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How Are Inflation Expectations Formed by Consumers, Economists and the Financial Market?

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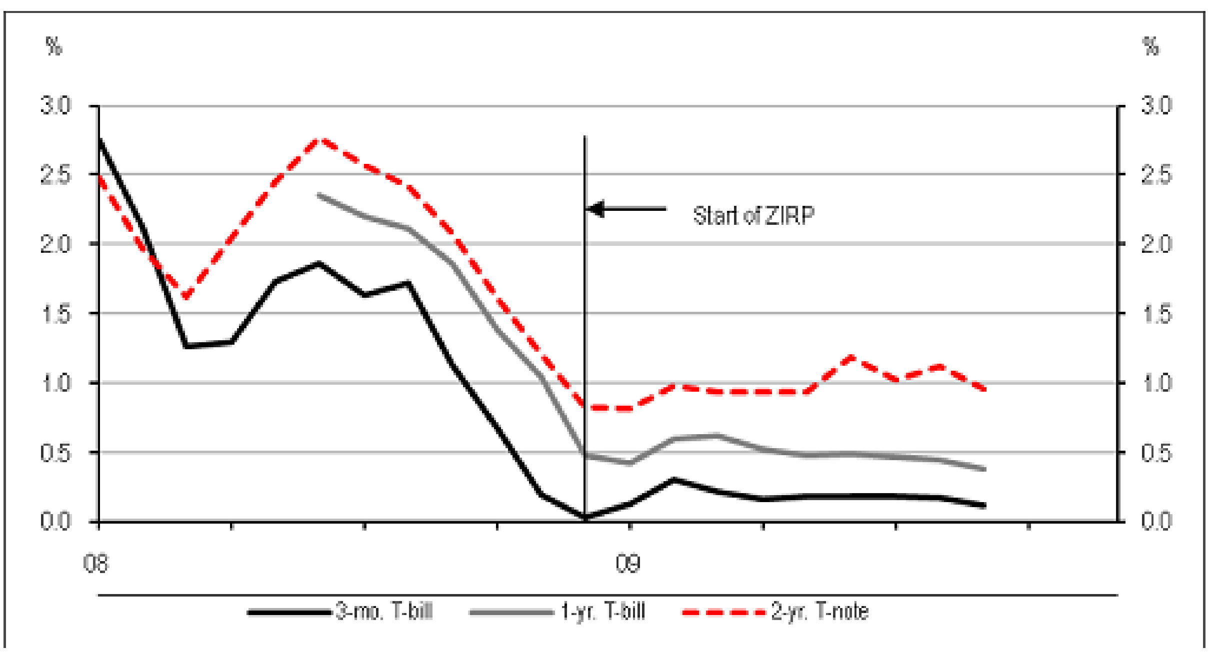
1. Introduction

The most recent economic downturn and the current economic conditions faced by the United States' economy throw light on the importance of macroeconomic variables as well as the factors driving such variables. The recent crisis can be appropriately described as a liquidity trap; wherein high levels of unemployment and alarmingly low interest rates render monetary policy completely ineffective. Economists have studied such crises in prolonged detail to unfold optimal solutions for freeing economies from such adverse economic conditions. Most academic literature indicates that inflation expectations are a crucial means of affecting real inflation in an economy and the central bank must be able to credibly shift inflation expectations in order to implement monetary policy effectively during liquidity crises.

Figure 1: US Short Term Government Bond Yields and Zero-Interest-Rate Policy



ZIRP = zero-interest-rate policy.

Source: CEIC Data Co. Ltd. database.

Figure 1 displays the nominal yield on the 3 month, 1 year and 2 year government Treasury bill. The zero interest rate policy (ZIRP) occurs immediately after the explosion of the housing bubble in 2008. This policy implementation hinders the Federal Reserve's ability to effectively conduct a monetary policy expansion.

This research aims to utilize the canonical models of how expectations are formed to determine which variables would significantly affect how forecasters build future price expectations. The motivation behind discovering how these expectations are formed is to be able to gauge how large of an effect macroeconomic variables have on inflation forecasts. By using a simple model of the economy, this thesis will test the size and magnitude of changes in the independent variables on the different economic agents' inflation expectations. By examining the quarterly shift in variables such as the federal funds rate, M1 and M2 monetary aggregates and the yield on the ten year and thirty year government treasuries, this paper will aim to capture the relationship that they share with inflation forecasts made by consumers, professional economists, the market and those made by the Federal Reserve Bank of Cleveland.

2. Literature Review

A liquidity trap can be characterized as a shock to the economy, which results in zero bound nominal interest rates and an significantly low level of employment, rendering monetary policy almost completely ineffective. At such low levels of interest, there is assumed to be an almost perfect substitutability between money and bonds because depositor's are unwilling to pay an almost negative interest rate for their savings. The underlying assumption behind open market operations is that money is neutral, and hence an increase in the monetary base should have a positive effect on the price level in an economy. We face a conundrum because during a liquidity trap, the monetary base is almost completely ineffective and therefore unable to affect output and prices in an economy. The solution to this problem is extremely simple; an increase in the money supply in the current and future periods will raise prices in the proprotionally. There is no corresponding argument that a rise in the money supply that is not expected to be sustained will raise prices equiproportionally[1]. To put this simply, as Krugman points at in his paper 'Its Baaack: Japan's Slump and the Return of the Liquidity Trap' if consumers are not expecting there to be a change in the monetary aggregates, they will not change their inflation expectations. He outlines the principal problem as one of inverse credibility where central bankers find it challenging to convince private agents of a convergence toward price stability. His results hint that unlike traditional liquidity traps in which monetary policy is completely ineffective, the central bank can implement monetary policy, if it credibly promises to be irresponsible and seek a higher future level. Eggertsson and Woodford (2003) built a model which outlines the responses of a central bank to an exogenous shock in aggregate demand that lowers the short-term interest rate consistently with full employment from 4 percent to -2 percent for a random number of quarters, after which the rate reverts back to normal. Given that rates cannot go below zero, the optimal policy in such a shock would be to keep short-term nominal interest rates low for more than 5 quarters after the interest rate returns to its natural rate. By doing so, there is a mild spurt of inflation in the economy that marginally increases output levels. A credible commitment to behave in this way after the zero bound has ceased to bind drastically reduces the price and output decline that occurs during the period when the central bank is constrained by the zero bound. Therefore, by shocking this model exogenously, they were able to predict the behavior of output and price both during and after a liquidity trap and hence point out that a credible commitment by the central bank to hold short term interest rates low could help shift

[1] Krugman, Paul R, 1998.

future inflation expectations and prevent a large decline in inflation. Their paper also describes ways in which other central bank policies may help increase their credibility to commit to an inflation target. They demonstrate a dynamic equilibrium game that uses the Markov equilibrium model as a purely forward-looking discretionary policy tool to test the reaction of inflation and output in the economy on sudden policy changes. The effect of these sudden changes in policy proves to be extremely deflationary, since the central banks' credibility would arbitrarily decrease as they change policy, which would drastically affect inflation expectations for the next period. An expectation that the central bank will behave in this fashion results in a deep and prolonged contraction of economic activity and a sustained deflation, in the case that the natural rate of interest remains negative for several quarters[2]. The authors conclude that policy implementation will always be ineffective if it remains purely forward looking then it.

