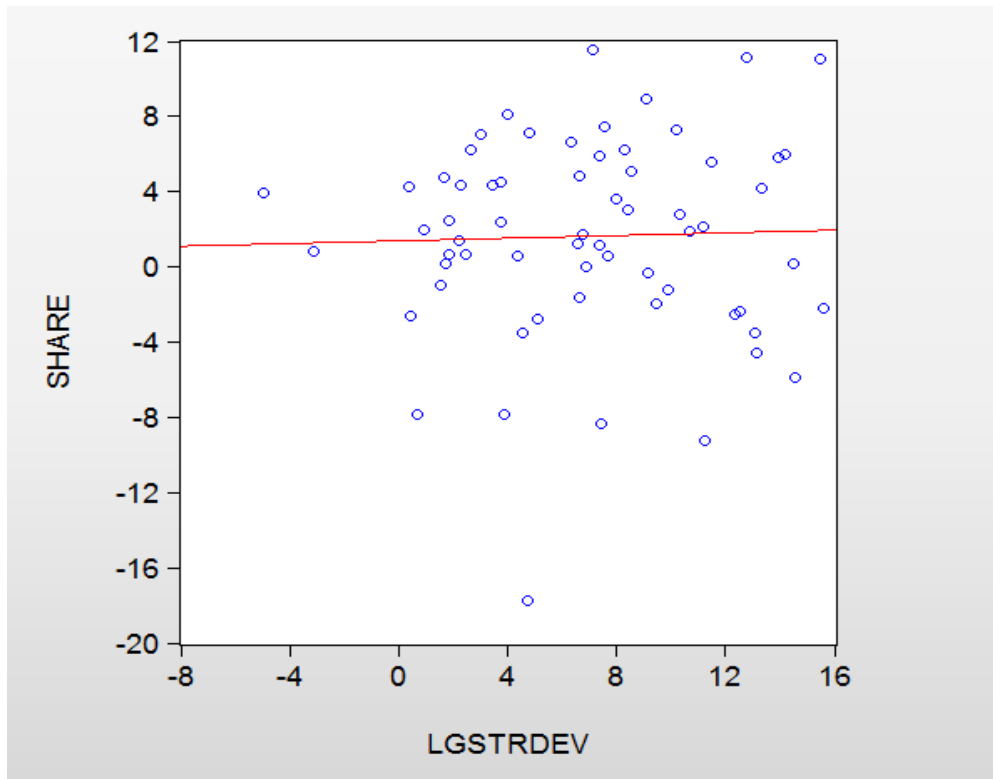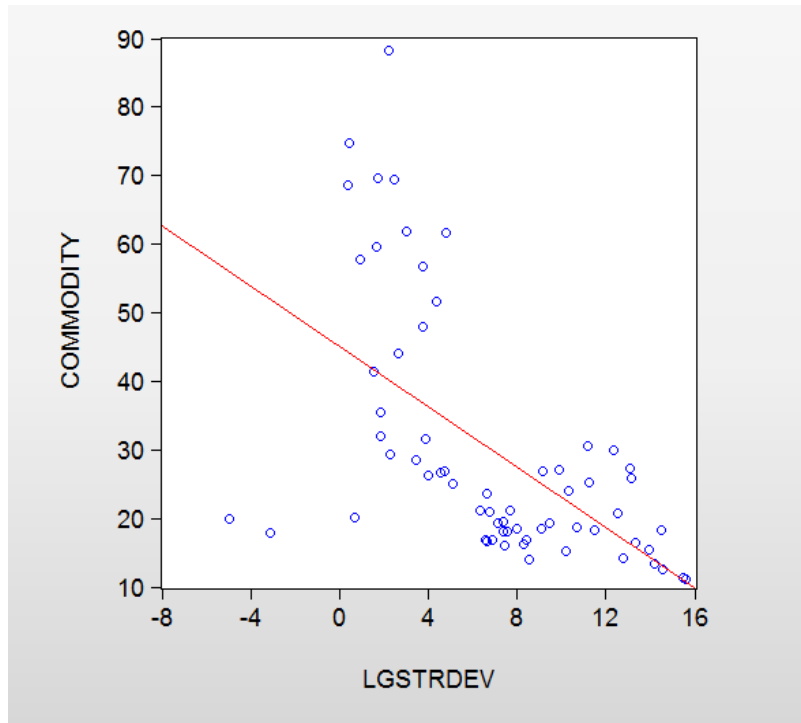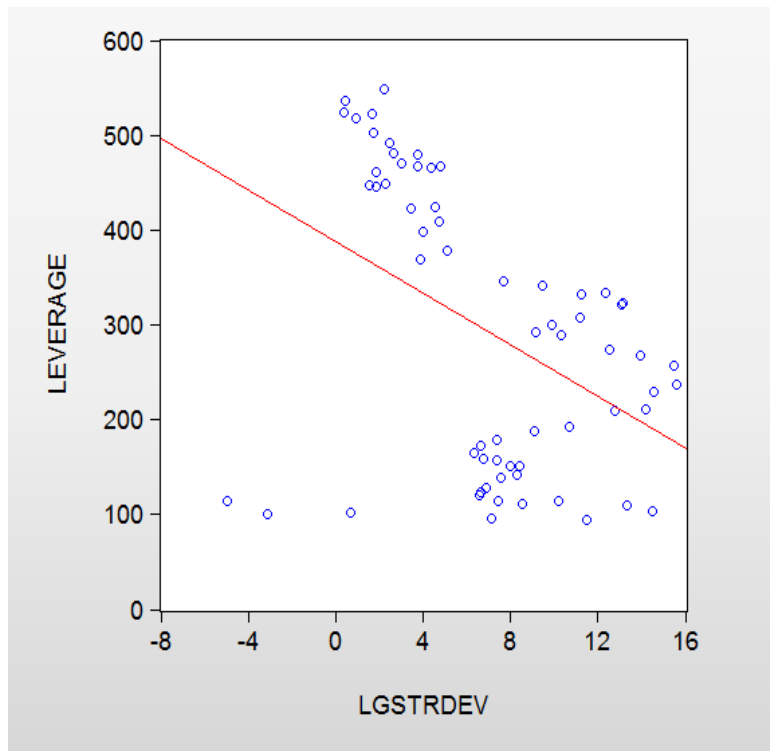
Appendix 2

Scatter points and regression lines for