Peter Morgan's paper on unconventional monetary policy helps elucidate the reactions of the private sector to the 'commitment effect' of the central bank. By analyzing a number of different empirical studies conducted in Japan on this specific effect, he concludes that these reactions are driven by short term interest rate forecasts and they subsequently tend to affect longer term inflation rates. The drawback is that such market reactions are not empirically large enough to affect expectations about the real economy and hence did not affect these interest rate forecasts. On December 16th 2008, Ben Bernanke announced that the Federal open markets committee (FOMC) anticipated weak economic conditions warranting an extremely low federal funds rate. The effect of the announcement was reflected by a large drop in the one-year T-bill rate, signaling that the market was receptive to Bernanke's commitment effect.

[2] Eggertsson, Gauti, and Michael Woodford, 2003.

Morgan points out that this evidence may mean that the drop is indicative of the worsening in the US economy, but the differential performance between the one-year and the two-year is suggestive that the commitment effect could be strongly correlated to the drop[3]. Morgan's paper serves as a good empirical basis for testing a theory such as the commitment effect and the credibility of an announcement made by the Federal Reserve Bank's Chairman would be on the future inflation expectations and the demand for government treasuries.

Auerbach and Obstfeld (2004) share the theory that even under conditions in which money and bonds serve as perfect substitutes for each other, open market operations serve as a strong monetary policy tool for the government. They use a dynamic equilibrium model to gauge the improvement in welfare conditions by the utilization of open market operations in Japan. The welfare improvement stems from large scale purchases of the government's debt. Similar to central bank announcements about the overnight federal funds rate, the Fed's commitment to buy back large quantities of debt would serve to improve inflation expectations and the significantly reduce the future burden of higher payments. However, the major source of uncertainty in bond returns is the future behavior of short-term interest rates. If those rates are at zero, they cannot fall. If investors cannot envision an eventuality in which short-term rates might rise, then investors no longer consider short-term rates to be random at all.[4] Under that circumstance, it would be impossible to generate positive risk premia, hence making money a perfect substitute for bonds. However, upon analysis of Japan's term structure, they notice positive long run interest rates. The conclusion is that consumers have positive expectations about both future interest rates and inflation. The paper neither defines the macroeconomic variable nor the

[3] Peter Morgan, 2009.
[4] Auerbach, Alan J., and Maurice Obstfeld, 2005.

magnitude of the welfare implications on inflation expectations, both faults representing large shortcomings in the study.

In his paper on Central bank communication, Stefano Eusepi discusses how essential a role a central bank has in the shaping of market expectations. Through an underlying theory of price stickiness, Eusepi studies a simple model based on monetary policy where the participants of the market lack complete information about the future decisions of the central bank. His findings show that an economy with a central bank that remains non-transparent about their policy suffers from "learning equilibria" characterized by lengthened periods of slower growth and deflationary prices. Small expectation errors can result in complex economic dynamics, inducing welfare-reducing fluctuations.[5] On the contrary, economies which enjoy transparent central banks display a more stable expectation trend around the set inflation target. Therefore, it is safe to conclude that information asymmetries that occur during a liquidity crisis affect inflation expectations and alter the speed at which the economy can alter inflation. Eusepi's paper serves supports this thesis, which will conduct a detailed analysis of what factors contribute to the formation of inflation expectations and the magnitude of their effects. Eusepi manages to highlight the importance of information asymmetries in an economy and how they would subsequently affect inflation.

Almost all academic papers on this topic point to the fact that monetary policy does not provide a sufficiently strong stimulus to relieve an economy from a liquidity trap. Both Japan and the United States during its 1930's recession struggled to find an optimal solution to the alarmingly low interest rates. A fair amount of literature looks at alternatives to the most commonly used central bank instruments. Christopher J. Erceg & Jesper Lindé discuss the effects of a fiscal

[5] Eusepi, Stefano, 2008.

expansion in economies where monetary policy is subject to the zero bound nominal interest rate by using a new Keynesian model where households and firms are forward looking. Using this model, they find that fiscal stimuli, if implemented in a timely manner, are extremely positive. They also find that if the fiscal multiplier has lags in its implementation, leading to an increase in distortionary taxes, then it can have the opposite effect on the economy, further slowing down economic activity.[6] The key observation made by this paper is that the efficiency of fiscal multipliers depends on expectations on future monetary policy implementation in the periods following the economies' exit from the liquidity trap.

For almost any policy implementation, inflation expectations will be crucial in determining whether the desired effects are achievable or not. In their paper 'Disagreement about Inflation Expectations', Mankiw, Reis, and Wolfers discuss disagreements in price expectations between consumers and professional economists. Their hypothesis is based on the theory that because information asymmetries exist in the market, agents will have different forecasts of price and consequently inflation. Since all the market agents will differ in their forecasts as well as make forecasting errors, changes in the money supply are attributed to a relative rather than general change in price per producer and hence these agents react by expanding production. "Each period only a fraction of the population updates themselves on the current state of the economy and determines their optimal actions, taking account of the likely delay until they will revisit their plans. This theory generates heterogeneity in expectations because different segments of the population will have updated their expectations at different points of time. Their model on expectations is based on disagreement which occurs due to a difference in information within the market and the dispersion in inflation expectation can be attributed to shifts in

[6] Erceg, Christopher, and Jesper Linde.

expectations. The paper uses the model of stick information on multiple different samples, consisting of a mix between professional economists, general public and academic, business, finance, market and labor economists"[7]. The conclusion derived from this paper is crucial to understanding how models forecasting inflation differ from the standard macroeconomic models. Expectations differ from person to person and the disagreement gives rise to changes in current and future inflation. The amount of disagreement is also time sensitive and hence it changes significantly with changes in economic variables. The reason that this model is so different from those based on both forward looking rational expectations and backward looking adaptive expectations is that it measures dispersion in the sample data, and the dispersion is one of the key dependent variables that explain a change in expectations. The emphasis of this literature review has been heavily based upon liquidity traps in order to highlight the importance of inflation expectations in an economy. Since liquidity traps are one instance where an economy's only exit solution to the zero bound interest rate zone is by augmenting future inflation, understanding how these expectations are formed is crucial to understanding how market agents react to changes in macroeconomic variables as well as identifying how these expectations shift.

3. Description of Data

3.1 Survey of Professional Forecasters and Michigan Survey of Consumer Attitudes and Behaviors

The data set for inflation expectations contains four different categories of forecasters, two of which happen to be professional economist and consumers. The Survey of Professional Forecasters, (SPF) and the Michigan Survey of Consumer Attitudes and Behaviors (MSCAB) are data sets which have been collected using survey responses of professional economists and

[7] Mankiw, Gregory, Ricardo Reis, and Justin Wolfers, 2003.

consumers based on their per quarter expectation of the consumer price index (CPI). My data set is quarterly, covering from 1980q1 to 2009q1. While I have not been able to procure the raw information from the data sets, I have the first and second moments of the distribution of the surveys. From these measures, I calculate the first difference of the mean forecast to ensure the data series is stationary. This first difference of the mean inflation forecasts is used as my dependent variable.

3.2 Treasury Inflation Protected Securities

A third measure of inflation expectations, is derived from the Treasury inflation protected securities (TIPS) issued by the US government. The TIPS deliver an implicit measure of the market's inflation expectations by giving us the expected real yield on a bond, while normal conventional treasuries give us the nominal yield on a bond. Therefore, by computing the difference between the nominal and the real yield, the expected inflation, I was able to derive the expected inflation for each quarter. Again, I calculate the first difference of the mean forecast to ensure that my data is stationary, and I use this first difference as another dependent variable.

$Y^n - Y^r = \pi^e$, where Y^n is the nominal yield on the 10-year conventional treasury and Y^r is the indexed real yield. [8]

There are two shortcomings when utilizing this financial instrument to measure inflation expectations. TIPS are adjusted for inflation risk; while conventional treasuries have their real return inversely related to actual inflation in the economy and is therefore not protected against this risk. "As a result, a conventional security will generally have to carry a higher expected real

[8] Shen, Pu, and Jonathan Corning, 2008.

yield than an indexed treasury just to be equally attractive to investors.” [9]Since TIPS lack the premium carried by inflation risk, the yield is adjusted to reflect this difference, which is often referred to as an inflation risk premium. The market for conventional bonds is the most liquid market in the United States whereas the market for TIPS is significantly smaller and more illiquid. Therefore, in order to compensate for the liquidity differential, there is a premium attached to TIPS, known as liquidity premium. Hence the yield from these securities is likely to be skewed by both the inflation risk and liquidity premium. The underlying assumption while using the TIPS as a means of expected inflation forecasts is that both the inflation risk and liquidity premium would be the same size so as to counteract the effect of each other. Given the controversy behind using TIPS as a means to forecast inflations, I attempted to get the data and test it nonetheless. Unfortunately because the data only goes back to 1997, the number of data points and the size of the standard errors may counteract my results.

3.3 Federal Reserve of Cleveland’s Inflation Expectations Model

Since the TIPS are heavily influenced by both liquidity and risk as aforementioned, the Cleveland Federal Reserve builds a data set for inflation expectations that are measured by nominal interest rates, inflation swaps, and the two survey forecasts, SPF and MSCAB which are used in this research paper. The reason why this model is preferred as a means to measure inflation expectations is because it is adjusted for both inflation risk and liquidity premiums. The model does accurately adjusts for inflation risk premium by explicitly calculating what the average risk premium should be (calculated as 0.5% in their model) and simply subtracting it from the expected inflation per quarter. The rationale behind this calculation is that inflation risk is associated more with the fear that inflation in the next quarter will deviate from that which is

[9] Shen, Pu, and Jonathan Corning, 2008.

expected rather than the fear of higher inflation itself. Hence, the model measures this premium and increases the size of the yield on the TIPS.

The model is also extremely advantageous over the TIPS model of expectations because it calculates short term real interest rates, without having to worry about premia associated with the TIPS expectations. Short term real interest rates are extremely crucial because comparing actual real rates to what the Fed sets to be the natural real rate would allow one to estimate whether it is implementing a contractionary or expansionary monetary policy. Therefore, if the current real interest rate is above the natural rate set by the Fed, then the policy is contractionary and vice versa.

I downloaded the data set from the Federal Reserve of Cleveland's website and changed monthly data to quarterly data from 1982q1 to 2009q1. As before, I use the first difference to ensure stationarity.

Figure 2 displays the correlation between the inflation expectations made by professional forecasters and consumers, using a sample period from 1980q1 to 2009q1. While I was able to access to the 2010 data, the most recent financial crises skews a number of my variables, and the large difference between the first and second order of my variables may also be distorted, therefore I chose to drop the last five data points. While the survey forecasts have extremely close means, the variance of the consumer forecasts is significantly larger than that made by the professional forecasters, leading me to believe that better access to market information would support the hypothesis of this paper. Furthermore, Figure 2 reflects the size and variance of the two market based expectations and shows the variance of these expectations to be significantly larger. The expectations derived from the TIPS have the largest variance due to the aforementioned presence of liquidity and inflation risk premia, that increase the size of the spread between the nominal treasury and the TIPS.

3.4 Independent Variables

One of my independent variables is lagged inflation because it can be used to measure backward looking inflation expectations. The monetary aggregates M1 and M2 are used to address Friedman's theory that an increase in money supply is positively correlated to an increase in future inflation and this theory could be reflected in inflation expectations. The nominal treasury bonds are used as a means to measure the relationship between nominal yields and future short term and long-term inflation. The federal funds rate, similarly, can be seen as a direct measure of monetary policy control, and hence a change in the overnight rate could have a significant impact on short run future inflation. In order to test whether the variance in stock market returns correlates to inflation expectations, the S&P 500 Total returns index is included as an independent variable. Lastly, I have also calculated and used the output gap and unemployment gap because they measure excess capacity in the economy and consequently price pressures, which help form rational expectations.

An output gap can be defined as the difference between actual and potential GDP, as a percentage of GDP. Therefore, if expectations are significant when regressed upon the output gap, it can be inferred that forecasters are make rational inflation forecasts.

Output Gap = $\frac{Yt - Yp}{Yp}$

Y_t represents GDP in real terms whereas Y_p represents potential output. In the long run, potential output of the economy is determined by how efficiently the economy is capable of allocating and utilizing the available factors of production for a given level of productivity.

However, in the short run, spurts of aggregate demand can drive the levels of demand far above long-term output expectations. This creates excessive demand pressure in the goods market that leads to rapidly increasing inflation. The reverse is true if the economy under-produces, a condition that would which would subsequently lead to lower levels of inflation[10]. In order to estimate the output gap, a Hodrick-Prescott filter is used to separate the trend component and the cyclical component of real GDP levels. The trend is representative of potential output as it is a broad growth curve around which GDP in terms of output fluctuates.

The unemployment gap, much like the output gap, helps predict whether forecasters are rational and forward-looking when making inflation expectations. The Philips curve states that the relationship between inflation and unemployment is inverse and hence this would be observable by looking at the deviation of unemployment in the economy, as a measure of how inflationary trends would occur. Therefore, the rationality of expectations can be accurately gauged by measuring the movement in the unemployment gap. The unemployment gap can be defined as:

Unemployment Gap $= \mu_{\alpha} - \mu_{\eta}$,

μ_{η} is defined as the non-accelerating inflation rate of unemployment, the level of unemployment below which inflation rises. The hypothesis put forward by Milton Friedman states that in order for any given labor market to exist, there must be a certain degree of unemployment, both frictional and classic. An exogenous shock leading to unexpected inflation would lower unemployment below the natural rate, but unemployment would revert back once inflation expectations adjust themselves.

[10] Monetary Bulletin, 2005 - 1

μ_α can be defined as the actual unemployment in the economy. Therefore, unemployment gap, if positive, indicates that the natural rate of unemployment is higher than the unemployment rate, which decreases in inflation expectations, and lowers price pressure in the economy. A larger cap is indicative of higher unemployment and hence lower inflation, therefore forcing the Federal Reserve to adjust inflation upward.

3.5 Short Run vs. Long run Inflation Forecasts

Given the sensitivity of inflation forecasts and the ability to change inflation expectations over a longer period of time, I will be testing two additional variables which are measured over a longer period of time (10 years). I will be using the 10-year TIPS inflation forecasts as well as the 10-year forecasts from the Cleveland model. By doing so, I will be able to accurately measure the deviation between short run and long run interest rates and how crucial of a role exogenous shocks play in affecting both short term and long run inflation expectations.