estimations of the UK, where LGSTRDEV represents lagged sum of Taylor rule deviations
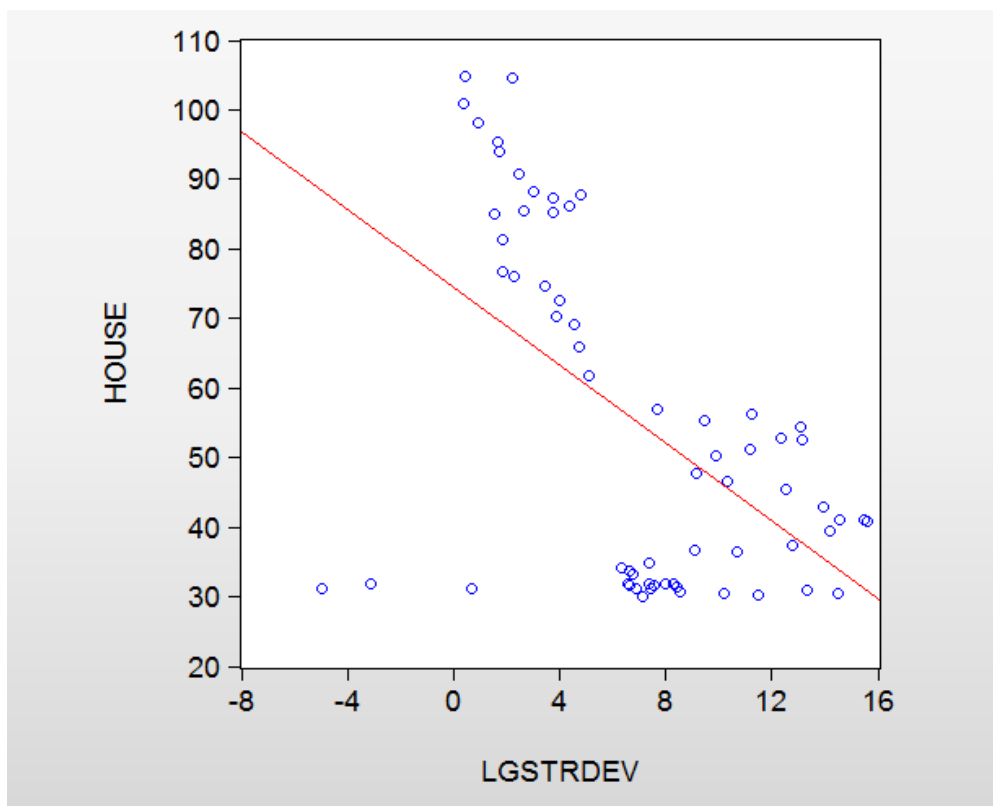
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