4. Methodology

The papers introduced in the literature review help to conclude that inflation expectations are the key determinant to helping shift an economy from a liquidity trap when monetary policy is completely ineffective. I am aiming to uncover the relationship between inflation expectations set by consumers, professional economists, the market, and various macroeconomic variables. My starting point is two canonical models of expectations. The first is backward looking and adaptive:

$\pi_t^e = \pi_{t-1}$, whereby inflation expectations are based on the median price level in the period t-1 and expectations are subsequently formed using a price lag of one period.

Or forward looking and rational:

$\pi_t^e = E[\pi_t]$, whereby inflation expectations are formed using an implicit model of the economy and all the available information.

I regress my gathered inflation forecasts, on the aforementioned macroeconomic variables which would contribute to or have a significant effect on formation of inflation expectations. Since most of these forecasts are short-term 1 year forward forecasts, I will also use two long-term forecasts to try to decipher how long term expectations differ from short term expectations when the factors contributing to these forecasts are the same for both time periods.

Because time series data usually displays autocorrelation I model the error as AR(1). As previously discussed, all variables are first differences to ensure stationarity. Denoting the first difference with a hat, the regression form is:

$$\hat{\pi}_t^e = \beta_0 + \beta_\pi \hat{\pi}_{t-1} + \beta_y \hat{y}_t + \beta_\mu \hat{\mu}_t + \beta_{FFR} \widehat{FFR}_t + \beta_{M1} \widehat{M1}_t + \beta_{M2} \widehat{M2}_t$$

$$+ \beta_{10yr} \widehat{10yr}_t + \beta_{30yr} \widehat{30yr}_t + \beta_{SPY} \widehat{SPY}_t + \varepsilon_t$$

$$\varepsilon_t = \rho \varepsilon_{t-1} + u_t \, , u_t \sim N(0, \sigma^2)$$

5. Empirical Results

5.1. Lagged Consumer Price Index, Unemployment & Output Gap

In order to understand how short run inflation expectations are formed and whether or not they are driven by price pressures or by adaptively looking at the (CPI) in the previous period, I regress the short-term inflation expectations on a one period lagged CPI as well as on both the unemployment and output gap. Since both output gap and unemployment gap explain one in the same effect of price pressures in the economy, I avoid running both regressions together.

Table 2.1 regresses the survey based inflation expectations on the output gap and lagged CPI in regressions (1) and (3). Both regressions reflect that professional economists and consumers are more receptive to a change in the CPI from period t-1. They also help conclude that potential price pressures caused by output gaps would have no significant effect on survey-based expectations. To measure whether Friedman's theory on the inverse relationship between inflation and unemployment holds true, regressions (2) and (4) measure the effect of the unemployment gap and a single period lagged CPI on the same set of inflation expectations. As expected, an increase in the size of the unemployment gap, which can be explained as a larger difference between the natural and actual unemployment rate, would lead to a decrease in future inflation because forecasters would expect high unemployment to lead to lower inflation in the future period. Therefore, while regressions (1) and (3) reflect that survey forecasters are purely backward looking and non responsive to price pressures, regressions (2) and (4) help conclude that while there is a strong correlation between lagged CPI and inflation expectations, there is no correlation between unemployment gap and survey inflation expectations.

I regress the Cleveland Federal Reserve's inflations expectations model, as well the inflation expectations derived from the TIPS, on the same independent variables to measure whether the market inflation expectations are rational or adaptive in nature. The results in Table 2.2 lead to very interesting conclusions. Unlike the survey-based forecasters, who are much more sensitive to the lagged consumer price index, both the dependent variables lack statistical significance and are not correlated to the independent variables. Regressions (1) and (3) in table 2.2 do not display a statistically significant correlation between an increase in the lagged CPI as well as an increase in the output gap. Regressions (2) and (4) reflect that while these market expectations are not correlated to a change in the lagged CPI, an increase in the unemployment gap has a significant and negative effect on the market's future inflation expectations.

The regressions performed in Table 2.1 and 2.2 help conclude that survey forecasters are more backward looking when forming expectations given the statistical significance of the lagged CPI, while market expectations are more rational or forward looking and hence react sensitively to price pressures in the economy.

I regress long run inflation expectations derived from both the TIPS and as the Cleveland model on the output gap, unemployment gap and the lagged CPI. Based on economic theory, one would expect there to be abatement in price pressures in the long run and a convergence between actual and natural output and unemployment. Therefore expectations would be more receptive to changes in lagged inflation as opposed to changes in the unemployment gap. Regressions (2) and (4) in table 3.1 reflect the economic assumptions underlying long run inflation expectations. The unemployment gap is statistically insignificant when regressed upon by long run inflation expectations derived from both the Cleveland model and the TIPS. The magnitude of change in future inflation when regressed upon lagged CPI displays strong statistical significance. Therefore, while short run market inflation expectations are receptive to price pressures, long run market expectations are more sensitive to changes in inflation in period (t-1).

5.2. Monetary Aggregates

Given the inferences made on the effect of actual inflation and price pressure on the rational and adaptive inflation forecasts, I regress a number of other variables on these expectations while controlling for the effects of both inflation and price pressure. Therefore, I regress the monetary aggregates M1 and M2 (money supply) on the same set of inflation expectations. M1 can be defined as the sum of the tender held by outside banks, traveler's checks, checking accounts net of the money supply held in the Federal Reserve float. The Federal Reserve can adjust this amount by adjusting the amount held in their float, hence either increasing or decreasing the quantity of M1 in the economy. M2 or money stock is the sum of small denomination time deposits, M1, and savings deposits. By adjusting the money stock, the Federal Reserve could control aggregate demand and hence inflation in the economy.

The regressions in 2.3 show that when there are price pressures present in the economy, the Fed would increase the supply of monetary aggregates to allay the pressure as well as increase inflation in the economy. Economic theory would suggest inflationary expectations increase when money supply in the economy increases significantly. Regression (1) in table 2.3 shows that while professional forecasters react positively to lagged inflation, they react negatively to an increase in the money supply. A possible explanation for this occurrence is an increase in inflation expectations by a larger percentage than the increase in money supply. I suspect that there is reverse causality between these variables whereby the Fed attempts to measure future inflation and hence increases the monetary base by less than is expected. Consumers react similarly to an increase in the monetary base, and the negative correlation is statistically significant.

The Cleveland model behaves in a similar manner; M2 is statistically significant while the lagged CPI has a positive and statistically significant effect on the inflation expectations derived from the model. The model is adjusted to smoothen short run exogenous shocks to the economy and is catered to react to changes that will have sustained long run effects on inflation, I assume that it is extremely challenging to capture the effects of short run changes in the macroeconomic variables. In his paper on gauging inflation expectations using the new expectations model, Joseph Aubrich states; “In the short run, there are price pressures, unemployment effects, and shifts in money demand that move the price level around in ways that are out of the control of the central bank. What's needed is a longer-term measure of inflation expectations that purges out the short-term effects." [11] Therefore, price pressures are statistically insignificant when regressed upon this set of inflation expectations.

The TIPS is significantly correlated to M2 as well. The expansion of the economy's monetary base would cause a large shift in the real interest rate, which should have adverse effects on the nominal yield as well, given a change in consumer savings and investments. Since the TIPS inflation expectations are not correlated to either of the control variables, it is hard to explain what is driving down their expectations when the money supply is increased. Another possible reason for a significant decrease in expectations may be low level of credibility of the Fed perceived by forecasters.

In order to measure the effect of an increase in the monetary base on long run inflation expectations, I regress the long term inflation expectations on M1 and M2. Economic theory suggests that long run inflation expectations should react positively to an increase in the monetary base, and the magnitude of the relationship would be measured by how credible the Fed is perceived to be by the forecasters. In table 3.2 regression (1), the TIPS long run inflation expectations behave similarly to the short run inflation expectations. There is negative correlation between the monetary supply, M2 and long run inflation expectations derived by the 10 year TIPS yield. This is surprising, as I would have expected to see a statistically significant and positive increase in the TIPS inflation expectations. Given the size of the dataset and the size of the liquidity premiums associated with the long term yield of the TIPS, the results could possibly be skewed. The long run inflation expectations forecasted by the Cleveland model react differently from those made in the short run. The long run expectations are adjusted upward

[11] Haubrich, Pennachi and Ritchken, 2009.

when the Federal Reserve expands the monetary base. This explains that because the Cleveland model is smoothened for short run effects, the effect of any independent variable change on inflation expectations made by the model are extremely different. Since the lagged CPI is statistically significant in regression (2), we can assume that expectations increase based on a change in the CPI within period (t-1). Hence when the Fed increases money supply (M2), future inflation is adjusted upward.

5.3 Federal Funds Rate

The federal funds rate serves as an indicator of the level of liquidity and volume of depository reserves in an economy. In order to gauge whether inflation expectations are heavily based on where the Federal Reserve sets the overnight federal funds rate, I regress the short run dependent variables on the quarterly change in the federal funds. Regressions (1) and (2) in table 2.4 display that both sets of survey forecasters are extremely sensitive to changes in the federal funds rate and have a significant and negative relationship with the this rate. An increase in the federal funds rate would lead to a disinflation because as the cost of borrowing increases, forecasters realize that businesses would be less willing to draw loans and hence inflation would be adjusted downward.

I regress the TIPS inflation expectations on changes in the federal funds rate per period with the expectation of a strong correlation between the two variables given the high volume of transactions which occur when Open market operations are conducted, which would have an adverse effect on the short term yield of government bonds. During a contractionary monetary policy, the volume of government bonds in the private market increases, changing the yields of both the conventional bonds and the TIPS. Therefore, the difference in the yield along with a potential increase in the inflation risk premium could account for a change in the expected inflation derived from TIPS. This could have an adverse effect on the relationship between inflation expectations derived from the TIPS and a change in the federal funds rate, as shown in table 2.6. On the other hand, the inflation expectations derived from the Cleveland model, are statistically significant and negatively correlated to the federal funds rate, hence supporting the economic theory that an increase in the overnight rate has a disinflationary effect on future prices.

In table 3.3, I regress long term inflation expectations on the change in the federal funds rate. Similar to the reactions of the short run inflation expectations, the long run inflation expectations derived from the 10-year TIPS are not correlated with shifts in the federal funds rate. My hypothesis holds strong when looking at the inflation expectations forecasted by the Cleveland model. There is a negative and significant relationship between an increase in the federal funds rate and long run inflation expectations. This negative relationship signifies that inflation expectations in the long run decrease marginally but move in the same direction as short run inflation expectations, confirming that a change in the federal funds rate will negatively affect future inflation in the long run.

5.4 Nominal Treasury Bill Yield Curves

In order to gauge whether the inflation expectations are being driven by the yield curve and if there is a significant correlation between nominal interest rates and inflation expectations, I regress both short and long term inflation expectations on quarterly changes between the 10 and 30 year yield curve.

Looking first at the survey forecasters, the regressions in table 2.5 show that there is no correlation between the change in the 10 year nominal yield and inflation expectations. The nominal yield of government treasuries is influenced by the conditions of the economy, and the demand of these treasuries is controlled by the economy's outlook on the volatility present within the market, which subsequently affects the yield of these instruments. When the yield on treasuries increases, the price of those securities decreases significantly, therefore allowing for market agents to secure a higher rate of return on their investment. Hence, we would expect to see an increase in the inflation expectations when the yield on US treasuries increases. In order to measure the change in short term inflation expectations I added in the change in the yield of the one year treasury as well. Table 2.5 (1), (2) and (3) show that a positive increase in the one year treasury yield has positive and significant effect on short term inflation expectations. Furthermore, the ten year and thirty year treasury yields are also positively correlated with short inflation expectations, showing that forecasters adjust expectations positively when the yield of both short and long term treasury bills change. The inflation expectations derived from the TIPS is negative and insignificant because the expected inflation decreases mathematically when the nominal yield increases, since the expected inflation is the difference between the nominal and TIPS yield. Since the TIPS are viewed as a flight to safety security from the risk of higher inflation, it can be inferred that an inflation risk premium would affect the expected inflation derived from the TIPS.

I regress long term inflation expectations on the change in the ten year and thirty year treasury yield in table 3.4. Long term inflation expectations are strongly correlated with the change in nominal yield curves for both the ten and thirty year treasuries allowing us to assume a positive relationship between inflation expectations and the yield on the ten and thirty year nominal treasury yield. This indicates that a higher yield curve implies a positive future effect on inflation, which may not be realized in the short run. Long term interest rates are often viewed as the average of individual short term interest rates. However because forecasters cannot correctly measure what the yield will be in the next year, long term bonds have an embedded term premium in their yields that could additionally affect the long run expectations[12].

5.5 Standard & Poor's 500 Total Returns Index

The Standard & Poor's (S&P) 500 Total returns index measures the total stock market return per quarter. I used this index as an independent variable to test whether there is any correlation between the formations of future inflation expectations and the performance of the S&P 500. Table 2.6 demonstrates that the relationship between the S&P total returns index and inflation expectations are insignificantly correlated for the survey forecasters and the inflation expectations derived from the Cleveland model. Surprisingly, there is a significant correlation in (4) between the inflation expectations derived from the TIPS and a positive change in the S&P 500 total returns. Given that bond traders would be most receptive to stock market, an increase in the S&P 500 returns would signal a lower demand for low yield, secure bonds such as government treasuries and the TIPS. It is probable that a lower demand for these securities affect the volume in which they are traded, hence causing a change in their price and yield. This could be attributed to an increase in inflation expectations as the spread between the TIPS and conventional bonds increases. This effect is similarly prevalent in the long run, as is reflected in table 3.6.

6. Conclusion

The objective of my research was to determine how market agents form expectations about future inflation and I used the two models of rational and adaptive expectations to achieve this

[12] Haubrich, Pennachi and Ritchken, 2009.

goal. The literature referred to in this paper is based on analysis of Keynesian liquidity traps and highlights the importance of inflation expectations in determining future output and prices Additionally, I looked at a simple model of the economy to determine which macroeconomic variables have statistically significant effects on these inflations. That being said, this thesis does not aim to measure causal relationships between macroeconomic variables, but instead aims to analyze which of these independent variables would be used by forecasters when basing where inflation in the economy would be in subsequent periods.

The discrepancy in information between different markets is the reason why I use inflation expectation forecasts made by professional economists, consumers, the financial market as well as a set of inflation expectations derived using a combination of the other three variables. Due to the time series sensitivity of the data set, I calculate the first difference for all the variables on a per quarter basis to ensure stationarity in my data.

Comparative time series regressions performed holding inflation expectations as the dependent variable reflect that consumers and professional economists are more sensitive to a change in the lagged period inflation, hence characteristic of an adaptive forecaster. The inflation expectations derived by the TIPS and the Cleveland model are more sensitive to an increase in the unemployment gap, representative of price pressures in the economy. Considering that they are statistically significant and negatively correlated to the unemployment gap, we can infer that this set of forecasters form their inflation expectations rationally, basing their forecasts on the size of the unemployment gap in the current period. The long run inflation expectations are also adaptive because they differ greatly due to price pressure abatements in the long run.

Regressing the inflation forecasts on various other macroeconomic variables while controlling for lagged inflation and unemployment gaps help to conclude that a change in both the federal funds rate and the yield on government treasuries have a statistically significant relationship with both sets of forecasters. The other macroeconomic variables, while having a statistically significant correlation with certain sets of inflation forecasts, are not uniform across inflation expectations. Therefore they not have a large enough effect to cause a substantial change in the future inflation.

Bibliography

Auerbach, Alan J., and Maurice Obstfeld. "The Case for Open Market Purchases in a Liquidity Trap." National Bureau of Economic Research 95.1 (2005): 110-40. Print.

Cecchetti, Stephen G., Monetary Policy and the Financial Crisis of 2007-2008. Economic Policy Review, March 2009. Print.

Cruijsen, Carin Van Der, and Maria Maria. "The Impact of Central Bank Transparency on Inflation Expectations." DNB Working Paper Series 31 (2005). Print.

Eggertsson, Gauti, and Michael Woodford. "The Zero Bound on Interest Rates and Optimal Monetary Policy." Brookings Papers on Economic Activity 1 (2003). Print.

Eusepi, Stefano. "Central Bank Communication and the Liquidity Trap." Journal of Money, Credit and Banking 42.2 (2008). Print.

Erceg, Christopher, and Jesper Linde. "Is There a Fiscal Free Lunch in a Liquidity Trap?" Center for Economic and Policy Research. Print.

Haubrich, J, G Pennacchi , and P Ritchken . "Estimating Real and Nominal Term Structures Using Treasury Yields, Inflation, Inflation Forecasts, and Inflation Swap Rates." *Federal Reserve of Cleveland: Economic Comments* (2009). Print.

Krugman, Paul R. "Its Baaack: Japan's Slump and the Return of the Liquidity Trap." Brookings Papers on Economic Activity 2 (1998): 137-205. Print.

Krugman, Paul. "Thinking About the Liquidity Trap." Journal of the Japanese and International Economies 14 (2000): 221-37. Print.

Maeda, Eiji, Bunya Fujiwara, Aiko Mineshima, and Ken Taniguchi. "Japan's Open Market Operations under the Quantatative Easing Policy." Bank of Japan Working Paper Series 5.3 (2005). Print.

Mankiw, Gregory, Ricardo Reis, and Justin Wolfers. "Disagreement About Inflation Expectations." National Bureau of Economic Research 3.8 (2003). Print.

Morgan, Peter. "The Role and Effectiveness of Unconventional Monetary Policy." *Asian Development Bank Institute* 163 (2009). Print.

Shen, Pu, and Jonathan Corning. "Can TIPS Help Identify Long-Term Inflation Expectations?" Federal Reserve Bank of Kansas City. Web. www.kc.frb.org

Table 1.2: Summary of Forecasters

	Michigan Survey	Survey of Professional Forecasters	Cleveland Survey	TIPS Inflation Expectations
Survey Population	Cross section of general public.	Market economists.	Nominal Interest rates, Inflation swaps, Michigan Survey and Survey of Professional Forecasters.	Based on market inflation expectations.
Survey Organization	Survey Research Centre, University of Michigan.	Originally ASA/NBER, currently the Philadelphia Federal Reserve.	Cleveland Federal Reserve.	United States Treasury.
Starting Date	Qualitative and Quantitative responses: Q1 – 1980.	GDP Deflator and CPI Inflation: Q1 1980.	Changes in CPI inflation. Q1 1982	Difference between nominal yield and TIPS yield. Q3 1997.
Periodicity	All quarters from Q1 - 1980 to Q1 – 2009.	All quarters from Q1 - 1980 to Q1 – 2009.	Monthly from Q1 - 1982 to Q1 – 2009.	Monthly from Q3 – 1997 to Q1– 2009.
Inflation Expectations	Expected change in price over next 12 months.	GDP deflator levels and Quarterly CPI levels.	Expected change in CPI over time period ranging from one month to thirty years.	Expected change in the quarterly yield between bonds of the same maturation.

Table 1.2: Summary of Variables

Variable	Description	Source
SPF_CPIpct	Quarterly percentage change in inflation expectations made by the Survey of Professional Forecasters	Federal Reserve of Philadelphia
MSCAB_CPIpct	Quarterly percentage change in inflation expectations made by the Michigan survey of consumer attitudes and behaviors	University of Michigan Survey Datasets
CLFEDINF_pct	Quarterly percentage change in inflation expectations made by the Cleveland Federal Reserve's model	Federal Reserve of Cleveland
TIPSINFL_pct	Quarterly percentage change in inflation expectations calculated by the difference in the 1 year TIPS yield and conventional 1 year treasury yield	Bloomberg Datasets
CLFLT_pct	Quarterly percentage change in long run inflation expectations made by the Cleveland Federal Reserve's model	Federal Reserve of Cleveland
TIPSLT_pct	Quarterly percentage change in inflation expectations calculated by the difference in the 10 year TIPS yield and conventional 10 year treasury yield	Bloomberg Datasets
CPI_pct	Quarterly percentage change in actual inflation measured by consumer price index	Global Financial Data
Outputgap_pct	Quarterly percentage change in output gap, calculated using a Hodrick-Prescott filter	Global Financial Data
M1_pct	Quarterly percentage change in the supply of monetary aggregate, M1	Federal Reserve of Saint Louis
M2_pct	Quarterly percentage change in the supply of monetary aggregate, M2	Federal Reserve of Saint Louis
FFR_pct	Quarterly percentage change in the overnight federal funds rate	Global Financial Data
tenyr_pct	Quarterly percentage change in the 10 year treasury yield	Global Financial Data
thrtyyr_pct	Quarterly percentage change in the 30 year treasury yield	Global Financial Data
oneyr_pct	Quarterly percentage change in the 1 year treasury yield	Federal Reserve of Saint Louis
unempgap_pct	Quarterly percentage change in output gap, calculated using a Hodrick-Prescott filter	Global Financial Data
spy_pct	Quarterly percentage change in the overnight federal funds rate	Federal Reserve of Saint Louis

Figure 2: Change in Short Run inflation expectations between 1980q1 and 2009q1.

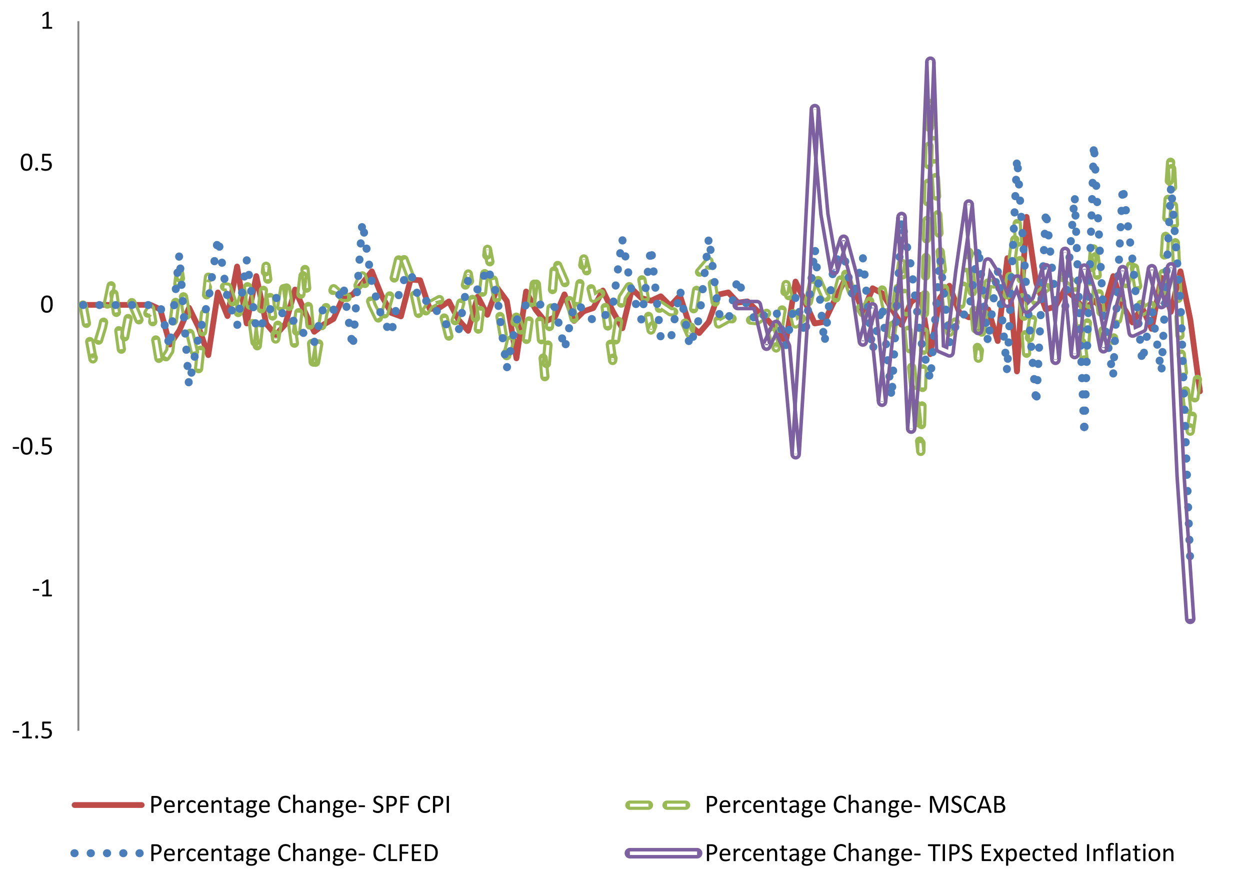
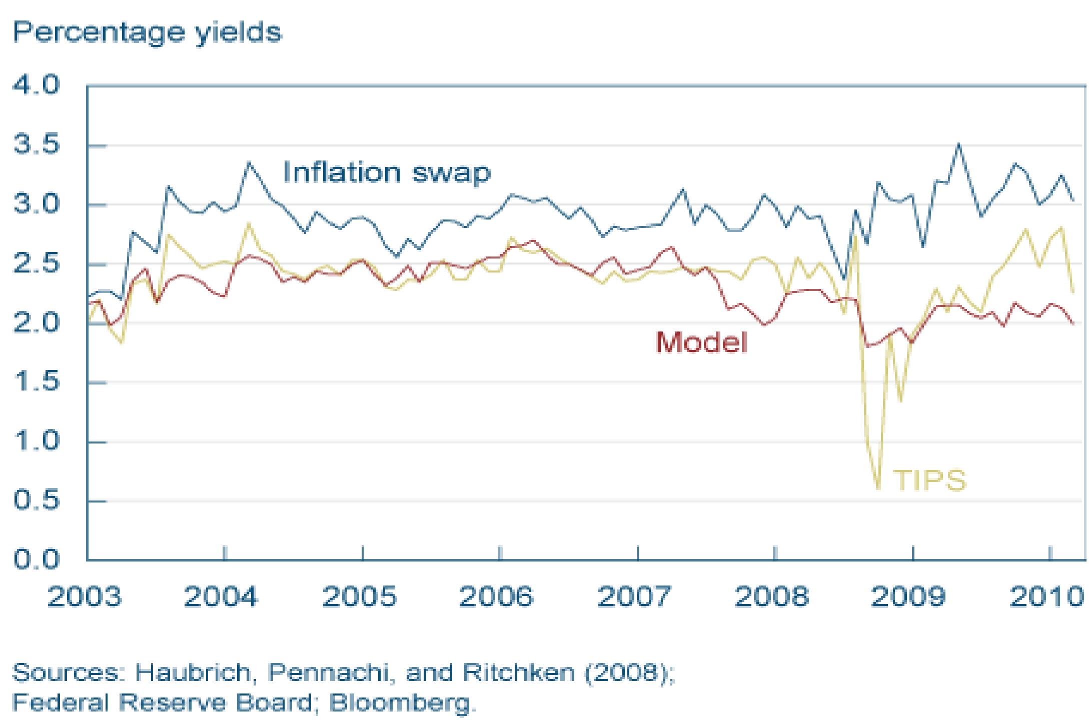


Figure 3: Federal Reserve of Cleveland's Model as compared to TIPS and Inflation Swaps



Short Run Inflation Expectations

Table 2.1: Regressing 1-year forward professional inflation forecasts on a single period lagged consumer price index, output gap and unemployment gap

	(1)	(2)	(3)	(4)
VARIABLES	SPF_CPIpct	SPF_CPIpct	MSCAB_CPIpct	MSCAB_CPIpct
CPI_pct	2.726***	2.706***	6.012***	5.962***
	(0.548)	(0.515)	(1.000)	(1.022)
outputgap_pct	0.00568		0.00488	
	(0.00430)		(0.00959)	
unempgap_pct		-0.00710		-0.00874
		(0.00459)		(0.00691)
Constant	-3.218***	-3.123***	-4.996***	-4.844***
	(0.684)	(0.629)	(1.492)	(1.640)
Observations	117	117	117	117

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.2: Regressing 1-year forward inflation expectations from the TIPS and the Cleveland Federal Reserve on a single period lagged consumer price index, output gap and unemployment gap

	(1)	(2)	(3)	(4)
VARIABLES	CLFEDINF_pct	CLFEDINF_pct	TIPSINFL_pct	TIPSINFL_pct
CPI_pct	-3.322	-2.951	0.0881	-0.0344
	(3.936)	(3.566)	(0.341)	(0.122)
outputgap_pct	-0.00594		-0.00196	
	(0.0346)		(0.00177)	
unempgap_pct		-0.0196*		-0.00423***
		(0.0116)		(0.00046)
Constant	-2.106	-1.961	-0.216	0.0118
	(11.23)	(11.1)	(0.492)	(0.291)
Observations	117	117	49	49

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.3: Regressing 1-year forward inflation forecasts on federal monetary aggregates, M1 and M2

VARIABLES	(1) SPF_CPIpct	(2) MSCAB_CPIpct	(3) CLFEDINF_pct	(4) TIPSINFL_pct
CPI_pct	2.106***	4.487***	6.518***	0.0810
	(0.763)	(1.278)	(1.377)	(0.0578)
unempgap_pct	-0.00735	-0.00930	-0.00835	1.30e-05
	(0.00511)	(0.00682)	(0.00786)	(0.000284)
M1_pct	0.000965	0.00160	-0.00403	0.000233
	(0.00803)	(0.0202)	(0.0156)	(0.000496)
M2_pct	-0.0551***	-0.123***	-0.0824**	-0.00451***
	(0.0189)	(0.0377)	(0.0403)	(0.00118)
Constant	0.113	2.515	-1.076	0.212***
	(1.155)	(2.667)	(2.507)	(0.0803)
Observations	117	117	117	49

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.4: Regressing 1-year forward inflation forecasts on the per period change in the overnight federal funds rate

VARIABLES	(1) SPF_CPIpct	(2) MSCAB_CPIpct	(3) CLFEDINF_pct	(4) TIPSINFL_pct
CPI_pct	1.805***	5.127***	6.016***	0.149**
	(0.662)	(1.175)	(1.102)	(0.0601)
unempgap_pct	-0.00642*	-0.00816	-0.00651	0.000325
	(0.00382)	(0.00696)	(0.00714)	(0.000374)
FFR_pct	-0.159***	-0.138**	-0.272***	0.00205
	(0.0331)	(0.0669)	(0.0516)	(0.00366)
Constant	-2.137***	-3.948**	-4.638***	-0.0779
	(0.725)	(1.857)	(1.267)	(0.0551)
Observations	117	117	117	49

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.5: Regressing 1-year forward inflation forecasts on the change in the one, ten and thirty-year treasury yields

VARIABLES	(1) SPF_CPIpct	(2) MSCAB_CPIpct	(3) CLFEDINF_pct	(4) TIPSINFL_pct
CPI_pct	1.428**	4.142***	3.640***	0.101**
	(0.674)	(1.298)	(1.195)	(0.0454)
unempgap_pct	-0.00572	-0.00677	-0.00404	0.000128
	(0.00401)	(0.00742)	(0.00706)	(0.000471)
tenyr_pct	0.375***	0.534**	0.518**	0.0167***
	(0.104)	(0.231)	(0.244)	(0.00436)
thrtyyr_pct	0.471***	0.729**	1.322***	0.0184*
	(0.131)	(0.332)	(0.310)	(0.00945)
oneyr_pct	0.180***	0.225*	0.254***	-0.00108
	(0.0403)	(0.131)	(0.0809)	(0.00233)
Constant	-1.699**	-2.810	-2.036	-0.0205
	(0.751)	(2.024)	(1.295)	(0.0494)
Observations	117	117	117	49

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.6: Regressing 1-year forward inflation forecasts on the S&P 500 Total Returns Index

VARIABLES	(1) SPF_CPIpct	(2) MSCAB_CPIpct	(3) CLFEDINF_pct	(4) TIPSINFL_pct
CPI_pct	2.730***	5.967***	7.594***	0.162***
	(0.542)	(1.008)	(0.996)	(0.0512)
unempgap_pct	-0.00691	-0.00857	-0.00815	2.65e-05
	(0.00455)	(0.00684)	(0.00817)	(0.000416)
spy_pct	-0.0473	-0.0419	0.0240	0.0142***
	(0.0798)	(0.171)	(0.166)	(0.00501)
Constant	-3.004***	-4.725***	-6.391***	-0.102*
	(0.615)	(1.614)	(1.173)	(0.0565)
Observations	117	117	117	49

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Long run Inflation Expectations

Table 3.1: Regressing 10 year forward market inflation forecasts as predicted by the Cleveland Federal Reserve on a single period lag consumer price index and output gap

	(1)	(2)	(3)	(4)
VARIABLES	TIPSLT_pct	TIPSLT_pct	CLFLT_pct	CLFLT_pct
CPI_pct	12.67***	13.90***	4.188***	4.267***
	(2.604)	(2.591)	(0.912)	(0.935)
outputgap_pct	0.0219		0.00571	
	(0.0202)		(0.00369)	
unempgap_pct		0.0376		0.000132
		(0.0282)		(0.00401)
Constant	-7.919*	-9.635**	-3.958***	-4.056***
	(4.143)	(4.152)	(0.916)	(0.917)
Observations	49	49	109	109

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.2: Regressing long run inflation forecasts on federal monetary aggregates, M1 and M2

	(1)	(2)
VARIABLES	TIPSLT_pct	CLFLT_pct
CPI_pct	7.632**	2.878***
	(3.098)	(1.106)
unempgap_pct	0.0167	5.71e-05
	(0.0225)	(0.00371)
M1_pct	0.0247	0.00653
	(0.0469)	(0.00882)
M2_pct	-0.342***	0.0783***
	(0.0858)	(0.0185)
Constant	12.84**	0.479
	(5.950)	(1.317)
Observations	49	109

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.3: Regressing long run inflation forecasts on the per period change in the overnight federal funds rate

VARIABLES	(1) TIPSLT_pct	(2) CLFLT_pct
CPI_pct	11.78***	3.026***
	(4.070)	(0.992)
unempgap_pct	0.0378	0.000949
	(0.0238)	(0.00375)
FFR_pct	0.233	-0.158***
	(0.223)	(0.0434)
Constant	-7.775	-2.900***
	(4.762)	(0.944)
Observations	49	109

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.4: Regressing long run inflation forecasts on the change in the ten and thirty year treasury yields

VARIABLES	(1) TIPSLT_pct	(2) CLFLT_pct
CPI_pct	7.718***	1.414*
	(2.367)	(0.726)
unempgap_pct	0.0169	0.00172
	(0.0363)	(0.00341)
tenyr_pct	1.366***	0.110*
	(0.242)	(0.0659)
thrtyyr_pct	1.811***	0.866***
	(0.547)	(0.0914)
Constant	-2.459	-0.866
	(2.682)	(0.735)
Observations	49	109

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.5: Regressing long run inflation forecasts on the S&P 500 Total Returns Index

VARIABLES	(1) TIPSLT_pct	(2) CLFLT_pct
CPI_pct	13.46***	4.255***
	(2.767)	(0.988)
unempgap_pct	0.0149	-8.65e-05
	(0.0272)	(0.00401)
spy_pct	1.106***	0.0509
	(0.328)	(0.0797)
Constant	-10.34**	-4.193***
	(4.655)	(0.973)
Observations	49	109

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1